ASSISTIVE TECHNOLOGY: FROM RESEARCH TO PRACTICE

Assistive Technology Research Series

The Assistive Technology Research Series (ATR) aims to disseminate and archive assistive technology research summaries widely through publishing proceedings, monographs, and edited collective works. The series aspires to become the primary world-wide source of information in assistive technology research, through publishing state-of-the-science material across all continents. ATR defines assistive technology (AT) as any tool, equipment, system, or service designed to help develop, maintain or improve a person with a disability to function in all aspects of his or her life. Assistive technology helps people of all ages who may have a broad range of disabilities or limitations. The ATR series will accept manuscripts and proposals for a wide range of relevant topics.

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ISSN 1383-813X (print)
ISSN 1879-8071 (online)

Assistive Technology: From Research to Practice

AAATE 2013

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IOS Press

Amsterdam • Berlin • Tokyo • Washington, DC

ISBN 978-1-61499-303-2 (print)
ISBN 978-1-61499-304-9 (online)
Library of Congress Control Number: 2013947307

Publisher
IOS Press BV
Nieuwe Hemweg 6B
1013 BG Amsterdam
Netherlands
fax: +31 20 687 0019
e-mail: order@iospress.nl

Distributor in the USA and Canada
IOS Press, Inc.
4502 Rachael Manor Drive
Fairfax, VA 22032
USA
fax: +1 703 323 3668
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PRINTED IN POLAND

Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

AAATE 2013 – From Research to Practice

This volume contains the proceedings of the AAATE 2013 conference, the 12th biennial European conference of the Association for the Advancement of Assistive Technology in Europe (www.aaate.net). AAATE's mission is "to stimulate the advancement of assistive technology for the benefit of people with disabilities, including elderly people". Assistive Technology (AT) is an umbrella term indicating any product or technology-based service that enables people of all ages with activity limitations in their daily life, education, work or leisure.

Those that have been associated to the area of AT in Europe for the last two decades might remember that the last of the ECART Conferences – the precursor of the AAATE Conferences - took place in Lisbon, Portugal in 1995. And it was during this ECART Conference that AAATE was officially created. In 2013, commemorating AAATE’s 18th anniversary, the AAATE biennial conference is again being held in Portugal, this time at Algarve.

The scientific field of AT is highly interdisciplinary, encompassing all aspects of assistive technology, such as use, research, development, manufacture, supply, provision and policy. One of the main objectives of the AAATE 2013 Conference is to bring together researchers, professionals, manufacturers, end users and their families, and combine their knowledge, expertise, needs and expectations, contributing in a multidisciplinary way to the advancement of Assistive Technology in Europe, *from research to practice*. With the goal of attracting all AT players to the conference, a Special Session Call for proposals was issued. As a result, 10 Special Sessions were organized parallel to the conference regular sessions:

- Alternative Human Computer Interfaces for People with Motor Disorders
- AT Centres and Service Delivery Issues
- Design for All and Mainstreaming in Ambient Assisted Living - The Role of Networking
- ICT-Based Learning Technologies for Disabled People
- Power Mobility: User experiences and Outcomes
- Predictors, Acceptance and Use of E-health Technology by Older Adults and Professionals
- (Semi-automatic) User Interface Generation
- Standardization within the Assistive Technology Field
- The Development and Implementation of “Remote Care”
- Using the Cloud to Enhance AT

High profile speakers were invited to give plenary talks sharing their knowledge, expertise and experience in different facets of Assistive Technology:

- Al Cook (University of Alberta, Canada) and Alan Newell (University of Dundee, UK) discussed and debated the impact of the increasing percentage of older people on AT development and service delivery;
- Fraser Bathgate (Disabled Divers International) addressed the role of scuba diving in the rehabilitation of persons with disabilities, sharing recent research projects findings and his personal experience;
- Inmaculada Placencia Porrero (DG Justice, European Commission) addressed the important subject of "Acessibility in Europe" focusing on European policies for persons with disabilities, namely the European Disability Strategy 2010-2020, the implementation of the UN Convention on the rights of persons with disabilities at EU level, and the preparation of the European Accessibility Act;
- Karin Astegger (EASPD - European Association of Service Providers for Persons with Disabilities) presented the concept of Person Centered Technology as a mean to empower technology users and to achieve effective, high quality, available, and affordable solutions to real needs;
- Sarah Blackstone (Augmentative Communication Inc., USA) proposed to reverse the acronym AAC - Augmentative and Alternative Communication yielding CAA - Communication Access for All to change the field perspective in the face of a time where many individuals, with or without disabilities, are dripping with devices that enable them to communicate easily and effectively almost anywhere, anytime, and with anyone.

Additionally, a session on Global Challenges in AT was organized where representatives from the United Nations, World Health Organization, European Union, AAATE and sister organizations RESNA, RESJA and ARATA, EASPD and from persons with disabilities organizations discussed existing global co-operation initiatives to further AT, and reflected on the needs and challenges, opportunities and difficulties of global co-operation in this field.

The AAATE 2013 conference has received 280 paper submissions from 39 countries in all continents. These papers were all reviewed by at least two of the 135 members of the conference Scientific Board. 182 papers (65%) were accepted and presented for oral presentation, 37 (13%) for poster presentation and 50 (18%) were rejected.

The program for this conference required the dedicated effort of many people. Firstly, we must thank the authors, whose research and development efforts are recorded here. Secondly, we thank the members of the Scientific Committee and the additional reviewers for their diligence and expert reviewing. Thirdly, we thank the keynote speakers for their invaluable contribution and for taking the time to synthesise and prepare their talks, and also the Special Sessions chairs that accepted our challenge to organize a Special Session in their field of expertise. Finally, special thanks to INSTICC - Institute for Systems and Technologies of Information, Control and

Communication (www.insticc.org) for accepting the challenge of organizing with us this conference and for their professionalism and competence that allowed us to concentrate only on the scientific aspects of the conference.

Pedro Encarnação

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Assistive Technology: From Research to Practice
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IOS Press, 2013

doi:10.3233/978-1-61499-304-9-3

A Test of a Walker Equipped with a Lifting Device

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Abstract. Studies have shown that about a third of all persons over 65 years who live at home fall at least once a year. Development of a lifting device that can help people raise themselves up entirely on their own, or with minimal assistance, would be a revolutionary step for the individual as compared with the lifting devices in use today. A prototype has been developed and the prototype has been tested to verify the approach. Studies have been conducted with nursing staff in a nursing home to find out the conditions for how a walker equipped with a lifting beam could facilitate the work. For caregivers dealing frequently with people who fall, this assistive device can contribute to decreasing occupational injuries.

Keywords. Walker, lifting aid, elderly, falls.

Background

Older persons want to have the possibility of staying in their homes as long as they can [1]. Important factors for being able to do so include feelings of security and accessibility in their homes.

According to Kangas et al. [2], about one-third of all persons over 65 fall once a year. In many care-related housing facilities efforts are made to reduce the number of falls, but no ”vision zero” concept will ever be formulated in relation to falls, as there is so much scientific evidence that exercise itself is important for the body’s physical well-being. A great deal of research has been done on how the risk of falls can be reduced in various ways, including reviewing older people’s medicines and making modifications in their living environments, as well as physical training and use of various assistive technology for walking [3-8].

The techniques that have been developed for lifting people who have fallen have so far been focused on reducing strain on the caregivers who must help the fall victims back up again. This has led to the development of lifting devices that are adapted to the environment where they are mostly used – hospitals and care facilities [9-11].

The various techniques that have been developed are meant to help people up from the floor with different degrees of assistance from caregivers/hospital staff, and include mobile lifts, inflatable lifting devices and even ceiling-mounted lifts. All of these devices are based on the patient not helping.

Development of a lifting device that can help people raise themselves up entirely on their own, or with minimal assistance, would be a revolutionary step for the

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individual as compared with the lifting devices in use today, which require much more extensive assistance from home helpers or others. It could even provide a potential for people to stay in their homes longer. In order for this to be both successful and feasible it is necessary that the process be analyzed. In an earlier project [12] we analyzed how older people prefer to rise themselves up, and in which stages they can gain the most benefit from an assistive device for lifting.

Our results showed that when older persons try to rise themselves up from the floor, 18 out of 20 choose first to get up to a kneeling position, then bring one leg forward and try to raise themselves. The greatest strain, and the step that determines whether one will rise oneself, is whether one is able to bring a leg forward in the kneeling position and push oneself up. All the participants in the trials were able to bring themselves to a kneeling position. Based on this fact, a device that helps a person to arise from a kneeling to a standing position would be the most optimal solution.

A prototype, based on an inclusive design methodology developed at Cambridge University [13] has been developed and the prototype has been tested to verify the approach.

The prototype was built on the basis of the most commonly marketed walker, the Ono. The elevating construction consists of a seat that runs along the vertical supports for the walker's handles. An electric motor, a battery and a control panel have been integrated into the elevation seat. Along the vertical supports for the handles a positive drive belt has been mounted. In this way the elevation seat can run along the entire length of the support.

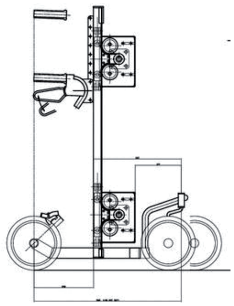

Figure 1. Elevating construction.

The elevation seat's construction is lightweight, and copes with loads up to 125 kg. It is designed to conform to various kinds of physical constitutions.

Figure 2. Prototype of the walker with elevating seat.

Tests

Twenty participants were recruited from a panel of older people who had declared their interest in taking part in experiments with new technology for better lives for older people. We mailed them a letter inviting them to participate in this special study. The criteria were that they were positive towards participating, that they had no symptoms of heart disease, and that they were over 75 years old. Ethical approval was given by the local ethical research committee in Stockholm, journal number (Dnr): 2011/1590-31/5. All participants took part voluntarily, were informed of the experiments' content ahead of time, and signed an agreement to participate.

Participants were helped to lie on their backs on the floor. When they were ready we asked them to raise themselves up to a kneeling position in any way they preferred. One person helped each participant, placing the walker in front of the participant so that he/she could crawl up and lie over the elevation seat. The assisting person then pushed the button to raise the seat. The seat was then elevated to a position where the participant's legs were vertical, making it possible to raise the upper body to an upright standing position.

Figure 3. The lifting process.

Participants were asked to describe if they experienced any pain, and whether there was any stage that was more difficult or more of a strain than others, or if they had any other comments about the lifting process.

The diagram below shows how they may have experienced any strain during the lifting process.

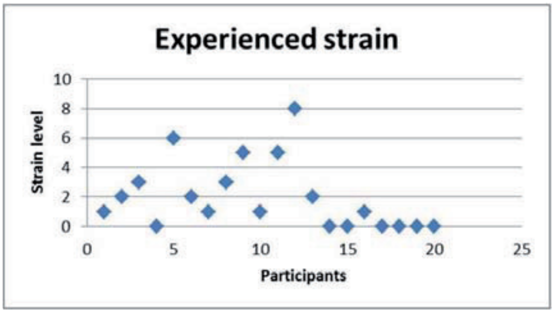

Figure 4. Experienced strain during lifting.

The process of rising from a kneeling position until the legs are straight takes an average of 25 seconds. Thirteen of the participants experienced some strain in their abdomens. The strain was evaluated, on the average, as a 3 on a scale of 10. The strain was primarily experienced just at the start of the lifting. One person felt some anxiety and dizziness during the lifting, while the remaining participants experienced the lifting as safe and secure.

When the lift is completed, the only step remaining is to raise the upper body. This stage can be accomplished at one's own pace, which the participants found positive because the risk of dizziness is then considerably reduced.

1 Objectives.

To analyze whether a walker equipped with a lifting beam can facilitate the rise of a fall from the floor and how it is perceived by users both patient and care staff.

1.1. Issues

- Can a walker equipped with a lifting beam be a help to rise up from the floor and under what conditions?
- How do the care staff and patients perceive the rising by the walker?

2 Method

Studies have been conducted with nursing staff in a nursing home to find out the conditions for how a walker equipped with a lifting beam could facilitate the work.

The research was conducted at a home for people with Parkinson's disease. The reason for the choice of accommodation for Parkinson's disease is that the residents due to the disease often falls, which would result in a qualified evaluation. The study focused on how the care staff perceives the use of the walker fitted with a lifting beam. The staff was asked to complete a "fall report" supplemented with a description of how the rising was carried out and how they experienced stress on their own body during the rise.

In connection with each fall, a report written about when where and how the fall occurred was made. This report includes also the research person's age and general functional status. Assisting care staff has been filling in a form about their experience. The persons listed as research persons are those who have fallen during the time when the study was conducted, and the method and helping aid as well as the staff who assisted in the rising was noted.

As a background, records of how falls normally was handled were evaluated. Only falls that occurred naturally have been used.

2.1 Results

In the background study, where the staff documented how the falls normally are handled, included the latest 19 falls. The staff did explain how they helped the patients up from the floor and if any devices were used. The following table shows how the rising was done:

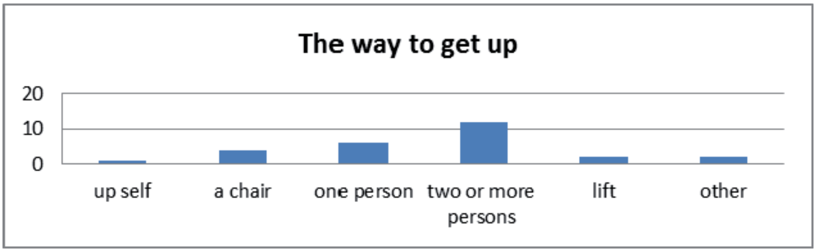

Figure 5. The normal way to handling falls.

The table shows that in 12 of the falls, when the staff had to help the patient up from the floor there where two or more from the staff who assisted. In only one of the 19 falls did the patient managed to get up himself. In two of the falls the mobile floor lift was used. In order to facilitate the lift and get a better grip the gait-belt was used in two falls. In four falls a chair was used to support and supplement the care staff's assistance.

Staff estimated which body parts that were stressed in the rising and it was primarily back, arms and shoulders. The load was estimated to be moderate but with some risk of acute injury.

The walker with the lifting beam was presented and demonstrated at the monthly meeting of staff. The staff was both instructed in how to handle the walker and tried to be raised by the walker. After this introduction the walker was left at the nursing home. The intention was that the staff would use the walker as much as possible in falls during the next month.

Total 17 falls were recorded. The table below shows how these falls were handled by the staff.

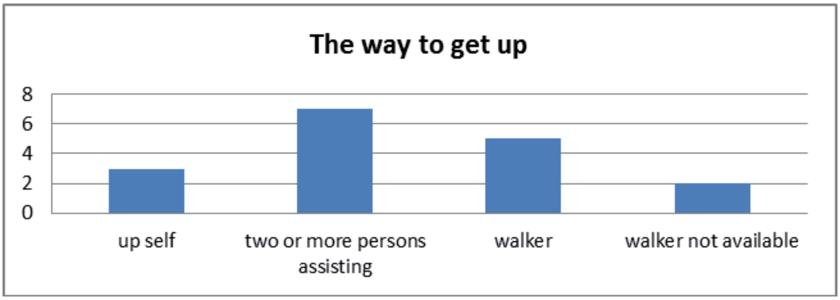

Figure 6. Handling of falls when the walker with lifting beam was available.

The table shows that in three of the cases, the patient has been able to get up him/herself. In two cases have not the walker been available because it was in another department. In the seven falls where the walker has not been used, it has been two or more of the staff that helped the patient up and therefore they did not considered that any aids were necessary. In one of these falls the patient was so stiff due to the disease that they had to use the mobile floor lift.

3 Conclusions

Studies have shown that about a third of all persons over 65 years who live at home fall at least once a year [14]. Of these ”only” 20% need medical attention [15-17]. Of the people who fall and do not injure themselves seriously, 50-95% cannot get up by themselves [17, 18]. To remain lying on the floor because one cannot raise oneself can have serious consequences. Studies have shown that people have lain on the floor for an hour or more before they received help [19]. Even though one does not live alone, a partner is not always able to help. That person may also have fears about the partner falling. This may be the case especially when the person falls often. For example, if one of them has Parkinson’s disease, this situation may be a great source of anxiety [20]. The partner/caregiver is often an older person who in turn often may be injured when he/she tries to help.

A simple assistive technology such as a walker equipped with an elevating seat would in many of these cases simplify matters and reduce the distress of people who fall often. In addition, such a device can allow people who fall often to live in their homes longer. For caregivers dealing frequently with people who fall, this assistive device can contribute to decreasing occupational injuries.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-10

End-User Involvement in E-MOSION Focusing on Mobility Services

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Abstract. The main objective of E-MOSION is to provide mobility services for older adults with age-related impairments. The idea is to help older adults in their daily routine activities far from home. The development and innovation process follows an iterative method where older adults are involved in the project from the beginning till the end. In the initial stage end-users were involved by means of a questionnaire and in focus groups. A result from the questionnaire was as expected that the reasons for getting around are manifold. Most of the participants mention shopping as the main reason for frequent mobility followed by visiting friends and cultural activities. Regarding the ways how people get around outside the responses show a broad spectrum. Walking, by car and by public transport services are the most prominent means. All in all the results highlighted the usefulness of the intended solution and revealed interesting insights which will be envisaged in the course of the project.

Keywords. Ambient Assisted Living, Mobility Services, Indoor and Outdoor Scenarios, User Involvement.

1. Introduction and Objective

The main objective of the project E-MOSION[2] (Elderly friendly MObility Services for Indoor and Outdoor sceNarios) is to provide integral indoor and outdoor localization and based thereupon mobility services for older adults with age-related sensory (visual, auditory) and cognitive (memory) impairments. The idea is to help older adults in their daily routine activities far from home. Special attention will be given to key activities for their autonomous living (e.g. shopping) and with a particular societal benefit procuring active

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[2]http://emosion-project.eu/

and convenient engagement of relevant stakeholders. This covers for example planning and security at home and guidance and support on the move and in the shop.

There is already research going on in several partial aspects, but none is covering the whole chain as mentioned above. Some of the research activities are mentioned in the following. HOMER is a platform for home event recognition [1][2] and will be deployed and extended to cover all intended security aspects at home. WayFis aims at supporting seniors (70+) to plan, manage and execute travel and transportation tasks at their own discretion in unknown indoor and outdoor environments [3]. ElderHop aims at making shopping a comfortable social event and is not just a simple device but a shopping companion for the older adults [4]. DALi pursues autonomous mobility through the development of the so-called c-walker, which is a mobility aid to support navigation in crowded and unstructured spaces by acquiring sensory information, by anticipating the intent of human agents and by deciding the path that minimizes the risk of accidents [5]. All existing solutions are not integrated together in a single device exclusively devoted to support older adults as E-MOSION is planned to be.

The project focuses on the development of new mobility and location assistance algorithms based on hybrid high-accurate space and terrestrial technologies and the consideration of new easy-to-wear, easy-to-use portable devices suited to the target users. The designed services will be able to take into account health-related, weather-related, and transport-related issues when offering mobility suggestions, as well as to direct call-for-help to the proper agent whenever needed to ensure the user's safety and self-confidence. Stakeholder commitment will be fostered through explicit and measurable trust-endorsement solutions addressing security, privacy, integrity and accuracy.

The projects target group are older adults above the age of 60, who live independently at home (either alone or with partner/family) and consider themselves hampered in their daily activities due to vision impairment (farsightedness) and/or chronic disease(s) and/or sensing a minor forgetfulness or dementia caused by aging. Furthermore, older adults with only basic, low or no digital skills are targeted. These people often face physiological and psychological difficulties related to daily activities and are thus limited in their mobility.

2. Methodology

The development and innovation process follows an iterative method where older adults are involved in the project from the beginning till the end to provide feedback about each component of the solution in every development stage (figure 1). The user involvement, which follows the seven principles of user participation in projects (FORTUNE) [6], is planned in several stages ranging from collecting user requirements and formative usability tests for mock-up testing to lab and field trials. Lab and field trials will include several pilot actions with end-users and scenarios mainly in The Netherlands, but probably also covering other partner countries. All user involvement is based on an informed consent and all participants get easy to understand information.

In the initial stage end-users were involved by means of an (online) questionnaire and in focus groups conducted in Austria, Finland and The Netherlands. In order to gather a higher amount of opinions and general information an (online) survey as one

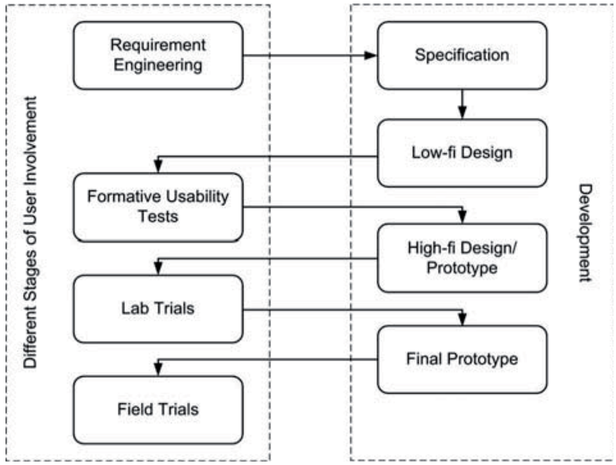


Figure 1. The different stages of user involvement and their influence on different development phases.

way to contact the end-user group was used. The survey was created in LimeSurvey[3], integrated in the project website and sent out via a survey-link included in an e-mail using various distribution channels from the partners. Besides a paper version was distributed to the participants of the focus groups and clients of the user organizations. Overall 169 total responses (101 full and 68 partial responses) were collected in December 2012, but just the full responses were analyzed. The sample is evenly distributed concerning gender (f = 49% and m = 51%) and age groups (<50: 7; 50-60: 5; 61-70: 36; 71-75:26; 76-80: 16; 81-90: 6; >90: 1) with a large share between 61 and 80 years.

Focus groups were run to collect additional qualitative data for the analysis of user needs and to derive user requirements. The focus groups were designed as suggested in and under consideration of the presented lessons-learned from [7]. These face-to-face meetings with end-users were used to initialize a valuable exchange and discussions that cannot be replaced by surveys. One to two focus groups (total number: 4) were conducted in each country involving 5 to 10 older adults. In total 25 older adults (12 male, 13 female) aged from 63 to 90 years participated. Unfortunately the number of people from rural and urban areas was not evenly distributed (2 rural, 23 urban). The user recruitment was done via involved user organizations and the focus has been on an early start of this task and to cover wide diversity in the participants as suggested in [8].

The focus groups, which were recorded on tape and an assistant moderator took notes, were structured as follows. The introduction by the moderator contained a warm welcome, a short presentation of the project and some guidelines for the communication behavior for the discussion (e.g. one person speaking at a time). After an introduction round of the participants the moderator used the beforehand distributed basic scenario as starting point for the discussions. The discussions were guided by the moderator by means of prepared guiding questions. Finally all participants could express final statements and a feedback and expression of thanks was given by the moderator. The data have been analyzed by means of the methodology proposed in [9]: (1) Noticing (i.e. making observations, taking notes, tape recording) and coding things (highlighting important

[3]http://www.limesurvey.org/

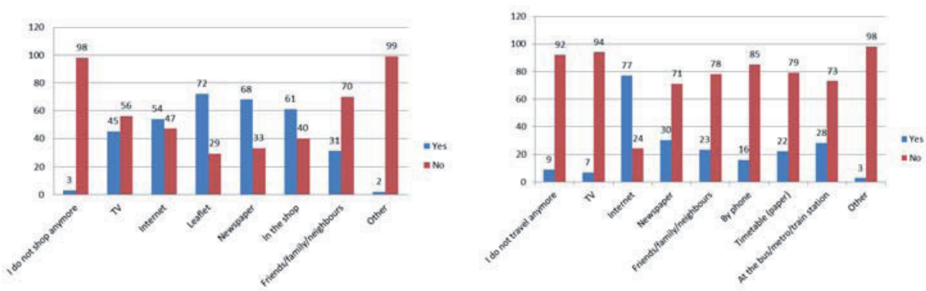
statements), (2) collecting and sorting instances of things and finally (3) thinking about things (i.e. deriving requirements and conclusions for the project). Step 1 was performed separately for each focus group and the latter steps for all groups together.

The method used in the remaining project for the formative usability tests and trials will be a task-based empirical investigation. A pre- and a post-interview will be conducted to cover the users' expectations (before the test) and to understand their experience (after the test). The usability will be evaluated via the System Usability Scale (SUS) [10] which is a simple, ten item Likert-scale giving a global view of subjective assessments of usability and allows to compare usability results of independent systems.

3. Results

3.1. Questionnaire

The answers of the questionnaire revealed some interesting insights for the project. Paper versions are still the most favored information sources about shops, products and offers within the researched target group. Leaflets and newspapers are ranked high, followed by information gathered in shops. The internet is an important source of information as well, i.e. over 53% (figure 2a). The main source of travel information is already to a very high extent the internet (figure 2b).



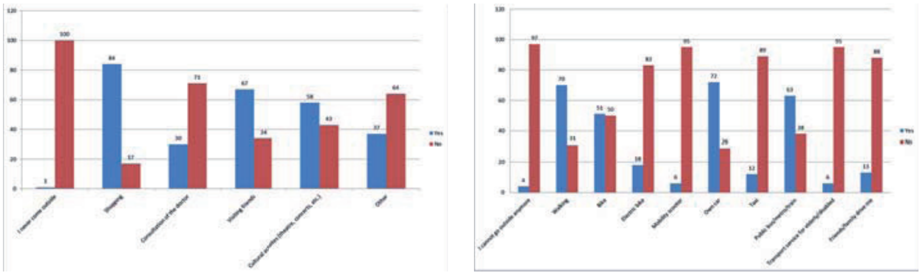
(a) Information about shops, products and offers

(b) Information for traveling

Figure 2. Sources for information regarding shopping/offers and travel (The absolute numbers are given in the graphic and correspond almost to the % value, since the sample size $n = 101$.)

As expected the reasons for getting around are manifold. Most of the participants mention shopping as the main reason for frequent mobility followed by visiting friends and cultural activities (all over 50%, figure 3a). Regarding the ways how people get around outside the responses show a broad spectrum. Walking, by car and by public transport services are the most prominent means (figure 3b).

The mobile phone penetration is very high within the group which participated in the survey. 97% use a mobile phone, but only a bit more than the half, i.e. 52%, of the people having a mobile phone is familiar with a touch screen. Regarding the device usage skills the majority shows high competences regarding phones, TV, the remote control for the TV and the internet. Mobile phones and PC skills lack a bit behind.



(a) Information about the main outdoor activities (b) Information about means of outdoor mobility

Figure 3. Activities outside the house and means of mobility therefor.

3.2. Focus Groups

The focus groups revealed as well very interesting results for the project and highlighted the usefulness of the intended solution. Several aspects of the project were appreciated. First of all an overall technical affinity of the sample could be seen. All participants were experienced using mobile phones and had a basic to advanced internet knowledge.

In general security functions for the home (e.g. alarms for open windows and switched-on stove, when leaving home) were rated positively and reminders for taking the key along seem to be an important issue, but alarms and warnings must not be inflationary. Tools for advanced planning of the trip and shopping combined with the possibility to receive real-time information on bus arrivals were appreciated as well. Guidance to and in the shop seems to be important as well and sending the location to formal/informal carers is no problem, if the user can decide. A modular solution for the user to decide which functionalities to use was favored. Furthermore the feeling of staying in control of his/her life is very important for the user.

The most important issue mentioned is usability regarding the device itself. Usage has to be simple and attributes like font size and contrast appropriate for the target group. The idea of an additional device such as a smart phone and/or watch was seen positive. Audio was mentioned as an important output modality.

In the course of the focus groups the moderator had to maintain the focus of the older adults and the structure in the meetings since the conversations sometimes wandered onto unrelated matters such as recounting anecdotes that were not relevant for the project similar as mentioned in [8]. But nevertheless the approach of using focus groups for gathering end-users' wishes and needs became apparent as the appropriate tool, since new aspects were revealed in fruitful discussions.

4. Conclusions and Future Work

The fact of the high technical affinity of the sample can be interpreted on the one hand as a bias of the sample, which is probably true for the questionnaire since it was mainly filled in online, but as well as representative for future users of ICT solutions in the AAL domain. The increased technical affinity of older adults is as well reflected in several statistics (e.g. Internet usage increased for the age group 55 - 74 from 30% in 2002 to 76% in 2011 in the Netherlands [11] and mobile phone usage for the age group 65+ from 49% in 2005 to 70% in 2011 in the UK [12]). The results of the online questionnaire and the focus groups underlined the need and market for the E-MOSION system. Furthermore it revealed some additional insights which will be envisaged in the course of the project. The main focus of E-MOSION for outdoor scenarios will be on the usage of public transport services and shopping, but keeping in mind additional functionalities and designing it in an extendible way for further activities and use cases.

Based on the derived end-user requirements the overall E-MOSION system is under specification and will be developed in the next months. Before starting the real implementation of the system front-end, mock-ups will be created which will be evaluated in formative usability tests. The results thereof will be used for the developments of the striven for solution. After the following development cycle lab trials will be conducted to receive valuable feedback on the first prototype when using it in a laboratory setting. Based thereupon the prototype will be improved to be finally evaluated in field trials in real life settings.

Acknowledgments

The project E-MOSION is co-funded by the AAL Joint Programme (AAL-2011-4-141) and the following National Authorities and R&D programs in Austria, Finland, Spain and The Netherlands: bmvit, program benefit, FFG (AT), Tekes (FI), MINETUR (ES) and ZonMw (NL).

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-17

Older Adults and the Use of Internet Communication: Results from a German Study-Sample

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Abstract. Background: Although much is known about communication patterns of young people, communication habits of older people still seem to be to be a neglected area of research. This seems surprising considering the great importance of information exchange, especially for this age group. Communication enables older people to participate in social life and thus can prevent loneliness and isolation.
Methods: After conducting a systematic literature search a questionnaire was designed to assess possible factors influencing the use of the internet for communication reasons. 150 persons aged 60 years and older were asked about socio-demographic information, conversation durations and dialogue partners. Additionally, participants were asked about subjective advantages and disadvantages of internet communication.
Results: Almost 50 % of the participants reported using the internet for communication (mainly e-mail). In particular, the socio-demographic factors age, gender and education influenced the use of internet for communication. Besides socio-demographic factors, we demonstrated that daily telephone use influences the use of the internet for communication. Contrary to our expectations, family situation, mobility and size of living area had no impact in this study-sample.
Conclusion: Using the internet for communication can be a possible solution to some of the problems many older people have to face, such as loneliness and isolation. Currently, the internet is used by only a small part of older adults. In order to strengthen internet communication in older people, it is necessary to know about factors influencing the use of internet for communication.

Keywords. Communication, Internet Use, older adults.

Introduction

In contrast to communication patterns of young people, the communication habits of older people are still a much neglected research area. To our knowledge, there are especially studies on the communication between older patients and their physicians [1] and on the communication patterns of older people with a specific disease such as aphasia [2].

This seems surprising considering the great importance of information exchange, especially for people from this age group [3]. Communication enables older people to participate in social life and thus can prevent loneliness and isolation. However, several recent studies have investigated the use of information and communication technology in older people in Germany [4, 5, 6]. The ongoing development in the field of media and telecommunication has yielded many new possibilities for communication.

Computers, internet and mobile devices have led to a digital revolution in telecommunication. Using the internet for communication offers older people with physical restrictions or people with few social contacts the opportunity to participate in social life. Thus, learning how to use new technologies is becoming more and more important in the lives of older adults [7].

1 State of the Art

To date, numerous surveys have been conducted on the general internet use within all age-groups. A lot of published data exists from public and private initiated research projects on internet usage in Germany, the EU and the world. One example is the (N)Onliner atlas, which constitutes the largest research project on internet use in Germany [4]. In this research project the authors classified the internet users by age, sex, education, family situation and occupation. Moreover, there have also been various studies focusing on internet use in older people. For example, Zickuhr & Madden [8] demonstrated that 53 % of American adults aged 65 and older use the internet. In a further study conducted by Selwyn et al. [9], the subjects reported using the internet and computers especially for writing and editing letters, reports and other documents, for furthering their own knowledge and for sending and reading e-mails. Koopman-Boyden & Reid [10] investigated the e-mail usage among 65 - 84 year olds in New Zealand. They demonstrated that 51.2 % use e-mail. Moreover, the specific topic internet communication is rarely of interest. To our knowledge there has not been any research on the specific characteristics of older internet users - i.e. their education, family situation or their general communication habits. Therefore, the present study focusses on these important aspects.

2 Methods

After conducting a systematic literature search a questionnaire was designed to identify the communication habits of older people. In a quantitative study with 150 senior citizens aged over 60 years, living mainly in the vicinity of Berlin, socio-demographic information and several questions regarding conversation-durations and dialogue partners were assessed in a written questionnaire. The assessment took place in May and June of 2012.

The participants were asked about their general internet use and their use of e-mail and other communication technologies in order to assess possible factors influencing the use of the internet for communication reasons. Additionally, participants were asked about the subjective advantages and disadvantages of internet communication and conclusively about their subjective importance of communication.

3 Results

Almost half of the older adults reported use of internet communication technologies. The average age was $M = 70.5$ years old ($SD = 5.9$ years). 41.3 % of the internet users reported writing e-mails on a daily basis. It was also demonstrated that chat programs, skype and social networks were only used by half of the respondents. The possibility to make phone calls on the internet was used occasionally by 46.7 %. On the other hand, the vast majority of the older adults (82.2 %) in our sample stated they did not use internet activities such as rating a product or reviewing a holiday, writing something in a guestbook or contributing to an internet forum or blog.

Table 1. Characteristics of older internet users in Germany, N=64.

		Frequency (%)
sex	male	53.1
	female	46.9
education	low education	7.9
	mid-level education	25.4
	high education	66.7
family situation	single	6.3
	married	60.3
	widowed	14.3
	divorced	19.0
at least weekly use of	e-mail	87.3
	skype	23.5
	chat	16.7
	social networks	10.3
main dialogue partners	family members	59.7
for internet	friends/acquaintances/neighbors	29.0
communication	clerks*	11.3
activities on internet	reviewing a journey or a product	23.8
	writing something in a guestbook	17.3
	writing something in a chat forum	12.6

* clerks = retail workers such as hairdressers, grocery clerks or bank clerks.

Our main finding was that the socio-demographic factors age, gender and education influenced the use of internet for communication. Furthermore, we demonstrated that daily telephone use had a significant impact on the use of the internet for communication reasons. Contrary to our expectations, family situation, mobility and size of living area had no impact in this study (Table 2).

Table 2. Results of a logistical regression.

		Exp (B)
age		0.908
sex	male	
	female	0.532
education	low education	
	mid-level education	2.245
	high education	7.802
size of living area	< 5.000 inhabitants	
	5.000 – 20.000 inhabitants	0.513
	20.000 – 100.000 inhabitants	6.168
	> 100.000 inhabitants	1.367
daily telephone use		3.867

$\chi^2 = 68.80$ $p<.001$ Nagelkerkes $R^2 = 0.494$

The advantages of internet use were seen in the speed, independence of time and space and the possibility to request information and to send pictures. The most important disadvantages the participants reported were excessive advertising, the fact that this form of communication is perceived as impersonal, lacking security and long waiting times.

4 The Impact and Contributions to the Field

The aim of this study was to provide a first attempt of presenting quantitative data focusing not only on the number of older internet users in Germany but also showing interesting specific data on their backgrounds, influencing factors and user opinions regarding advantages and disadvantages of this communication medium.
In future, the growing number of older internet users will influence the overall internet usage and will have an impact on new senior-based content and applications. It seems more than likely that a fundamental change in the internet behavior of the older people will be seen. Currently, the daily internet use is still focused on e-mail and some other web features but there is a trend towards various new ways of internet usage. Computer-based communication is an essential component for research activities and development in the field of ambient assisted living (AAL) or eHealth. Hence, information about the use of the target group very important. Knowledge about the habits of older users can have a significant impact on project results and are essential for encouraging the target group to use such newly developed systems.

5 Conclusions and Planned Activities

Overall, there is a lack of quantitative data on internet communication in older adults. Especially reasons for a reluctance of using these opportunities or potential barriers have not been thoroughly analyzed. The present findings may be a first step for further qualitative and quantitative research. Future large-scale studies conducted on an international level might point out differences between countries (taking into account specific national digital strategies) or the impact of national and EU policy towards minimizing the digital divide. It is necessary to encourage research activities regarding the usage of new communication mediums such as smartphones and tablets in older adults. Software and hardware firms in the EU should consider these findings and see the target group as a heterogenic group. Especially the non-users should be in the focus of attention for policy and advertising strategies.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-22

The Use of Assistive Technology in Different Age-Groups of Old People

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Abstract. The aim of this study is to explore the use and perceived unfilled need for assistive technology (AT) for everyday life in three age-groups during the ageing process. Data on use and perceived unfilled need for AT from three age-groups were used; the very old age-group; 81-90, n=314, the oldest old age-group; 85-94, n=154 and younger age-group, 67-71. The results show that the proportion of users highly increased between the youngest age-group and the very old age-group. An increase of use was also seen between the very old and oldest old age-groups, however not so prominent. In most respects the perceived unfilled need followed the same pattern. The result of this study can contribute to increased effectiveness of the supply of AT.

Keywords. Assistive devices, technology, ageing, ageing process, ADL, disability.

Introduction

Assistive technology (AT) is of outmost importance for old peoples' daily life in order to participate and carry out daily life as independent as possible [1, 2]. Since AT often is used to compensate for functional limitations and to overcome environmental demands, a large proportion of AT users are among the old population [3, 4]. Studies have shown that the most common used AT among old people around Europe are quite simple low-tech devices such as aids for mobility, e.g. walking stick and rollator, aids for showering and bath and for communication, e.g. magnifier and hearing aids [5]. Use and need of AT differs over time and in order to meet the challenges with the ageing society and the increasing number of ageing people living at home in need for health services, it is important to expand the knowledge base on which AT are in use and need for and when in time during the ageing process these AT are requested.

The aim of this study is to explore the use and perceived unfilled need for AT for everyday life in three age-groups during the ageing process. More specific the aim is to describe the proportion of users of ISO classified AT products, the most commonly used AT products and perceived unfilled needs for AT products, within each age-group.

1 Methods

1.1 Project Context

This study is based on data from two comprehensive longitudinal research projects targeting aspects of home and health during different phases of the ageing process. Two measurement occasions were used from the Swedish sub-sample of the ENABLE-

AGE Survey Study; a very old age-group; 81-90 (mean 85), n=314, and an oldest old age-group; 85-94 (mean 89), n=154 [6]. From the Swedish SNAC-GÅS project one sub-sample (n=371), comprising a younger age-group, 67-71 (mean 69) was utilized [7]. Data was collected at home visits by project-specifically trained interviewers.

1.2 Participants

In the younger age-group, 43 percent were male while in the other two age-groups the proportion of men constituted one quarter of the sample. Fifty-seven percent in the younger age-group lived in multi-dwelling housing, while 84 and 87 percent respectively, in the very old and the oldest old age-groups did. Self-assessed level of health was worse in the very old and oldest old age-groups, as was mobility, compared with the younger age-group.

1.3 Instrument and Data Treatment

The structured interview and observation questionnaire used in both the ENABLE-AGE Survey Study and the SNAC-GÅS project comprised well-proven self-report scales and observational formats on the home environment and various health indicators, along with questions about basic demographics and socio-structural data. The study-specific questions on AT comprised questions according to the ISO classification [8] in the following domains: optical, hearing, mobility, separated for indoor and outdoor use, and AT for daily activities, such as equipment for feeding, dressing, showering, and for toileting, in total questions regarding 28 different AT products. In the results these AT products were structured into seven groups: aids for communications, aids for mobility; in/out of bed, for indoor- and outdoor use, aids for toilet/shower, household and aids for furnishing and adaptation.

Data was based on subjective statements and only the responses reflecting the actual use of and perceived unfilled need for AT were utilised for this study. The proportion of AT users in the different age-groups, within the different domains of AT are presented by means of descriptive statistics.

2 Results

The proportion of AT users highly increased between the youngest age-group and the very old age-group. An increase of use was also seen between the very old and oldest old age-groups, however not so prominent (see figure 1). In most respects the perceived unfilled need followed the same pattern (see figure 2). In the youngest age-

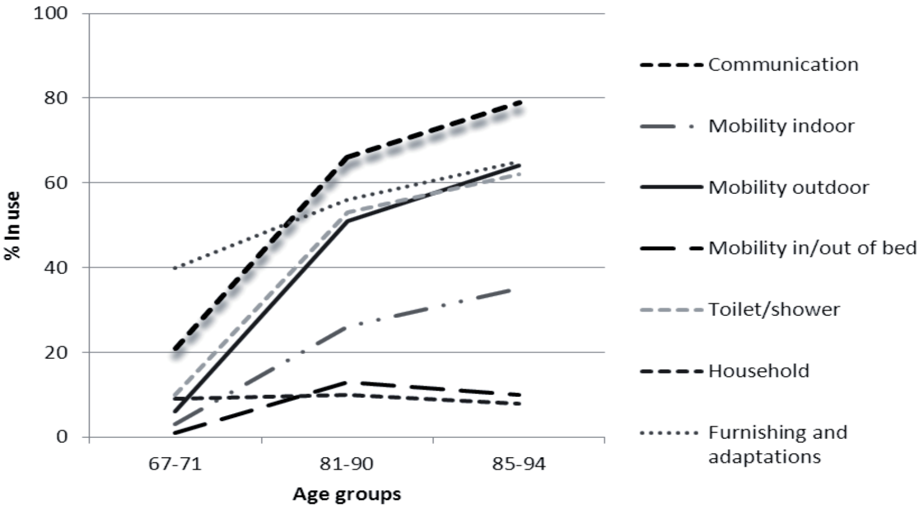

Figure 1. The proportion of users in the younger age-group, 67-71 (n=371), the very old age-group, 81-90, (n=314) and in the oldest old age-group, 85-94, (n=154).

group, 21% reported that they had and used some kind of AT for communication (irrespective of product), while eight percent expressed perceived unfilled need for this kind of AT. In the very old age-group, 66% had and used and 29% expressed perceived unfilled need for AT for communication. Among the oldest old age-group, 79% had and used, and 34% expressed perceived unfilled need for AT for communication. Among the youngest age-group, 6% used aids for mobility outdoors, while 51% used in the very old age-group, and 64% used aids for mobility outdoors in the oldest old age-group. The perceived unfilled need within these age-groups was 2, 6 and 11% respectively. Assistive technology for personal care (toileting, bath and showering) followed almost the same increase in use; 10% used in the youngest age-group, while 53% used this AT in the very old age-group, and 62% in the oldest old age-group. The expressed perceived unfilled need was 2, 8 and 18% respectively in the different age-groups. Aids for furnishing and adaptation, e.g. ergonomic/adjustable chairs and beds, handrails and pick-up sticks were used to high extent in all age-groups: 40% among the youngest age-group and 56% among the very old and 65% among the oldest old age-groups. Perceived unfilled need for this kind of AT was expressed by 6, 15 and 33% respectively among participants in the three age-groups. Aids for mobility in and out of bed/chair increased from 1 to 13% between the youngest age group and the very old, but later on decreased to 10% users among the oldest old. The only AT where the use decreased as age increased was aids for household (see figure 1). The perceived unfilled need for this type of AT was low for all age-groups (see figure 2).

Among the youngest age-group, the most common situation was to have and use one single AT (irrespective of product), while in the other two age-groups, the use of several AT was just as common as using one single AT. This was e.g. most prominent in the oldest old age-group; in particular for aids for personal care where 35% had and used several AT.

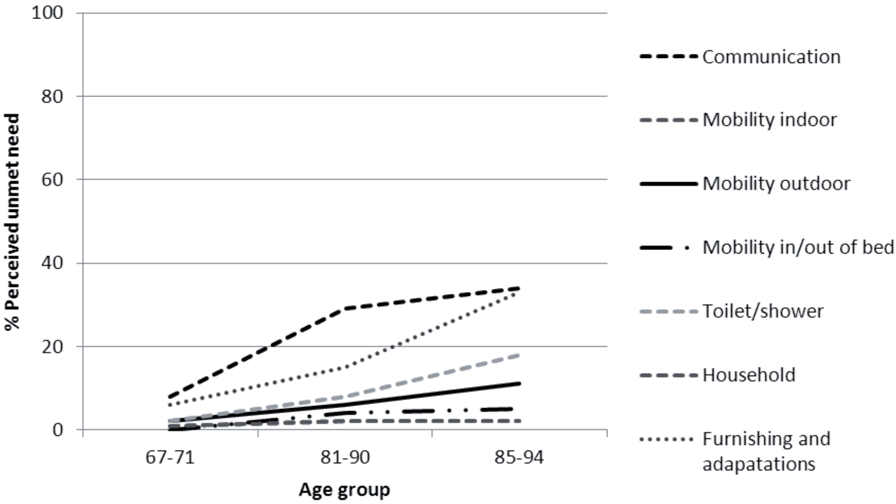

Figure 2. The perceived unfilled need in the younger age-group, 67-71 (n=371), the very old age-group, 81-90, (n=314) and in the oldest old age-group, 85-94, (n=154).

3 Discussion

This study contributes with detailed information on the use and perceived unfilled need for AT, for three different age-groups representing different time-point during the ageing process. The results imply that the use and perceived unfilled need of AT increases with increased age. The proportion of AT users was markedly clearly lower in the younger age group and the start to become an evident user of AT appears to happen somewhere in between 72 and 81 years of age. The increased proportions of AT users along the ageing process are results that are supported by others [9] [10]. Others have also found that frail elderly people need specifically developed support in the process of becoming users of AT [11], which might be part of the explanation of our results that the use of AT slightly decreased in the very old age-group.
Knowledge on when and why old people become users of AT are however still scare and more research targeting longitudinal aspects of AT use are called for [10].

Even though, there are differences among countries in the system for provision of AT and the Nordic universalistic model [12] imply high availability based on need assessments regardless of age, result from studies like this are of importance for future policy-making within the Europe Union as well as for planning regarding provision of AT within Europe countries. The knowledge achieved so far can serve as input for future development of and to improve health care and social services for older people living in the community across Europe. The information regarding which AT being used in everyday life among very old people is valuable due to the effort being made to meet the demands from this increasing proportion of the population living in European communities. More precisely, results of this kind highlighting unfilled perceived need and when in time the need occur, can contribute to increased effectiveness of the services delivery process and the supply of AT.

The results must be interpreted and understood against the specific empirical background making use of different research projects in the Swedish context, and far-reaching generalisation is not valid. In spite of these limitations, these results highlight the need for attention to rapid changes in use and perceived unfilled need during the ageing process, posing explicit demands on rehabilitation staff and public authorities and health services.

In conclusion, information regarding which AT being used in everyday life at certain ages during the aging process is of great value. Even more important is the perceived unfilled needs expressed, indicating the necessity of further development of rehabilitation services as well as information and services as regards AT, i.e. knowledge essential for future planning and policy to improve health care and social services for older people. The result of this study can contribute to increased effectiveness of the supply of AT.

Acknowledgements

The paper was partly funded by the Swedish Research Council on Social Science and Working Life and
accomplished in the context of the Centre of Ageing and Supportive Environments (CASE), Lund University, Sweden.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-27

Accessibility for Elderly using a Four-Wheeled Walker – an Interview and Observation Analysis

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Abstract. Accessibility for all is an overall goal in many communities around the world. The UN has the Convention on the Rights of Persons with Disabilities which Sweden along with many other countries has agreed to follow. The aim with this project was to analyse which environmental difficulties elderly people over 65 years of age experience in their daily life when walking with a four-wheeled walker. The focus area was the surroundings close to their home. It is necessary to learn more about the difficulties for people with disabilities as a base for future development of the built environment. The group of elderly is increasing daily. In Sweden the four-wheeled walker is a commonly used assistive device by the elderly when, for example, their balance decreases; this is why we chose to focus on this specific assistive device.

Keywords. Walking Accessibility, Four-wheeled Walker, Accessibility Experience, Stairs, Entrance Doors.

Introduction

In Sweden, currently about 250,000 people use a four-wheeled walker (walker) [1]. Sweden has a long tradition of evaluation and develops walkers to increase stability and safety for the users [2]. One reason for prescribing a walker is decreased balance or other walking difficulties [3]. With age the locomotion ability decreases [4], which could be a reason for using a walker. Studies show that the amount of people using a walker in Sweden is high compared to other countries in Europe [5], which can explain our interest in accessibility for these persons. Studies have been done according to the elderly's experiences of using a walker; one shows that elderly people are pleased with the walker as an assistive device. They described the walker to be a necessary device to be able to be active and mobile [6]. To walk with a walker could increase the ability to be active, but it also means other claims on the surrounding environment. Mobility promotes healthy ageing and well-being [7], and therefore it is important to work for an accessible environment. In 2010 there was a project financed by the SIAT (Swedish Institute of Assistive Technology) and the SABO (Swedish Association of Public Housing Companies), which resulted in an inspection protocol for property managers to use when they perform accessibility inventories in their properties. The tool was named the TIBB and is described as a "tool for inventory of accessibility". The TIBB

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protocol has five levels of accessibility and is mainly focusing on entrances and other community parts of the building. In the TIBB protocol, five levels are described. The focus is visual accessibility describing the need for light and contrasts and also describes level differences and the need for support with, for example, a handrail, a ramp or a door opener. [8]In this project, the focus has been on the last mentioned areas in the TIBB protocol.

1 Method

1.1 Participants

The participants were people over 65 who used a walker daily. We recruited the participants through ads displayed in buildings which included senior apartments. The participants were invited to participate at a given time.

1.2 Interview

We used structured interviews which included 18 questions, which were conducted to find out why the participants used the walker and how and when they used it. We also asked about how they experienced the accessibility in their immediate environment. The participants were asked to estimate how they experienced their possibility to perform different tasks. The described tasks were how they manage to walk through an entrance door, pass a curb or different types of stairs, etc. The tasks were exemplified with photos. The participants were asked to make an estimation of their experience of each task on an ordinal scale with five stages ranging from "very easy" to "impossible."

Fig. 1. Observation on analysing carpet area requirements.

1.3 Observation

To be able to estimate the area needed for moving with a walker, the last part of the test included an observation of the participants when they were performing a given task: turning 360 degrees with the walker. The turn took place on an analysis carpet which was designed with six circles on it with 10cm intervals and a range from the smallest circle 100cm in diameter and to the biggest circle 150cm in diameter. See Figure 1. The participants were instructed to do the turn in the smallest way they possibly could. The turning on the analysis carpet made it possible to see the amount of surface they needed to perform the task.

1.4 Data Analysis

The analysis consisted of two parts; the first one was to summarize the answers and search for similarities in how the group of elderly experiences the performance of the different tasks. The second part consisted of measuring the use of floor surface needed by participants when they were turning. In the Swedish building regulations, it is stated that a room is accessible if it is possible to turn a wheelchair 360 degrees without difficulty. In the Swedish accessibility standards, this is described with a circle that has a diameter of either 130cm, which is considered the standard level of accessibility or 150cm, which is the higher level accessible for big wheelchairs. In our analyses we measured the space needed and used the accessibility standard as a guideline.

2 Result

2.1 Participants

Thirty-four (34) persons with an average age of 90 years participated. The gender distribution was 30 females and four men; all of them were using a walker daily. The participants had one or more reasons for using a walker. The most common reason was unspecified balance difficulties (18 participants); the second most common reason was related to a fracture of any kind in a leg or hip (10 participants). Other reasons were arthritis (5), stroke (4), vertigo (4) or reduced general condition (2).

Table 1. Self-estimated maximum walking length with the walker.

Length in metres	Number of participants
<100	2
100-500	12
500-1000	11
1000-3000	9
>3000	0

The experience time for walking with the walker varied from one month to about 20years. The average time for using the walker, as the participants remembered, was estimated to six years, but they were not always sure about this time aspect. The shortest time for using a walker was about two months.

The mean age in the group of participants was high, and their walking ability and strength were limited. In Table 1, the participants self-estimated maximum length of walking is presented.

2.2 Interview

All participants were able to take part in the interviews, but not all could answer all the questions. In Tables 2-4, we present those answers as “don’t know”. It is not the same person who answered “don’t know” in all the questions.

2.2.1 Average Experience of Difficulties When using the Walker

Most of participants could not describe any average difficulties when using the four-wheeled walker: instead they made comments as “I don’t want to live without it!” and “I think it is simple to use the walker!” But eleven participants described some kind of difficulties; the most common comment was that “It is difficult to manoeuver” said by eight participants. Seven participants thought their walker was heavy and two participants had complaints about pain from their hands, which they related to the use of the walker. The same participant could give more than one alternative in this answer.

In our interview we asked if the participant had difficulties with folding the walker; no one said they had problems with this, but there were 14 participants who never had tried it.

2.2.2 Walking Surface

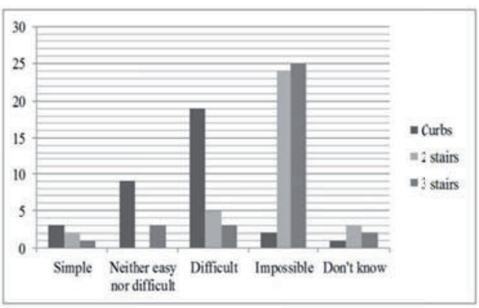
All the participants described ability to walk on a hard ground surface, for example, asphalt. Only three of the participants could walk on loose gravel: all of them had a walker especially equipped for outdoor walking. Eight participants were able to walk on an uneven surface such as cobblestone.

2.2.3 Curbs and Stairs

The questions about their ability to walk passing a curb or stairs mainly focused on situations when they were using the walker. Passing a curb with the walker is possible for most participants 31 (34) but difficult for most of them 19 (34). To walk on stairs and bring the walker was impossible for most of the participants. Only one person thought passing a curb was “very easy”: that person is included in Table 2 in “simple”.

We presented two different stair scenarios with a walker. The first one was walking on two-step stairs and the second one was walking on three-step stairs. This was only described as possible for seven of the participants in each scenario. In both scenarios there were two participants who did not know their ability to walk on stairs. In Table 2 we present the data from the participants’ description of their experience of their ability to pass a curb or stairs with the walker.

Table 2. The participants’ experience of walking on stairs or passing a curb with the walker.



We asked the participants about their ability to walk on three-step stairs if they had assistance from someone helping with the walker and instead could use a handrail to hold onto. To climb the stairs was described to be “difficult” for most of the participants 18 (34), but it was only impossible for five participants. The result from this question is presented in Table 3.

Table 3. The participants' experience of walking on stairs with support from a handrail.

Experience	Number of participants
Simple	4
Neither easy nor difficult	6
Difficult	18
Impossible	5
Don't know	1

2.2.4 Passing an Entrance Door to a Building

Most of the participants, 24, think it is "difficult" to pass an entrance door to a building with the four-wheeled walker and four describe it as "impossible". Only five people describe it as "not difficult. One did not know. In the interview some participants made comments and during this question the participants described the effect when the automatic door opener did not work. One story ended with the participant being stuck outside the door waiting for someone to come and help because she was not able to come inside the building. We had more comments and examples related to this question than the others.

2.3 Observation

Most of the participants, 23 of 34, were able to do a turn with a space requirement of 100 centimetres in diameter or less. Only two participants needed more than 120cm in diameter to turn and no one needed more than 130cm. The frequencies of space requirements for turning 360 degrees are presented in Table 4.

Table 4. Diameter of turning area needed for participants.

Diameter	Number of participants
<100cm	2
100cm	21
110cm	5
120cm	4
130cm	2

During observation we found that the need for service on the participants' walkers was common. There were brakes which did not work, wheels which needed air, etc. None of the participants had taken their walker to any service; they did not know where to ask for it.

3 Discussion

The use of walkers will increase with time, according to the changes in demography and an increasing group of elderly. When you use an assistive device it is important to feel in control and you use it to handle hindrances in the environment [7]. Therefore, it is important to work with the accessibility for persons with assistive devices. A walker could be an assistive device but it could also increase the risk of falling. In Sweden we have worked with developing the four-wheeled walker to increase the safety and stability for the user [2], and therefore it is also important to eliminate hindrances in the environment such as curbs, which many of our participants found difficult to pass. Stairs were impossible to manoeuver with the walker for most of our participants, and we suggest that there are alternatives offered for users of walkers who need to pass the stairs. The walker itself is causing difficulties in the stairs, and this is also confirmed by Anslow et al. [9]. Several of the participants could use stairs if there was a handrail to hold onto, and they did not need to lift the walker up or down the stairs.

To be able to walk through a door was described by the participants as difficult and their stories indicated that this was really frustrating. During the interviews the participants described situations where automatic door openers did not work, and they were not able to get inside the building. Or they got stuck in the space between two heavy doors. Their stories clearly indicated that being able to get through a door was something they expected to manage themselves, if necessary with some kind of assistive technology such as a door opener.

3.1 Conclusions

An environment accessible for all should include automatic door openers on every heavy door. An effort should be made to develop the technology so this product is reliable without being too expensive.

Stairs are a hindrance for users of a walker. Stairs should be used only when absolutely necessary and always supplemented with an alternative route which is accessible for persons using wheelchairs or walkers. The study also supports earlier assumptions (in the TIBB [8]for example) that handrails and the possibility to leave the walker outside make entrances with stairs possible to master for some users of walkers.

The regulation for wheelchair use with a turn circle of 130 centimetres in diameter is large enough for all users of a walker.

3.2 Planned Activities

In our continued work following this research project, we have started to develop a technical solution designed to help elderly people walk with their four-wheeled walker on stairs. Our goal is to find a product that is easily fitted on most stairs, is simple to manage and hopefully not too expensive. A prototype has been built and will be tested soon.

Acknowledgements

This work was founded by the Swedish Institute of Assistive Technology and for that we thank them.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-34

"I Need to Know, I Cannot, I Don't Understand": Older Users' Requirements for a Navigation Application

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Abstract. With the goal to design a mobile navigation solution for older users, we performed a user requirements analysis study with 49 participants in four different cities: Zaragoza (Spain), Paris (France), Oslo (Norway) and Vienna (Austria). The study focused on older users' mobility and interaction with mobile technology and it included focus group discussions, brainstorming, questionnaires, observations and interviews with tourism organizations for older adults. Our findings suggest that older users "need to know" information that will make their routes accessible and predictable; they often "cannot" properly use gestures, speech interfaces or read from the screen and in many instances they "do not understand" common navigation interfaces and their symbols.

Keywords. Mobility, Navigation, Mobile Navigation Applications, Older Users.

Among Introduction

Social relationships, home, neighborhood, environment and psychological well-being, mobility is considered a key factor of quality of life by older people [1]. With age, mobility is affected [2] and urban infrastructure is often only partially adapted to accommodate people with mobility- and age-related limitations [3].

The present study aims to contribute to the knowledge of the barriers older users face when confronted with mobile technology and in particular with navigation applications as well as insights on their everyday mobility issues. The design implications that stem from the results will inform the design of a mobile navigation application, developed in the frame of the T&Tnet (Travel and Transport solutions through emotional-social Networking) project [4].

In literature, older users' issues with mobile technology are mostly attributed to their cognitive and physical limitations, but they also depend on their transient goals and expectations. Holzinger et al. identify cognition, motivation, physical and perception issues in the interaction of older people with mobile technology [5]. Specifically for location-based applications, Kaasinen presents older users' requirements in regards to content, interaction, privacy and services provided [6] and Riegelsberger and Nakhimovsky present their methodological and usability findings from field trials with the Google Maps mobile application [7]. Further, a comparative study of map versus text-based interfaces for location-based applications is presented in [8] and rendering and user interaction with mobile map interfaces are discussed in [9].

1 Methods

First, we defined the profile of our target user and thus the criteria for participation in our study. Eligible participants were 65 years old or older, owned a cellphone of any kind, had a good level of mobility (that could be proved by their ability to arrive at the study facility without assistance) and no specific mental or cognitive impairments. The traits we defined describe a target user of older age who possesses the necessary background (a certain level of mobility and acquaintance with technology) to benefit from a mobile navigation application.

In the next step, we identified four areas in which our target users have experiences relevant to mobile navigation technology: their mobility (routes they perform on a daily basis or occasionally), their usage of mobile technology, their experience with navigation tools and their views on interacting with their mobile phones. All four topics were explored through focus group sessions in which participants filled in a questionnaire, participated in discussions and brainstorming. In detail, participants received a multiple-choice questionnaire asking their level of familiarity with relevant technology (in particular with smartphones, tablets, WiFi, GPS, e-mail and Facebook) and examined frequency of use of public and private transportation means (train, metro, bus, tram, taxi, own car, relative's car, bike and walking). The discussions that followed focused on each of the four areas, putting emphasis on motivation, habits and barriers. Participants were then requested to participate in a brainstorming session, producing ideas of features and information they would expect from an ideal navigation system. Upon the completion of the session, each participant voted for her four favorite ideas among all participants' ideas. The brainstorming resulted in a vast number of ideas that were later clustered into broader categories from the researchers. After the focus group sessions, user observation sessions were conducted, aiming at gathering additional insights on the users' interaction with current navigation technology. Focus group participants who owned a smartphone (a prerequisite for selecting participants for the observation sessions), each accompanied by one observer, navigated thinking-aloud towards a destination with the help of Google Maps on a smartphone. Gathering insights on mobility, mobile technology, navigation technology and interaction with technology through various methods, ensured that the users would have the chance to express their views in a way that was suitable for them and that issues that appeared though various methods would be emphasized.

The focus group sessions (questionnaire, discussions and brainstorming) were performed in four different cities with 49 participants aged from 65 to 86 (average age 70 years): 16 from Zaragoza (Spain), 11 from Vienna (Austria), 6 from Paris (France) and 16 from Oslo (Norway). The user observations were performed in Vienna and Paris with 4 participants who were smartphone users. Additionally, we performed 6 interviews with representatives from older adults' leisure & tourism organizations in Zaragoza, Vienna and Oslo as their expertise and years of experience dealing with older adults' mobility needs was considered a valuable input for our study.

2 Results

In total, 37% of all participants owned a smartphone. The highest percentage of smartphone owners appeared in Norway (two third of participants). Norwegian participants also reported the highest use of WiFi (70% compared to approximately 30% of

Austrian, French and Spanish participants). More than half of the participants in Austria, France and Norway had used a GPS in-car navigation system at least once or more, while only 13% of Spanish participants reported the same.

Regarding mobility, French and Spanish participants reported very little need for planning their routes, as they visit places already known to them. For Zaragoza, Paris and Vienna, participants stated to prefer public means of transportation over private vehicles (taxi, relative's vehicle and their own car). In Norway, on the contrary, transportation with private vehicles seems to be the norm among participants. We should note here that the results on usage of mobile technology and mobility are not intended to be used for comparison of the different populations, but for understanding the background of the study participants and to an extent, to explain their views on mobile navigation technology, as described in the following sections.

The results that appear multiple times as wishes, experiences or opinions across different methods are presented in sections 2.1, 2.2, 2.3. They are classified in three categories that relate directly to the design of a mobile navigation application: **content or "I need to know"** refers to information and functionality older users consider important, while they are on the road; **physical interaction or "I cannot"** includes all the aspects that define the users' physical interaction with a mobile system; **user's attitude and understanding or "I don't understand"** refers to how users perceive mobile technology in relation to their navigation tasks. The quotes that describe each category express in an eloquent way the three kinds of barriers our study participants might face with mobile technology in a mobility context.

2.1 Content or "I Need to Know"

During the brainstorming, in all cities, most ideas concentrated around public means of transportation; information about routes, timetables and delays, getting-off notifications and ticket-purchasing functions would be highly appreciated. In Zaragoza and Paris, where the main means of public transit are buses, participants pinpointed issues with them, such as lack of punctuality, *"steps being too high"* and confusion about routes.

Accessibility information (barriers, elevators, weather-protecting bus-sheds) was the second most populated cluster of ideas. Particularly in Oslo, perhaps due to climate, participants stressed accessibility issues throughout the focus group session. Moreover, participants were in favor of customizing their route according to weather, accessibility or route intent.

Besides public transportation means, accessibility and personalization, other categories of interest were necessities (medical facilities, opening hours, toilets), usability (big fonts, pleasant voice, simple menus), position and orientation information. In general, participants had little interest in getting location information for friends or other users in a navigation application, with the exception of participants from Zaragoza.

In a nutshell, participants favored practical information that would make their trip predictable (timetables, delays, opening hours) and comfortable (ticket purchasing, getting off notification, toilets, elevators, escalators) over entertainment information (tourist guides, restaurants, museums, cinemas, shopping malls). Moreover, the information required by participants, especially for public transit means and accessibility was different across the four cities, due to infrastructure and environmental conditions.

2.2 Physical Interaction or *"I Cannot"*

Participants in Oslo and Vienna preferred smartphone over tablet for on-site navigation and desktop at home. In Zaragoza and Paris, participants acknowledged the comfortable size of the tablet screen, as well as the portability of the smartphone. With the exception of Oslo, where two thirds of participants use smartphones for navigation, other participants' current practice is to bring paper maps and map prints they created online.

During focus groups, participants – both, the ones who had experience with GPS in-car systems and those without – had a positive attitude towards speech-based interfaces. However, during the observation sessions, participants did not attempt to customize the application for speech interaction or other options and preferred the default choice of visual navigation. This lack of interest for customization can be attributed to the fact that their attention was captured more by the street than by the device and complies with Kaasinen's findings [6] that, despite the benefits personalization offers, few users would invest the required effort.

During observation sessions, mild sensory limitations, not mentioned during focus groups emerged: *"I cannot see small fonts well", "My ear makes a buzz if I listen to something for more than 20 minutes", "My fingers are not too stable"*. In particular, a lack of haptic precision in combination with the unconstrained zooming on Google Maps often hindered participants from successfully switching between map overview and details. Participants then turned to the observers to ask *"where has the information gone? Can I go back to the previous screen?"*. In some cases, when they zoomed in, they landed on a wrong location and relevant details (e.g. street names) were not visible anymore, while when they zoomed out, route marking was reduced to a small line on a map, without any meaningful information for the user.

Regarding physical interaction, older users stated to prefer to use their desktop computer at home and smartphone or map prints on the way. Moreover, they are partially capable of handling different modalities such as visuals, speech and touch. Thus, attention should be paid in identifying their limits – font size, gesture control, right volume and wording for speech interfaces – and designing for them.

2.3 User's Attitude or *"I Don't Understand"*

In Vienna, Paris and Zaragoza, participants often used the phrase "*when it is necessary"* to explain their usage of mobile phones, expressed privacy concerns and criticized the *"constantly connected"* youth. While being outside, they need to allocate their attention to the street: *"I prefer to look at the ground and not at the smartphone, because I recently fell and hurt my ankle"*. In the phone interviews, organization representatives mentioned that older people were afraid of attracting unwanted attention, being robbed or falling when using a smartphone.

During user observations, participants had difficulties recognizing the marking of the route on the map. This remark along with the fact that "actual position and orientation information" was voted as one of the most important features during the brainstorming session, shows that seniors do not always comprehend common map formatting and marking.

Moreover, participants from Oslo said to be confused by the multiple choices Google Maps returns when they enter a destination and participants from Paris found the car-navigation system "*not so precise"*. The confusion with search results (also a finding in [7]) might be due to the users' ambiguous queries and the unclear system responses they might produce; Church et al. classified queries made in location-based applications into general, location explicit, location implicit and miscellaneous queries [8].

In general, older users have privacy, safety and lifestyle issues with mobile technology, but are willing to use it *"when it is necessary"*. Moreover, the way navigation information is presented to them often does not meet their expectations; in case of Google Maps, the multiple results corresponding to a single query can be confusing, the marking of a route unclear at first sight and the switching between different map screens overwhelming (see section 2.2).

3 Conclusions

The results of our study can be summed up in the triplet *"I need to know, I cannot, I don't understand",* along with users' attitude towards the product domain *"when it is necessary"*. In particular, we have found that older adults appreciate accessibility and comfort information, cannot always handle the modalities present in a smartphone and can be confused by the way navigation information is presented to them.

We plan to investigate in the future how this requirements' taxonomy could be extended and enriched in order to explain older users' barriers and issues with technology and mobile technology in different contexts. Such a taxonomy could serve as an evaluation framework to designers that would allow them to focus on what the user "needs to know", "cannot do" and "does not understand", when confronted with interface design decisions.

Acknowledgements

The research presented in this paper was conducted as part of the T&Tnet project (AAL-2011-4-032), which is partially funded by the European Ambient Assisted Living Joint Programme and the National Funding Agencies from Austria, Cyprus, France, Italy, Norway and Spain.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-40

Bank4Elder: Innovative Banking Interfaces Adapted to Older People Needs and Capabilities

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Abstract. Older persons turn directly to the branch for accessing to banking services because they feel safer and they have problems when they interact with bank interfaces. These interfaces are not adapted to older people needs and capabilities. Bank4Elder project aims to develop innovative web and Automatic Teller Machine (ATM) interfaces involving older persons along all the design and development process. The results showed high levels of satisfaction of older persons with the new interfaces, which combine age-friendly and aesthetic characteristics. Moreover, designers and developers have become aware of the older persons profiles and their real needs.

Keywords. Human Centered Design, Older Persons, Co-Creation Session, User Needs, Conceptual Design, Validation Concept, Banking Interfaces, Automatic Teller Machines (ATM), Web Banking.

Introduction

The structure of population within European Region countries has changed during last decade. Ageing population is a reality in our society, older people represents 17% of European population and this will continue increasing until 30% in 2060.

The ageing can limit persons capabilities from physical (e.g. reduced movement ranks and muscular strength), cognitive (e.g. memory loss) and sensorial point of view (e.g. reduced vision); which can be reinforced by pathological processes (e.g. Alzheimer). However, the older population is a very heterogonous group as it includes people without any functional limitation and people with severe disabilities. Therefore, it is important to adequate products, services and environments to their capabilities to ensure a comfort interaction of most of older persons.

The reduced functional capabilities together with lack of technologic skills and/or low education levels cause serious difficulties during interaction with new technologies, because needs and capabilities of older persons are not taken into account [1]. Recent European projects have focused on solving these problems for public digital terminals (e.g. Apsis4all [2]) and even some private initiatives have focused on banking field such as the innovative ATM of BBVA bank developed by

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IDEO [3].

This problem is more evident for banking interfaces. Although the percentage of older persons accessing to internet is increasing, only a residual percentage use online banking. Most of them access by the branch, because they feel safer than using other solutions as web or ATM or because they have problems to interact with these interfaces.

Therefore, Bank4Elder project is focused on developing innovative and age friendly Automatic Teller Machines (ATM) and web interfaces adapted to needs and capabilities of older persons to guarantee a comfortable access to bank services. This paper is focused on the following objectives:

- Gather older people needs and expectations and identify user profiles.
- Develop the conceptual designs of ATM and web interfaces.
- Validate acceptance and age-friendly of the conceptual designs.

1 Methods and Tools

Human-centered methodologies have been applied along this project, exactly more than ten different techniques. For achieving the first goal, to identify user´s banking needs, requirements and expectations, the following techniques were employed (see Figure 1):

- Review of the state of the art about bank services, interfaces and future trends.
- Three focus groups with older people and one focus group with future generation of older persons (50-60 years) to explore bank services/interfaces use.
- A survey for extracting problems related to bank services and interfaces.
- Repertory Grid Technique to compare ATM and web interfaces of different bank branches to detect key criteria of older people preference.
- Observation protocol and deep interviews during interface interactions.

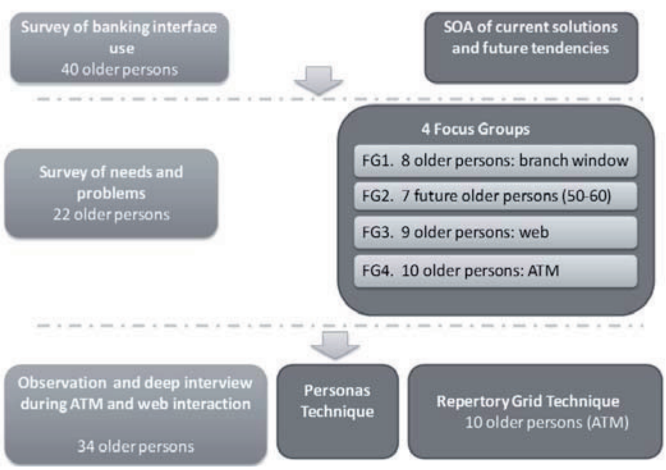

Fig. 1. Timeline of methodologies to explore older user needs, problems and expectative.

For achieving the second goal, our main concern was to gather the opinion and knowledge of all the partners of the project in order to create a strong new banking concept supported by everyone and to incite the developers to be sensitive with older persons needs. We conducted two days co-creation workshop sessions. Ten people from the seven partners of the consortium participated.

This workshop fostered the divergent and convergent thinking in three different steps: inspiration, ideation and implementation of the new interfaces banking solutions adapted to older people [4].

Finally, for validating the new ATM and Web Banking interfaces concept reached in the previous step, ten older persons per interface participated in the validation process and two digital interactive mockups were used for making the validation test more realistic. It consists of 3 phases:

- *Selection of the participants*: Users were selected from IBV Data Base taking into account the results obtained in the first phase of the project. Therefore, we invited five people with low skills and five with high profile. Table 1 summarizes the characteristics of these people.
- Concept validation: a) *Free navigation* through the new mockup interfaces for presenting the prototypes to the users; and b) Role-playing, in order to verify if users understood B4E web/ATM new concept.
- Functional and usability Validation: a) *Task performance*: Users were told to perform the five main tasks (Table 2) for each interface. b) Think Aloud and observational protocol: When users were performing the tasks, the researcher was paying attention to all the comments that users were thinking aloud, filling this information in screenshots of the interfaces [5].

Table 1. Description of the users who participated in the validation.

Low profile	High profile
Only branch window	Frequently use of web Banking
Do not feel save using ICT	Do not feel very unsafe
Lack of technological skills	Some technological skills
ICT use: Mobile phone	Use email, smartphone, tablet and PC
Need support to use ATM	Not need support for most of e-banking tasks
Cannot use tactile interfaces easily	Not difficulties for using tactile interfaces

Table 2. Description of the tasks performed by users during the test.

ATM Tasks	Web Banking Tasks
Withdraw 100€ with small money	Access to bank web
Update the bankbook	Check your balance
Pay 50€ in home account	Check your recent activity
Pay two checks in the home account	Read a bank statement
	Send a bank transfer

2 Results

2.1 Banking Older User Needs

The findings revealed that older people are willing to use ICT banking services but it is necessary to adapt their services and interfaces to their needs and capabilities. There are three key aspects for increasing the use of ICT banking services within older population: to provide more security (including security perception), usability and motivation.

In relation to bank ATM, the most common service used by older people is withdrawal money. Other services such as update bankbook, check bank statement and get balance are also frequently use by them. Concerning online banking, checking their accounts activity and get balance are the services most used by older persons.

Taking into account older user´s opinions, the general requirements for both kinds of interfaces were to create interfaces more emotional, secure, accessible, usable, customizable and simple.

During this phase, we obtained a large amount of information (older persons needs, user interface requirements, bank services characteristics) so our challenge consisted of synthesized all this information coming from older persons for making it interesting, comprehensible and useful to the designers and developers during the ideation process of new banking interface design concepts.

To achieve that, we elaborated inspiration cards and Personas profiles [7]. A visual summary card was developed for each interface, which contained the general and specific interfaces banking requirements, inspiring capsules and an associated challenge that described the main need to cover by the new interface design concept to be done. Meanwhile, we defined two Persona profiles: Amparo, the low-tech profile and ATM user and Juan (see Figure 2), the advanced-tech profile and Web Banking older user.

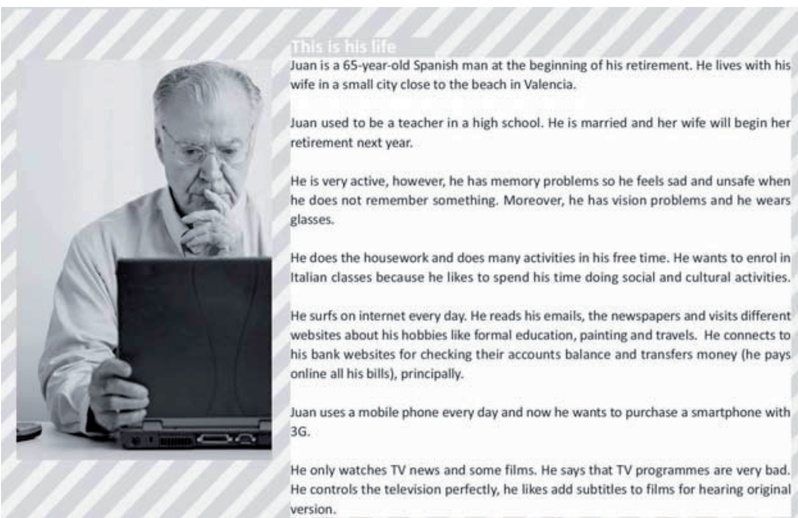

Fig. 2. Persona profile of Juan.

2.2 Conceptual Design of ATM and Web Banking

The co-creation workshop [6] was a success because we managed to convey older people needs and requirements to all the project partners especially to the ones in charge of the new interface designs. Concerning the web banking, partners created an innovative and customizable interface divided into four windows similar to widget system (Figure 3). For the ATM, partners ideated a visual way to communicate banking services in a natural graphic language for older persons (Figure 3).

Fig. 3. Conceptual proposal of Welcome screen of web banking (left) and get money screen for the new ATM (right).

2.3 Validation of the Conceptual Designs

The detailed mockups allowed to the designers and developers partners to create user-friendly interactive prototypes for both interfaces (Figure 4).

The results of the validation showed that the proposed ATM and web banking concepts are intuitive. The participants highlighted the simplicity and the ease of use of both new interfaces and the innovative look and feel of the web banking interface. Nonetheless, a general critic was referred to the informative menu since older people thought it was an interactive element in both interfaces.

After performing the five tasks, users were asked to express their general satisfaction using a Likert scale ranging from 1 to 7, where 1 stood for not satisfied at all and 7 for very satisfied. In general terms, users felt very satisfied with the performance of all the tasks (most of them with scores above 6).

However, in order to improve the development of the interfaces, it is necessary to prioritize the lowest assessed tasks. In the case of ATM interface, the challenge has to be focused on “Pay 50€ in the home account” (Task 3) and for the web, on “Check your recent activity” and “Read a bank statement” (Task 3 and 4, respectively).

3 Conclusions

The main conclusions in relation to the objectives are:

- We reached older people profiles related to the use of ICT banking services and we detected the key design requirements for web and ATM interfaces adapted to the needs and capabilities of this population.
- Innovative conceptual designs of ATM and web interfaces were developed combining all points of view: older persons, banking experts, interface designers and usability experts. The design of age friendly interface is not confronted with aesthetic appealing.
- Older persons have positively assessed the new approach for the banking interfaces, highlighting the combination of ease-to-use and attractive look and feel.

Future work will be the implementation of the validation results in the final prototypes before starting usability tests in controlled conditions (2013) and a pilot in real context (2014).

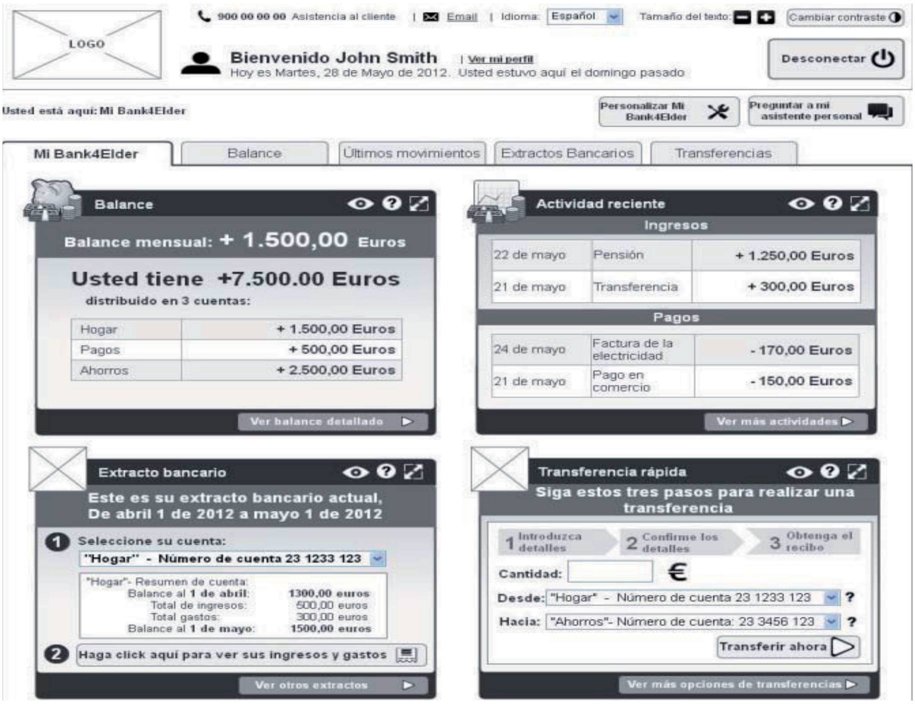

Fig. 4. Interactive prototype for web banking new concept.

Acknowledgements

The project Bank4Elde (AAL-2010-3-039) is founded from AAL Joint Programme.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-49

A User Friendly Robot Architecture for Re-ablement and Co-learning in A sensorised Home

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Abstract. To meet the needs of an ever ageing population it has been proposed that assitive technology might provide aid and support for elderly people and allow them to reside for longer in their own homes. Such proposals face many social, ethical and technical challenges. In the research presented in this paper we study how a commercially available robot situated in a fully sensorised, although in all other ways typical home, can meet some of these challenges. We focus especially on the technical integration of the robot, the home and the actions of the house residents especially in relation to the learning and control architectures. We envisage that such a software architecture would not only be useful as a physical and memory prosthetic but would also provides active support for *re-ablement* and *co-learning*.

Keywords. Assistive technology, Robot Control Architectures,, Robotic Companion, Sensorised Homes

Introduction

Robotic companions have been suggested as an assistive technology to meet an ever ageing population. In the European Framework 7 ACCOMPANY project [1] we are investigating this idea by using a commercially available robot (Care-O-Bot) manufactured by Fraunhofer IPA [5] sited in a fully sensorised house (which we call the *robot house*). The house itself is a normal British three bedroom house near the University of Hertfordshire and specifically chosen to be a realistic home environment rather than a modified scientific laboratory. One of the many challenges faced in such an environment is to provide a robotic companion that is not only useful as a physical and memory prosthetic but also provides active support in terms of *re-ablement* and *co-learning*.

A concise definition of re-ablement is given by the Welsh Social Services Improvement Agency as "Support people 'to do' rather than 'doing to / for people' "[19]. We envisaged that typical behaviours for a house robot might be, for example, to act as a memory aid and issue reminders e.g. for medicine, to assist in fetch and carry tasks, and to provide monitoring facilities both for the house and for the person e.g. warning them

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that the fridge door has been left open or reminding them to take a drink if the robot has noticed nothing has been drunk for a long period. However in addition to the above, and to support re-ablement the robot needs to provide motivation for the user to be more active, both physically and mentally. Thus the robot, rather than offering to do something *for* the user, may suggest that the person and the robot carry a task out *together* or additionally that the user *does it themselves*. For example, the robot might suggest that contact is made with friends, bring relevant events (such as birthdays) to the users attention or even suggest that the user take a walk. These latter forms of co-operation designed primarily to attempt to avoid social isolation of the individual in the home.

Co-learning refers to where a person and a robot work together to achieve a particular goal. Typically a robot can provide help and assistance, but in return may also require help and assistance. The user will typically teach the robot how to solve a problem, however the robot can also assist by suggesting to the person that it has particular capabilities which may prove fruitful (or indeed that it already knows how to address this particular problem). We believe that the co-learning approach will be useful as rather than treating the robot solely as a support mechanism for an elderly person, and possibly disenfranchising the person from the problem being solved, both the robot and person find a solution together. The elderly person remains at the heart of the problem solving exercise.

We therefore faced a number of challenges, firstly, the disciplined integration of the robot house sensor network (the robot house ontology), the sensory capabilities of the robot itself, and the social memory aspects from the user themselves, into a common framework. Secondly, a mechanism which allowed activities within the house, at both a sensory level and a more abstract contextual level to be joined as rules or preconditions for resulting robot behaviours. Thirdly, mechanisms to apply temporal constraints where necessary to such rules. Fourthly, a facility to invoke actions on the robot, at both an primitive/actuator level or a more distant abstract level. Finally, flexibility in behaviour creation and scheduling. Given that our robot may be asked to carry out a large number of tasks, many of which may not be originally envisaged by the system designer, a flexible and 'easy to use' way of creating robot behaviours together with a mechanism for effectively scheduling such behaviours was required. Our goal was to make such facilities available to non-technical personnel such as the elderly persons themselves, carers or relatives.

1. Existing Approaches for Robot Control Architectures

There are many and varied approaches to robot architectures operating in complex and partially observable situations. Arkin extensively describes both behaviour based and deliberative approaches [2] and provides a spectrum (from purely reactive to completely deliberative) of control issues that result. Many robot architectures also exploit research within the sphere of cognitive architectures (for a detailed survey see [9]). The need to cope in a timely fashion within uncertain environments, which would be typically experienced by robots in domestic and care environments, both reactive [4,14], planning approaches [20,15] and combined approaches (often called three-level architectures [6,11,17]) have been attempted. All of these approaches have in common the need to link the environment with the robot, and typically to maintain some kind of knowledge representation layer. Robot actions and decisions must be made in real-time and the robot must have a way of deciding which actions to take in a given situation, sometimes when more than one set of actions are possible. Abstraction of perception is also needed which, rather than focussing on low level sensory information, either experienced by the robot, or from a sensorised house (such as the robot house), instead offers predictions of activity (e.g. making lunch). In our framework we describe a three-layer approach, based on a memory framework, where episodic, semantic and procedural memories can be constructed and implemented. Both reactive, temporal and state of the art planning elements [12] are included in a uniform design.

2. Robot, House and People as One Environment

In this section we consider in detail the actual representation used to support behaviour generation within the robot house. We regard the house as one entity rather than as a collection of individual parts. In practise this means that the house sensor information is considered to be no different from robot sensor information, the sensory information derived from the occupants activities or from sensory predicates (described in section 2.4.1). This provides the bedrock for the main focus of our work enabling co-learning and reablement by not artificially separating the robot, user (or indeed the house) as separate entities but rather focus the generation of behavioural activity (which in our case is via the robot, but in an ambient home could be via actuation of household devices) on the complete system.

2.1. Robot House Ontology

The robot house consists of sensors, locations, objects, people, the robot and (robot) behaviours. These were analysed to yield a house ontology which is instantiated in a ‘mySQL’ database. One of the advantages of this strategy is that house episodes can be modelled and tested without actually needing to be in the house by simply updating the sensor tables in the database. Episodic information, which consists of both images and sensory feedback during behaviour execution, can be accessed via GUI’s allowing post-review of activities of the robot and the user. Procedural memory, which is here defined as the robot actions together with pre and post behavioural conditions, is also held as tables in the database. However the rules themselves are encoded as SQL statements which refer back to the semantic information created by the sensor system.

2.2. Robot Capabilities

For this work we use the Care-O-Bot robot [5] (see picture in figure 1) which has been especially designed for research in assistive environments. The Care-o-Bot uses ROS navigation (a form of SLAM) [21] using its laser range-finders to update a map of the house in real-time and can thus navigate to any given location whilst avoiding obstacles and replanning routes. Similarly the robot is equipped with facilities for manipulating the arm, torso, ‘eyes’, robot LED’s, tray and has a voice synthesiser to express given text. High level commands are sent via the ROS ‘script server’ mechanism and interpreted into low level commands by the robot software. Typical commands would be for example, ‘raise tray’, ‘nod’, ‘look forward’, ‘move to location x’, ‘grab object on tray’, ‘put object x at location y’, ‘say hello’ etc.

2.3. Robot House Sensors

The robot house itself contains around 50 ‘low level’ sensors. These range from electrical (fridge door open, microwave on etc.), to furniture (cupboard door and drawers open etc.), to services (such as toilet flushing, taps running etc.) and pressure devices (sofa or bed occupied). Sensory information from the robot is also sent to the database or for high throughput, is acquired via ROS messaging [21]. In addition user locations via ceiling mounted cameras [8] and robot locations via ROS navigation [21] are available in a common framework.

2.3.1. Behaviour Encoding

Behaviours are automatically generated from the teaching facilities described in section 2.6. However each behaviour generated follows a familiar template (similar to Nillson’s T-R formalism [14]) of evaluating pre-conditions, followed by execution of robot actions and updating of post-conditions (similar to the add/delete lists of planning systems but held as ‘predicate sensors, see section 2.4.1). Pre-conditions here can be any form of sensory information, both set by the environment or set at a contextual or abstract/predicated level. An example of such a behaviour would be

```
IF   the fridge door has been open for 10 minutes         (env. sensor pre-cond)
AND  the user has not already been told to close the door (pred. sensor pre-cond)
THEN send the robot to the user location in the house     (action)
     make the robot say ’The fridge door is open’         (action)
     update the database to signal
       that the user has been told to close the door      (set pred. post-cond)
```

These pre-conditions (which by default are assumed as conjunctions but also allow disjunctions) would be automatically encoded by the teaching system as follows:

```
SELECT * FROM Sensors WHERE sensorId = 50
   AND value > 30 AND lastUpdate+INTERVAL 600 SECOND <= NOW()
SELECT * FROM Sensors WHERE sensorId = 701 AND value = ‘notGiven’
```

If a row is returned from the execution of the SQL statement, then that pre-condition is deemed to be true, otherwise false. Typical robot actions, e.g. calling the navigation system to move the base, making the robot say something and setting a predicate sensor (explained in section 2.4.1), are shown below:

```
base,0,[4.329:0.837:51],999,wait
speak,0,The fridge door is open
cond,701,given
```

These commands, depending on the command type, would then be sent the planner (see section 2.5), or directly sent to a lower level control module if planning was not required.

2.4. Sensors and Sensor Abstraction

All sensory information updates the database in real-time and all robot behaviours continually retrieve information from these sensors to assess whether their behavioural preconditions are met allowing behavioural scheduling and execution (explained in section 2.5.2). Behaviours will continue to execute if their pre-conditions remain true or unless they are pre-empted by a higher priority behaviour.

2.4.1. Context and Predicate Sensors

Two further abstract sensors are updated, the first via a rule based context analysis system derived from HRI experiments (described here [3]). This provides contextual information as ‘context’ sensors e.g. ‘User Preparing Evening Meal’ would be a sensor set by the context analysis system. Secondly, in order to cope with ongoing events in the house which are not reflected by the environmental sensors a set of ‘predicate’ sensors can be created by the teaching system, e.g. a binary sensor with the label ‘User has been reminded to close fridge door’. This latter sensor would be set following the fridge reminder above.

2.4.2. Temporal Aspects of Sensors

Using sensors at a low, abstract and predicate level provides the opportunity to apply temporal constraints. Consider for example a doorbell, this type of sensor is ‘on’ only for a short period of time, and thus rather than ask ‘Is the doorbell ringing?’ we would ask ‘has the doorbell rung within the last 30 seconds?’. This is checked by exploiting the underlying capabilities of the SQL database by holding episodic values and we thus have the ability to query previous values at a previous point in time:

```
SELECT * FROM Sensors WHERE sensorId = 59
   AND lastActiveValue > 0 and lastUpdate+INTERVAL 30 SECOND >= NOW()
```

The further capability of assessing how long a sensor has been active (or inactive) allows for greater behavioural expressivity. For example ‘Has the user been sitting on the sofa for longer than 2 hours?’, ‘has the user opened the fridge in the last 3 hours?, ‘has the TV been on for more than 4 hours?’, ‘has the user been reminded to call his friend Albert this week?’. These encoding facilities can therefore cope with a very wide range of possibilities and capture information related to both current activity, past activity and socially desirable activity, the latter being primarily set though the creation of predicate sensors.

2.4.3. External Sensors and External Actions

The sensor system provides a standardised way of encoding information and therefore provides possibilities for associating predicate sensors with other, typically external, events. For example, by polling an external weather service it would be possible to set a ‘weather’ sensor. This could then be checked by a behaviour which might suggest to the user that this was a good day for a walk, or to do some gardening. In this way the idea of *re-ablement* can be operationalised. External actions could also be run, for example calling a text messaging (SMS) service. For example, a behaviour that checks whether the bed pressure sensor had been active for more than 12 hours and that there had been no activity in the kitchen might then send a text message to the users’ caregivers suggesting that the person might need assistance to get out of bed.

2.5. Planning and Scheduling

Our general approach is to plan only when needed and when necessary. Thus the overall behaviour of the system is driven primarily by the environmental conditions via low level sensors or from context or predicate sensors. Behaviours are explicitly scheduled

However there are instances where, due to multiple choices being available for robot action (e.g. in a multi-room environment navigation may take multiple paths), or when there is conflict between available resources (for example, only one item should be put on the tray at any one time), when planning is necessary.

2.5.1. Planning Domain

We use an open source state-of-the-art HTN (Hierarchical Task Network) planner (SHOP2 [12]) to cope with these situations. We follow the approach described by Hartanto [7] and Off and Zhang [15], in that each planning domain is individually coded in the lisp-like syntax of SHOP2 and called when the high level action is required. For example, asking the robot to fetch a cup, SHOP2 will plan the appropriate actions on the robot to get the cup (i.e. if the cup were in the kitchen and the robot was in the kitchen the robot would not need to drive to the kitchen, however if the robot were elsewhere then some form of navigation would be necessary). SHOP2 returns the planning actions as robot actions. After each action execution we recall the planning component just in case the environment has changed between actions.

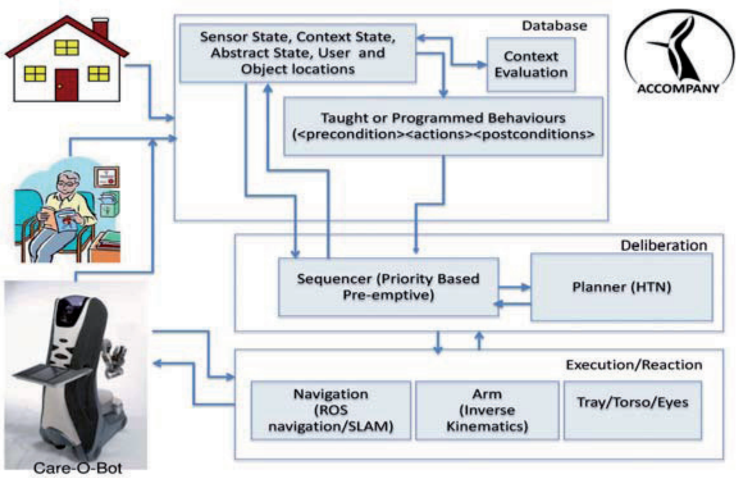

Figure 1. The diagram shows the layers in operation in the robot house. Sensory information from the robot, house and people together with contextual information and abstract/predicate sensors update the database in real-time. Taught behaviours use these sensors to access behavioural pre-conditions and may subsequently set abstract/predicated sensors during execution. All behavioural pre-conditions are continually evaluated by the sequencer component and become available for execution if all pre-conditions are met. Where actions require planning a HTN planner is called. Lower level functions, such as navigation and arm manipulation work at a reactive level.

2.5.2. Pre-emptive Scheduling

Once behaviours are created a scheduling priority (as an integer) is attached to them. On execution the scheduling system continually checks all of the preconditions of all of the behaviours (in a manner similar to Nilsson [13]). Should all of the pre-conditions of a behaviour be satisfied the behaviour becomes available for execution, with the highest priority behaviour being executed first. Priority ties result in a random choice of behaviour for execution. Note that due to continual checking of all behavioural pre-conditions, behaviours may become valid or invalid for execution as the currently executing behaviour operates. In this manner the set of environment, context and predicate sensors drive behaviour execution. Some behaviours can also be set as non-interruptible, for example if a behaviour was reporting on a critical house event - such as the bathroom taps running for a long time. Figure 1 provides a pictorial overview of the architecture.

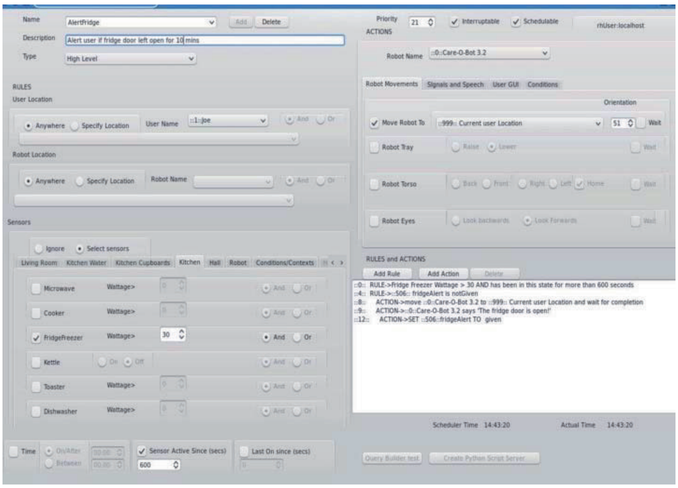

Figure 2. The teaching interface for semi-technical users. The left half of the screen allows for pre-conditions based on sensors of all types (low-level,context and predicate) to be chosen and given temporal constraints if required. These result in the RULE preconditions shown in the bottom right hand side of the screen. The top right hand side shows the robot ACTIONS and allows the user to choose robot actions or setting of predicates/postconditions. Scheduling information is entered on the extreme top right.

2.6. *Teaching and Learning*

One of our goals in this work was to allow *co-learning*, whereby robot and user work together to achieve a goal. To achieve this we approach the problem in two ways. Firstly, by directly *teaching* the robot, via a GUI, what has to be achieved and when it should happen and secondly, via the robot (or the house) *learning* what is happening and learning to adapt itself to those conditions. The learning objective is future work described in section 4. Here, we describe our teaching interface.

2.6.1. *Teaching Interface*

In order to create behaviours the user as a minimum would need to specify *what needs to happen* (the actions of the robot) and *when those actions should take place* (setting pre-conditions). We provide two levels of interface (in addition to direct programming of behaviours by robotic experts). The first allows direct entry of behaviours by specifying rules explicitly based on sensor values (see figure 2), and choosing actions on the robot including the setting of post-conditions via predicate sensors. We envisage that this facility would be used by ‘semi-technical’ persons generating sets of behaviours for the first time. Note that this teaching facility allows behaviours to have direct interaction with the user via an automatic GUI generation facility. This operates by associating behaviours with buttons on a screen presented to the user. Hierarchical scaffolding of behaviours is also possible by choosing existing behaviours as actions.

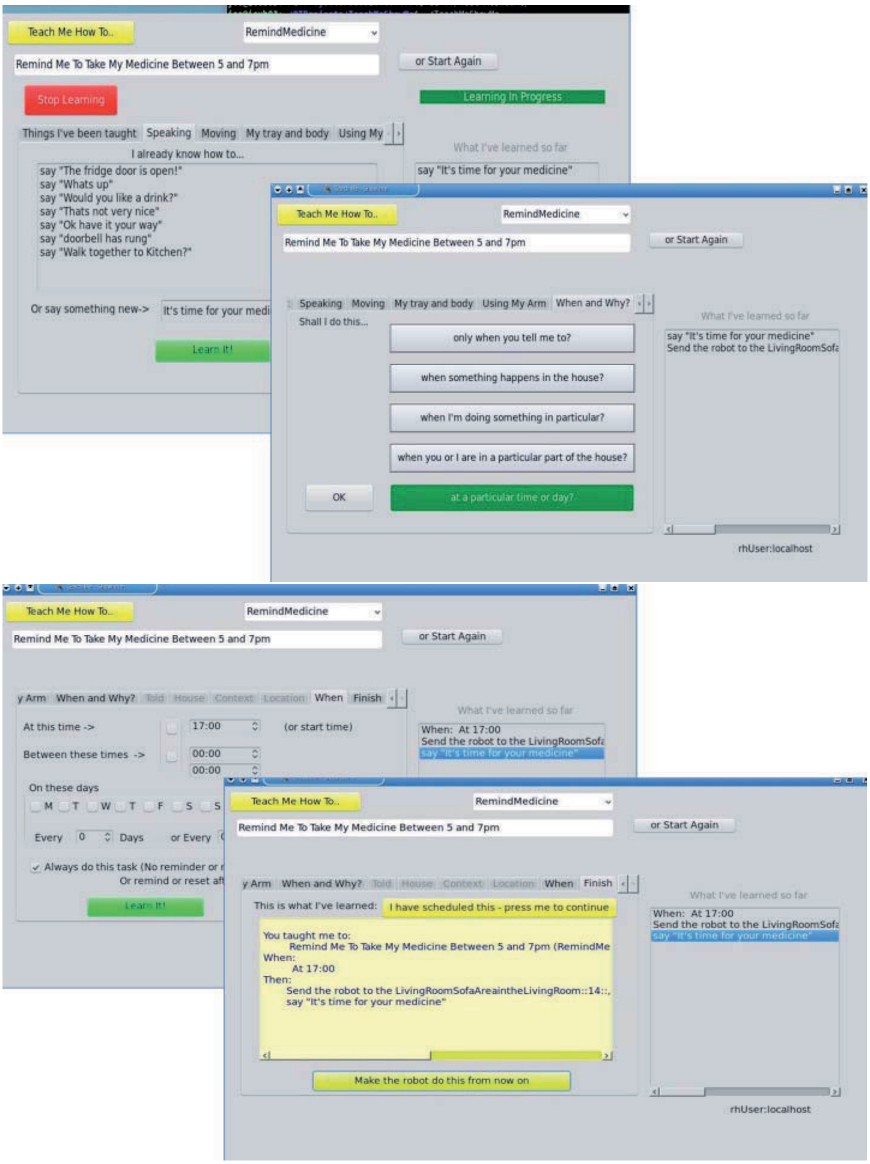

Figure 3. The teaching interface for non-technical users. The GUI presents a series of screens allowing choices of 'what' to do and 'when' to do it. During the interaction the robot always presents the capabilities it currently has and that the user can exploit. In the background the necessary procedural wrapping, including predicated pre- and post-conditions are generated invisibly.

The second facility (see figure 3) takes away much of the complexity of the former by automatically generating many of the sub-behaviours required to operationalise the system. The cost of this simplification is a loss of generality, however it is compensated for by ease of use. Taking again the fridge example described in section 2.3.1, in the first 'semi-technical' approach the user would associate each precondition with the appropriate sensor, including the predicate sensors. To some extent this requires a logical approach akin to creating simple programs or planning domains. In the second, less complex facility, the user need only specify *what is important* (that the fridge be checked) and the background system automatically generates the appropriate predicate pre-conditions to ensure the behaviour is generated accordingly. This is possible as the majority of behaviours envisaged tend to follow a common template, and we exploit this template to generate the appropriate conditional 'wrapping'. In this manner much of the cognitive load is removed from the user and left to the behaviour generation system. Co-learning is operationalised by allowing the robot to provide details of its existing sets of skills that can then be exploited by the user.

3. Experiments and Results

Our initial experiments in employing this architecture have allowed us to deploy the robot in realistic scenarios derived from user requirements [10]. In the first of these scenarios the user was reminded to take medicine at a particular time (medical re-ablement), asked to accompany the robot to the kitchen (a form of physical re-ablement), gave a reminder about medicine 10 minutes after the first reminder, warned that the fridge had been left open (safety warning), and suggested to the user that they watched TV together (social partner). In total around 30 behavioural components were created using the teaching facility shown in figure 2. All operated successfully. Usage of the 'non-technical' interface was used to create an interaction with the Care-o-Bot during an artistic event held at the robot house in May 2013 [18]. Again, this operated successfully and in real-time in a house of around 20 people. Longer term testing with large numbers of users is due to start in July 2013.

4. Ongoing and Future Activities

In relation to co-learning the architectural framework above derives sets of hierarchically ordered tasks. During learning phases the user may engage the robot in carrying out a new task. This will typically be via direct tele-operation of the robot and the exploitation of existing robot capabilities. However, in order to assist the user the robot should be able to poll its existing competencies and suggest ways of providing solutions to the user's problem. Our ongoing work uses an approach [16] which allows each robotic behaviour to act as a forward model that predicts sets of possible next actions for the robot in the current state. These are then matched against the users current requirement. High similarity between the model and the user learning sequences indicate that the robot may have existing competencies which the user could exploit.

5. Conclusion

We have described an approach to integrating disparate agents operating within a realistic home environment. The key part of the architecture is to treat all sources of information, both external, internal and abstract with a common representation. This makes possible complex behavioural generation and scheduling as well as the opportunity to exploit robot teaching. Using this architecture has allowed us to continue to explore how co-learning could operate with a robot in a domestic environment and allow the robot to act as a re-abling device for the user.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-59

Semi-automated Video-based In-home Fall Risk Assessment

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Abstract. The development of an in-home fall risk assessment tool is under investigation. Several fall risk screening tests such as the Timed-Get-Up-and-Go-test (TGUG) only provide a snapshot taken at a given time and place, where automated in-home fall risk assessment tools can assess the fall risk of a person on a continuous basis. During this study we monitored four older people in their own home for a period of three months and automatically assessed fall risk parameters. We selected a subset of fixed walking sequences from the resulting real-life video for analysis of the time needed to perform these sequences. The results show a significant diurnal and health-related variance in the time needed to cross the same distance. These results also suggest that trends in the transfer time can be detected with the presented system.

Introduction

Falls are one of the major health risks in our rapidly aging population. Approximately one in three people older than 65 fall at least once each year [1]. Falls frequently result in moderate to severe injuries and fear of falling [1], which both can limit the activity of the older person. The mobility and balance of the person that is already at risk therefore further declines. This subsequently increases the risk of future falls [1,2].

An accurate fall risk estimation can be an important aid in the prevention of these fall incidents. When an elevated risk is detected, both therapeutic and preventive actions can be initiated, e.g. installing an exercise and training program to enhance gait and mobility, adapting the medication, etc.

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One of the commonly used screening tools to assess fall risk is the Timed Get-Up-and-Go test (TGUG) [3,4], where the subject is asked to rise from a chair, walk three meters, turn around, return to the chair and sit down. The manually recorded time needed to complete the test, together with the observations of the patient's walking pattern by the clinical staff, are used to estimate the fall risk. The TGUG test, however, is typically administered in a clinical setting, e.g. in the hospital. Studies have shown that due to the test awareness of the person and the unnatural setting the results of the TGUG test are not always representative of the fall risk of a person in his natural home environment [5,6].

Although automating the TGUG test is currently investigated by several research groups [5,7,8], these systems are thus far only used in a simulated environment and therefore do not reduce the effects of the test awareness and the unnatural setting on the test results. They also do not incorporate any additional challenges related to real-life measurements [9].

Our research focuses on the development of an automated in-home fall risk assessment tool which uses real-life data acquired with cameras. The goal of the system is to automatically assess the transfer time, which is a component of the TGUG test, in the home environment on a daily basis. Previous studies have shown that gait speed can be used as one of the factors to predict falls [11,12]. Although the TGUG test provides more information than gait speed because it includes standing, turning, and sitting, in [3] it is shown that the walking speed is one of the components of the TGUG test which is significantly different between people with and without an elevated fall risk. An in-home daily assessment of the transfer time can therefore provide a continuous measure which in turn can provide valuable information for the caregivers.

1. Methods

The presented system measures the time each participant needs to cross a fixed distance between the living room and bathroom based on video data. We opted for these transfers because they frequently occur during the day and are mostly executed in the exact same way. This time is measured several times a day.

1.1. The Participants and the Resulting Dataset

For a period of three to twelve months four camera systems consisting of multiple wall-mounted IP-cameras were installed in the homes of 4 senior citizens. An overview of the demographic characteristics of the four participants can be found in table 1. When multiple walking aids are mentioned the participant alternates between different walking aids. A TGUG test was obtained from each participant before the acquisition period (table 1). Depending on the person one or more TGUG tests were obtained during the study (see table 2).

1.2. The Algorithm

1.2.1. Preprocessing

To facilitate the timing of the walking sequences the video data are processed isolating the participants from their surroundings in the video images. To accomplish this four

Table 1. Demographic characteristics of the test subjects.

Participant	Age	sex	Home	TGUG results	Walking aid	Measured sequences
A	74	m	his own home	11 sec	na*	80
B	75	f	service flat	16 sec	rollator, cane, na*	64
C	95	f	service flat	23 sec	rollator, na*	33
D	95	f	retirement home	+ 20 sec	rollator	34

Notes:
TGUG test obtained before the acquisition period
* na: no walking aid

(a) *Partitioned frame*

(b) *Unpartitioned frame*

Figure 1. Frames used for the timing of walking sequences.

image processing steps are performed. First, the foreground is detected using an estimation of the background which is subtracted from each video frame. From the resulting foreground the shadows are removed using a technique of background cross correlation. After this an erosion / dilation step is applied to all the foreground pixels followed by a connected component analysis to detect all foreground objects. A bounding box is subsequently drawn around the largest foreground object, this being the person in the video.

A more detailed explanation of these different steps can be found in [9].

1.2.2. Timing of walking Sequences

To measure the walking time over a fixed track a start and stop point needs to be defined. Two different methods can be used to define these points. The first method consists of the division of each frame into three regions using two predefined borders (figure 1a). The time measurement starts when the test subject crosses the first line and stops when the test subject crosses the second line. The subject is detected as crossing the line when the bottom right corner of the surrounding bounding box, corresponding with the feet of the test subject, crosses the line. The second method uses start and stop events and can be used in situations where the camera position causes the walking distance in view to be too short to create 3 subdivisions (figure 1b). For instance, the opening or closing of a door which causes a sudden change in the dimensions of the bounding box can be used as start or stop points. Start and stop events were used to time the walking sequences of participant A. In this case the time was measured from when the participant walked into the camera view until he started to open the door.

2. Results

First, we measured diurnal variation in transfer time. To evaluate this, 57 walking sequences of participant A were selected during 17 consecutive days. For each of these sequences the duration of the walk was measured.

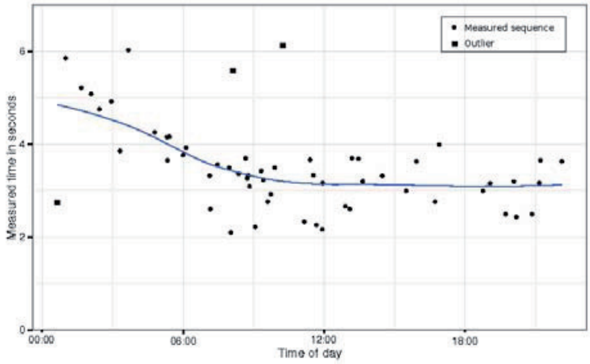

Figure 2. Automatically measured times per walking sequence during a period of 17 days.

During the second analysis the transfer times were measured on the day before the manually recorded TGUG test, during the day of the test and the day after. These times were then compared to the results of the TGUG test. The walking sequences were manually classified per walking aid, therefore the semi-automatically measured times are also classified per walking aid. Transfer times between subjects cannot be compared due to the variation in walking trajectories between participants.

2.1. Transfer Time during the Day

Figure 2 shows the semi-automatically measured times of each walk, performed by participant A, during the first experiment. A local regression model was fitted on the presented data using a sliding window to detect trends in the presented data [10], the resulting model is also shown in figure 2. The time needed to perform the transfer to the toilet before 7 a.m. is higher than after 7 a.m. Figure 2 also shows three outliers. The first outlier was measured during a night when the participant suffered from nausea and diarrhea. The other 2 were measured on the morning following this night time episode.

2.2. Transfer Time compared to the TGUG Test

During the second analysis the semi-automatically measured transfer times were compared to the manually recorded TGUG test. Only measurements between 7 a.m. and 11 p.m. are included in this analysis. Table 2 shows the results measured during the first three months of the project. This table consists of the TGUG test for all participants and the semi-automatically measured transfer times per walking aid. The results are assessed individually per participant.

2.2.1. Participant A

The results of the first TGUG test of participant A are slightly better than the results of the other TGUG tests. But when measuring the first test the clinical staff observed a very unstable gait. During the second and the third TGUG test the gait of the first participant was more stable but he needed more time to complete these tests. The semi-automatically measured times for gait speed remain stable during these three months. This suggests that the fall risk of participant A did not change during the measurement period.

Table 2. Timed-Get-Up-and-Go test (TGUG) and semi-automatically measured results.

Participant	TGUG		No walking aid		Cane		Walker	
	Date	Result	Result	Events	Result	Events	Result	Events
A	29 Oct	11	3.1 ± 0.5	10	na	na	na	na
	26 Nov	14	3.1 ± 0.3	4	na	na	na	na
	4 Jan	13	2.9 ± 0.5	9	na	na	na	na
B	30 Oct	22.3	na	na	5.0 ± 0.9	11	7.6 ± 0.9	9
	26 Nov	27.3	4.2 ± 0.3	4	4.6 ± 0.2	8	8.4	1
	8 Jan	25	5.2 ± 1.1	9	5.9 ± 0.9	11	7.2 ± 1.2	11
C	3 Nov	23	8.7 ± 0.9	3	na	na	11.7 ± 1.1	10
	27 Nov	na	8.7 ± 0.5	3	na	na	11.2 ± 1.5	10
	4 Jan	19	6.2 ± 0.2	2	na	na	10.0 ± 0.6	5
D	26 Oct	+20	na	na	na	na	17.5 ± 3.6	10
	17 Nov	na	na	na	na	na	17.8 ± 5.4	11
	30 Nov	+20	na	na	na	na	10.8 ± 3.1	13

Notes:
Measured times in seconds
Times given in columns 'No walking aid', 'cane' and 'walker' are measured semi-automatically

2.2.2. *Participant B*

Participant B suffered several minor strokes before and during the data acquisition period. In the days before the second TGUG test she suffered another minor stroke resulting in a loss of strength in her right arm and leg. During the second TGUG test she felt the need to support herself with the furniture surrounding her. This significantly slowed her down and had a negative influence on the result of this TGUG test. Although she felt very insecure during the second TGUG test she did not use the walker on several occasions during the measurement period before and after the second TGUG test.

Participant B needed more time to complete the last TGUG test compared to the first test. This can also be seen when comparing the semi-automatically measured times for gait speed measured in the same period as the first TGUG test and the third TGUG test when the participant is using a cane or not using a walking aid. It can also be seen that the time needed to complete the same trajectory depends on the used walking aid.

2.2.3. *Participant C*

The third TGUG test of participant C was completed faster than the first TGUG test suggesting a slight decline in the fall risk of participant C. This can also be seen in the semi-automatically measured times.

2.2.4. *Participant D*

A very abnormal and unstable gait was observed for participant D during the whole measurement period. Although she always used a walker to walk to the bathroom she often needed to take short breaks during the walk. This resulted in very fluctuating semi-automatically measured times for gait speed, which can be seen in the standard deviations of these measurements. Although the semi-automatically measured times in the third measurement period are significantly better than during the first period the large standard deviations do not allow us to conclude that her gait improved.

3. Conclusion

These preliminary results indicate that transfer times can be measured from video sequences. The results show a large diurnal and health-related variance in the time needed to cross the same distance. They can therefore provide valuable additional information to the results of the TGUG test, which is currently still a snapshot. Since the automated system cannot provide automated observations of the gait quality itself, it cannot be used as a replacement of the TGUG test. It may, however, be used to detect trends in the walking speed of a person.

Acknowledgements

This work is funded by the iMinds FallRisk project. The iMinds FallRisk project is cofunded by iMinds (Interdisciplinary Institute for Technology), a research institute founded by the Flemish Government. Companies and organizations involved in the project are COMmeto, Televic Healthcare, TP Vision, Verhaert and Wit-Gele Kruis Limburg, with project support of IWT.

This work is also funded by the FWO via project G039811N: ”Monitoring van gedrag en ongebruikelijke menselijke activiteit met meerdere camera's”, by the IWT via TETRA project 80150 ”Fallcam: Detection of fall in older persons with a camera system.” and by the EU via ERASME (FP7) project IWT 100404 ”AMACS: Automatic Monitoring of Activities using Contactless Sensors.” The authors like to thank the persons who participated in the research by giving their permission to be monitored during several months.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-65

Using Smart Home Technology in Brain Injury Rehabilitation: The Road towards Service Development

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Abstract. This paper reports the process of developing an assistive technology transitional living service for brain injury rehabilitation. The aim of the service is to take advantage of smart home technology to assess, rehabilitate and promote independence in individuals with acquired brain injury who wish to live on their own in the community.

Keywords. Assistive Technology, Independent Living, Evaluation, Efficacy.

Introduction

Smart home technology (integrated technology fitted in a building that supports and assists users through automation, prompting and alerting) offers the promise of allowing the elderly and those with physical disabilities to live independently in their own homes [1]. However, the technology is still in the early stages of development and recent reviews [2, 3] have concluded that there is limited evidence concerning the efficacy of smart home interventions for people with disabilities.

Acquired brain injury may result in physical disability (e.g. mobility, sensory problems), cognitive difficulties (e. g. memory, reasoning) and changes in emotions and behaviour (self-control, motivation). These effects vary from person to person and depend on the aetiology, severity and location of the lesion, as well as the pre-existing intellectual ability and personality traits of the individual. There have been attempts to utilise this smart home technology to support the rehabilitation of individuals with cognitive impairment due to brain injury [4]. However, the heterogeneity of impairments and abilities across individuals with acquired brain injury means it is important to have specialised input from a clinical team throughout the process of assessment, prescription of technology and follow-up. It is difficult to maintain this level of support in smart home installations [5]. The Tampa Smart Home project in Florida [6] has provided useful information regarding the effectiveness of whole system technologies to support and promote rehabilitation in an in-patient setting. However, we do not know whether such systems can be equally helpful and effective in supporting individuals in transition from in-patient environments to long-term support within the community.

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The aim of the BIRT Assistive Technology (BAT) House is to explore the potential of using smart home technology to maintain safety and support areas of cognitive impairment, thus maximising the independence of individuals who have sustained a severe brain injury, ultimately enabling them to live in the community with minimal support from paid or family carers.

2 Method

2.1 Participants

The present report comprises the case-studies of two individuals with acquired brain injury who lived in the BAT House, before permanently moving from a residential rehabilitation setting into the community.

2.2 Smart House Properties

The smart house is an implementation of the i-Cue dynamic support environment (Halliday James Ltd, England). It comprises a Central Processing Unit (CPU) which can be programmed by a simple event based programming language, an LCD keypad and a door station. The CPU is connected to sensors using a wired RS485 data bus, in the BAT house data is gathered by passive infra-red sensors (N=6), door sensors (N=3) and utility sensors (N=4). There is also a fingerprint reader for door entry and exit. The CPU has an Ethernet connection to allow remote access for data gathering and programming as well as wireless control of appliances and shower.

2.3 Technology and Outcome Evaluation

The effectiveness of the technology was evaluated through analysis of a log of all requests for support to staff in the adjacent houses, a record of all pager alerts, and analysis of the occupancy data recorded by the system. Usability was assessed by asking service users and staff about their experience and impressions of interacting with the smart house environment.

2.4 Procedure

Individuals were admitted to the BAT House after a period of intensive residential neurobehavioural rehabilitation. During this time, a multidisciplinary team completed a thorough assessment of the service user's abilities and needs. This included formal neuropsychological assessment, as well as assessments of the extent of independence in Activities of Daily Living (ADL) by an occupational therapist. The second stage of the process included an assessment of whether the identified needs could be supported through the use of smart house technology. Individuals identified as having the potential to benefit from a period of transitional living with the technological support provided by the BAT House were referred to the service.

3 Results

3.1 Independent Living Effectiveness

The first resident of the house was RK, a 22-year old man who had sustained a Traumatic Brain Injury (TBI) after an attack outside a nightclub. He was 1.5 year post-injury at the time he moved to the smart house, having undergone a period of neurobehavioural assessment and rehabilitation (14.3 months). RK spent 4 weeks at the smart house.

The second resident was PT, a 43-year old man who had suffered a non-traumatic brain injury 2.4 months before he was first admitted to residential rehabilitation, where he stayed for 3.5 months. He spent 5 weeks at the smart house.

Table 1 displays a summary of RK's and PT's needs, goals and technology solutions. The two service users presented with very similar needs and therefore the settings were the same with the exception of safety within the house overnight for PT (see shaded cells). However, due to difficulties in programming the system to deliver a pager message to support staff in the event PT would leave the house after dark, this solution was never implemented. Subsequent analysis of the occupancy data suggested that although PT often left his bedroom during the night, he never attempted to leave the house. This information was corroborated by staff members from the adjacent houses and suggests that PT was responsive to the prompt that was in place.

The two service users had different routines while in the transitional living technology service. RK followed a programme with activities in the assessment and rehabilitation unit, where he previously had been, as well as other leisure and voluntary activities. PT received support from a member of staff for a few hours each day to assist with meal preparations, but was independent for the rest of his time. RK sought assistance from staff for complex activities as required, such as changing light bulbs, fixing a blocked drain, and advice on washing machine programmes. PT requested less assistance. Staff also noted that RK needed to be prompted to keep the property clean and tidy, to do his laundry regularly and to sort out the recycle bins. PT was more able to do this spontaneously. For RK, examination of pager system alerts over the four week period, suggested that the kitchen safety goals were partially achieved, with only two instances of an alert due to the cooker being left on and one instance of non-return at 22:00. PT triggered a total of 9 kitchen alerts, but 8 of these occurred in his first 2 weeks at the house. On the basis of these results, the clinical team recommended that both RK and PT should have access to electric cookers and ovens with auto-shut off systems installed in their new placements as a safety precaution. For RK it was further recommended that his new accommodation would be fitted with automatic sensors and reminders to prompt him to take his belongings when leaving the house (as this was effective for keys). Neither RK nor PT were considered to be ready to live fully independently at this stage. RK continued to have persistent complex needs with managing finances, social vulnerability, running a home, and coping with unplanned events. PT needed continued assistance with meal preparation and support in monitoring an unrelated chronic health problem (diabetes). However, a period of transitional living in the BAT House was crucial in establishing that both service users would be safe to spend long periods of time within the home without supervision, including overnight.

Table 1. Summary of Needs, Goals and Technology Solutions.

Needs	Goals	Technology solution
Personal Care		
Level of hygiene	To ensure that RK/PT keeps an adequate level of hygiene	Monitor number of showers taken, and flag if none or more than 2 are taken daily
Domestic skills		
Safety within the kitchen	To ensure that RK/PT remembers to turn appliances off (hob and oven) once cooking is completed	Prompt to turn hob (10') and oven (1h) off if left unattended Auto-switch off and pager message to staff if no action upon prompt
	To ensure that fridge and freezer are kept at correct temperatures at all times	Prompt to close fridge/freezer and pager message to staff if no action
General safety and wellbeing		
Safety within the house	To ensure that RK/PT do not let strangers in the house.	Pager message to staff if RK/PT opens the door to strangers
	To ensure that RK/PT returns to the house every evening	Pager message to staff if there is no house occupancy by 22:00
	To ensure that PT does not leave the house after 22:00	Prompt that it is too late to leave the house is played when PT appears to be leaving the house. Pager message to staff if PT leaves the house after 22:00
Functional routine	To ensure that RK/PT keeps a functional routine	Occupancy data and appliance usage recorded, overnight bedroom exits counted, instances of non-fridge usage within 24h counted
Memory	To ensure that RK/PT takes the house keys with him when leaving	Prompt to take keys is played when RK/PT appears to be leaving the house

3.2 Technology Evaluation

RK was keen to take part in the project and had a very positive reaction to the technology. However, it should be noted that one of the behaviours associated with his social vulnerability was his eagerness to please others, often saying what he believed they wished to hear.

PT was less effusive regarding his own benefits from the technology. He commented that he did not really use or need it, but later on in the trial, he acknowledged that the automated prompts had, overtime, made him anticipate the need to ensure that appliances were turned off and that he had his keys when leaving the house.

Clinical and support staff initially expressed some reservations about the project, and were nervous about using the technology. Once they fully understood its aims, they became more confident and commented that "*it highlighted his [service user] needs perfectly*".

4 Discussion

To our knowledge, this is the first study that has used smart house technology to assess and monitor independent living skills in individuals with acquired brain injury prior to discharge to their own home. It has illustrated the usefulness of a customised system, with a data recording capability which can be used to assess the needs and effectiveness of automated technology. It also highlights the inability of existing systems to address some of the more complex difficulties that individuals with acquired brain injury may experience (e. g. managing finances, social vulnerability).

This pilot project extends existing research on the efficacy and outcomes of using technology for disability beyond the studies of off-the-shelf electronic aids [7-10]. The findings suggest that this technology has a role in the assessment and support of individuals with acquired brain injury.

The project demonstrates both the potential and the difficulties in using smart home technology in a flexible way, with greater reliance on recorded sensor data than is usually the case for standard smart home systems. The system described here is more complex than that in the Tampa House project [6], where the basic operations are similar (use of the same sensor data in a similar fashion), only with changes at a content level (e. g. individual prompts, etc). The settings of the BAT House need to be changed for each service user depending on their individual abilities and rehabilitation goals, but as we gain experience in using the system it may become possible to determine whether there is a basic configuration that is suitable for most clients. These early results suggest that this is the case. As highlighted in 3.1, at present the clinical team is still dependent on the input of technology experts to set and modify the characteristics of the smart house and the data that is to be recorded and displayed. Ideally, an improved system would enable set-up by individuals with minimal experience of the technology [11].

4.1 Conclusions and Future Directions

Further case studies will better inform the optimal assessment and follow-up procedures that need to be in place, and identify the factors that may influence positive outcomes in terms of independence and life satisfaction of service users. At the technical level, the project revealed that configuring the system is not straightforward. If there is to be reliable and consistent use of these systems by clinicians, they will need to be made more user-friendly.

We plan to continue using a systematic process of admission and outcome evaluation at the BAT House. Further work is needed to i) assess the impact of using technology on risk management, independence and wellbeing; ii) assess the potential for cost savings with long-term care; iii) identify solutions for helping individuals with behavioural problems in a community setting, iv) work together with the industry to investigate the potential for incorporating existing stand-alone technology as modules to an integrated system, and v) improve the human-computer interface for selecting and displaying sensor data and configuring the system's controls and responses.

Acknowledgements

First we would like to thank the service users who were willing to take part in this project. We would also like to thank Bernard Wignall from Halliday James for his availability and support in transforming clinical ideas in smart house settings. Finally, we thank all the staff of The Disabilities Trust and the Brain Injury Rehabilitation Trust who, in one way or the other, contributed to the work reported here.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-71

Non-Intrusive Recognition of Activities of Daily Living in the Homes of Alzheimer Patients

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Introduction

The average life expectancy is increasing [1]. This leads to an increasing prevalence of age-associated disorders, such as Alzheimer Disease (AD) and other forms of dementia. AD affects cognitive performance and, with the progression of the disease, the ability to solve everyday problems decreases and patients have more difficulties coping with Activities of Daily Living (ADL). These difficulties can affect both, basal ADL such as sleeping, grooming, eating, and toileting [2], as well as instrumental ADL such as cooking, watching TV, reading, and other seated activities [3, 4]. Decreasing ADL are associated with increasing dependency and need for greater levels of care. Despite this development, most patients have a strong desire to live autonomously in their known home-environment as long as possible [5]. This leads to tradeoffs between the patient's desires and the risks that increase with the progression of cognitive decline. To enable AD patients to stay at home safely, we hypothesize that it is an advantage for formal and informal caregivers to know about the patient's activities throughout the day and during the night. We are developing an assistive technology system that recognizes ADL in the home environment in a non-intrusive way. This data is then used to determine current well-being, acute events, and long-term risks, so caregivers can schedule their visits based on the patient's current needs.

Other researchers have developed technology to measure activities of elderly persons, albeit with a slightly different focus [6]. Their systems are either prototypes [7-13], or they are already commercially available [14-17]. These systems attempt to measure specific behavior patterns or ADL of elderly people and provide assistance when needed [9, 18-20]. There are also systems to measure a single ADL to study the performance on a specific task [21, 22] or to investigate the association between behavior and well-being [23, 24]. Recently, a study used multiple accelerometers to capture the movements of AD patients to diagnose the progression of dementia [25] with the aid of Artificial Intelligence (AI) algorithms.

Many existing approaches require the patient to wear body-mounted sensors [7, 14] for data acquisition or make use of image-based sensors such as video cameras and thermal imaging [26, 27]. Our project aims to develop a passive, non-intrusive, assistive technology system that estimates the well-being of AD patients by measuring ambient values in the patient's home. We hypothesize that a system that captures no images or sound and avoids using body-mounted sensors but measures only ambient values will be well accepted by patients and caregivers. This project seeks to develop and validate the algorithms that determine the current activity based on ambient measures (i.e. light, motion) and to use this information to derive current well-being and detect acute events and long-term risks.

1 Methods

The new assistive technology system is placed in the individual's home and consists of i) a number of sensors that are distributed in all rooms (Figure 1A) and ii) a central computer. The sensor data is collected on the central computer and analyzed by several AI-algorithms that determine the patient's activity.

A total of 50 sensors measuring temperature [°C] (DS18B20, Dallas Inc.), humidity [g/m3] (SHT21P, SENSIRION), luminescence [lx] (AMS302, Panasonic Inc.), motion [binary] (EKMB1101111, Panasonic Inc.), and acceleration [m/s2] (ADXL345, Analog Devices, Inc.) are assembled in 10 sensor boxes that digitize the analog data and send it to the central computer (Figure 1A). Each sensor box is powered by a 2900mAh AAA alkaline primary cell that, due to consequent low-power hardware architecture, keeps each device in service for six months. The environmental parameters are acquired by a sampling rate of 1/5 Hz. To facilitate installation and avoid cables, wireless communication is used. Each set of values is composed to a data package and sent to the data-logging computer over a wireless link based on EZRadioPro-Technology from Silabs. A low byte order marked bidirectional protocol placed on an 868MHz carrier transmitted by frequency modulation is used. Even-parity error handling and frame collision detection are implemented. Due to the receiver's digital received signal strength indication and its sensitivity of -117dBm, as well as the transmitter's programmable output power of up to 13dBm, a theoretical range of 2000m is achieved. In addition to the five sensor values, each frame includes a status word comprised of timestamp, date, node number, supply voltage, and data fields for sent, received, and lost data packages. Hence the proper functioning of each sensor box can be monitored at any time, which leads to a high degree of transparency regarding the transmitted, lost, and compromised data. By interpreting the status word, each dataset can be bijectively matched to its origin to take statistical advantage of paired data.

Figure 2 shows the block diagram that is implemented on the central computer. The output of the "data collection" block is the current data from 50 ambient sensors. This data is stored in a database. The rule-based AI-algorithm A (Figure 2) estimates the current activity of the patient. The inputs to this block consist of the current data, historical data, and expert knowledge. Output is the current activity of the patient.

With the approval of the local ethics committee, five healthy volunteers (ages 28, 29, 29, 30, and 62 years) were monitored over 20 days. Assuming that each person

Figure 1A. One of ten 10 wireless sensor boxes with AAA battery, PIR-, light-, and temperature sensor.

Figure 1B. Electronic protocol box worn by a healthy test volunteer. The volunteer can protocol the current activity by tripping the according switches.

follows a daily routine, specific patterns of nearly the same duration and course can be recognized each day. Such behavior patterns occur several times during the day and night. Among these patterns, eight ADL (sleeping, grooming, toileting, getting ready for bed, cooking, eating, watching TV, and seated activities) are recognized autonomously by the system. To judge the system's performance, the five healthy volunteers were asked to document their daily activities. Each time a volunteer performed one of the eight specified ADL, he or she tripped the corresponding switch on the mobile wireless input device, called electronic protocol box (Figure 1B), for the duration of this activity.

At the end of a measurement, a dataset of ambient values and a set of protocol data from the electronic protocol box were obtained. A rule-based AI-algorithm parsed the acquired data and determined the actual ADL performed by the individual. Both algorithms are written in MATLAB (The MathWorks Inc.). By comparing the outcome with the data of the corresponding individual's electronic protocol box, the sensitivity and specificity of the system's recognition performance can be calculated.

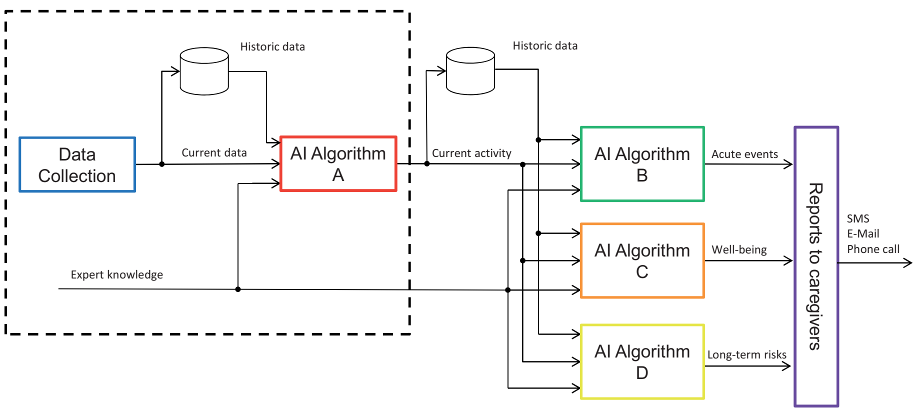

Figure 2. Block diagram of the AI-algorithms. The blocks inside the dashed square are already implemented and tested.

2 Results

To date, data from five healthy volunteers has been recorded during 2,400 h at a sampling rate of 1/5 Hz. Of a total of 15,179,994 measurements, 1.48% were lost due to transmission errors. Hence, a net of 14,953,964 ambient values (SD = 822,546) were captured.

Table 1. Results of five healthy volunteers.

ADL	N	Correctly recognized	Missed	Sensitivity [%]	Specificity [%]
Sleeping	75	69	6	92.00	89.84
Grooming	54	51	3	94.44	97.03
Toileting	121	112	9	92.56	95.68
Getting ready for bed	45	42	3	93.33	94.70
Cooking	34	29	5	85.29	91.79
Eating	48	42	6	87.50	93.26
Watching TV	78	71	7	91.03	87.75
Seated activity	94	82	12	87.23	93.96
TOTAL	549	498	51	90.71	93.41

In total, 549 ADL have been performed by the healthy volunteers. Of those, 498 ADL were determined correctly by the system. This leads to an overall sensitivity of 90.71% and a specificity of 93.41%.

3 Discussion

With the measurement of the first five healthy volunteers, the feasibility and reliability of the hardware and software have been proven. Hence, it is possible to recognize activities of individuals by measuring ambient values.

The approach of the AI-algorithm A to evaluate the ADL looks promising. Despite the fact that some ADL evoke only slightly different ambient values, the system performance meets expectations. As expected, the algorithms show better performance for some ADL than for others. This is because some ADL are exclusively room-related (i.e. toileting) or show very unique patterns (i.e. cooking), while others only differ slightly among one another. Similar problems were reported by others. S. Bang et al. [21] used a set of pressure sensors, PIR sensors, and a worn accelerometer to determine ADL. A. Fleury et al. [28] used video cameras and wearable kinetic sensors, door contacts, and microphones.

A strength of the system is its small and discrete shape. Once the system is deployed, we observed that healthy volunteers tended to forget about the sensors and act naturally after a short amount of time.

A limitation could be the average age of the healthy volunteers measured so far. AD patients tend to be about 75 years old [29]. To match the demography of the patients, in the next phase, we will measure older healthy volunteers. In a next step, the algorithms B, C and D for detecting acute events, patient well-being, and long-term risks will be implemented and tested in healthy volunteers and AD patients.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-77

Detecting and preventing Falls with Depth Camera, Tracking the Body Center

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Abstract. Fall is a major risk for elderly people. This paper is an outline of the research work that we are conducting in our group concerning the development of new technologies for fall detection and prevention at home. Our aim is to propose new affordable devices at home which: (1) automatically detect falls, and then alert whom is concern when a fall has been detected, (2) proceed with some measure in order to define an indicator associated with the risk of fall. Such devices could reassure persons affected by mobility problems or being recently injured in a fall, thus permitting them to stay at home longer. We are currently examining how low-cost RGB-D cameras could be used to track continuously a person at home. We show that we can easily extract, from depth images, the body center of mass of a person and some other simple parameters from which we can detect and prevent falls. Preliminary results are presented based on two real experimentations with young people, within an experimental smart home. 208 sequences were recorded for the first experimentation concerning fall detection and 106 strides were analyzed for gait parameters measurement.

Keywords. Detecting and preventing falls, Center of mass, Depth camera, Elderly people.

Introduction

In the next decades, the population of elderly people will continue to grow. In France the number of people of more than 60 years old will increase by 10,4 million between 2007 and 2060 [3]. One third of elderly people at home fall each year [9] and this has motivated an increasing number of researchers to propose technological solutions to address fall detection and prevention. This is an important issue in order to permit people with autonomy loss to stay longer at home with satisfactory security.

Current fall detection systems are unsatisfactory because these systems are mainly based on sensors that the person must think to wear. We want to develop a system allowing to detect when a person falls and to call for help automatically. The aim is to avoid that the person stay a long time on the ground because some study showed that staying on the ground shortens life [11].

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The risk of falling for a person may be detected through some clinical tests such as timed up-and-go test [6], Berg test [2], Tinetti test, etc. But these tests are subjective and arent applicable to everyone as for people having mobility problems or cognitive impairment [8]. Thus there is a real need to develop systems for objectively analyzing gait and for detecting mobility and balance. According to Auvinet et al [1], the irregularity of the lengths of steps is regarded as a relevant variable for the prediction of falls. Our aim is to develop a system allowing to analyze the evolution of gait parameters over time (in particular the lengths of steps) so as to be able to prevent eventual falls.

To develop a system able to detect and prevent falls we use a RGB-Depth camera, which has the advantage to be a low-cost sensor. We show that we can easily extract in real-time from RGB-D images, with a good accuracy, the center of mass of any person moving in the field of view of the camera. We also show that this parameter is an important feature to detect falls and to characterize the risk of fall.

We made the choice to include the detection of the falls in the more general context of activity recognition which consists in automatically determining the activity of a person over time. Our method uses the position and the velocity of the center of mass and the body shape of the person. For the prevention of falls, the lengths of steps of the person is estimated from the dynamics of the position of the center of mass on the vertical plane. In this work, we show that it is possible, from the center of mass, to detect the activity of the person, in particular to detect the falls, and also to measure the length of steps and thus to develop a tool to prevent the falls.

This paper is organized as follows. Section 1 is dedicated to a method for extracting the center of mass. Then, section 2 describes the system for detecting falls. Finally in section 3, we present a method for preventing falls.

1. Method for extracting the Center of Mass

In addition to the color image, the RGB-D camera provides a depth map allowing to reconstruct the real world 3D coordinates of all the points of the image. The first stage is to extract the background in order to extract the pixels corresponding to a moving person/object. We use a simple and fast method, the ”running average” [5] method, which consists in learning the background by averaging over time the distances for each point of the depth map. At each time, the background distances are subtracted from the current distances to keep only mobile points. In Figure 2, in the top right-hand corner is the current depth image and in the top left-hand corner is the learnt background. Then we gather, with the method Component labelling [10], the mobile points belonging to a same object. In Figure 2, in the bottom left-hand corner the mobile points are represented in blue color. The displacement of the body can be analyzed by looking at the displacement of the center of mass as shown in Figure 1. In our system the center of mass is calculated by averaging all the mobile points of the person (geometric center of 3D mobile points). In Figure 2, in the bottom right-hand corner, the center of mass, obtained with the camera, is drawn on the vertical plane.

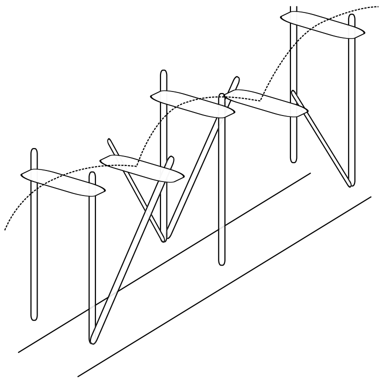

Figure 1. Vertical displacement of the center of mass.

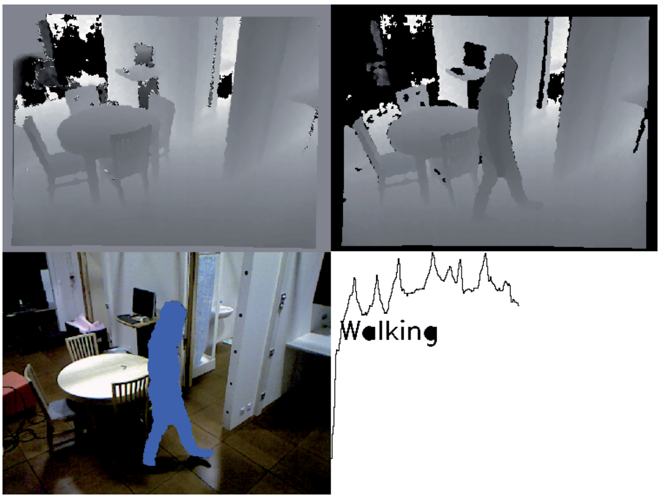

Figure 2. Center of mass extraction with RGB-D camera.

2. Detecting Falls

The aim of this work is to discriminate falls among other activities such as sitting, lying on a couch... The approach is based on a Hidden Markov Model (HMM) [7], in which the behavior of a person is seen as a sequence of states over time, each state corresponding to one among eight activities of daily life: falling, walking (including the position upright), lying (on a bed, on a couch for example), sitting, lying down, squatting, going up on an obstacle (a chair, a footboard for example) and bending [4]. The center of mass of the person is the main observation for detecting in which state the person is, more precisely we use the vertical position and the vertical speed of the center of mass and the standard deviation of all the points belonging to the person. In Figure 3 we represent the trajectory of the center of mass for two activities, walking and sitting. The Forward-Backward algorithm [7] calculates the probability of being in each state at each time step. Twenty six healthy subjects performed eight activities and the model was trained with these eight situations from sixteen subjects which represented a learning database of 128 sequences.

We kept ten subjects, which represented 80 sequences, to test our model. The result is that each situation is recognized exept ”bending”. There are no false positives exept ”sitting” and ”squatting” which are detected instead of ”bending”. Falls are correctly detected exept for one of them due to the fact that the subject rose immediately after he fell. Falls are detected without false positives. In Figure 2, the bottom right-hand corner is an example of decision taken by the algorithm detecting the state in which the person is.

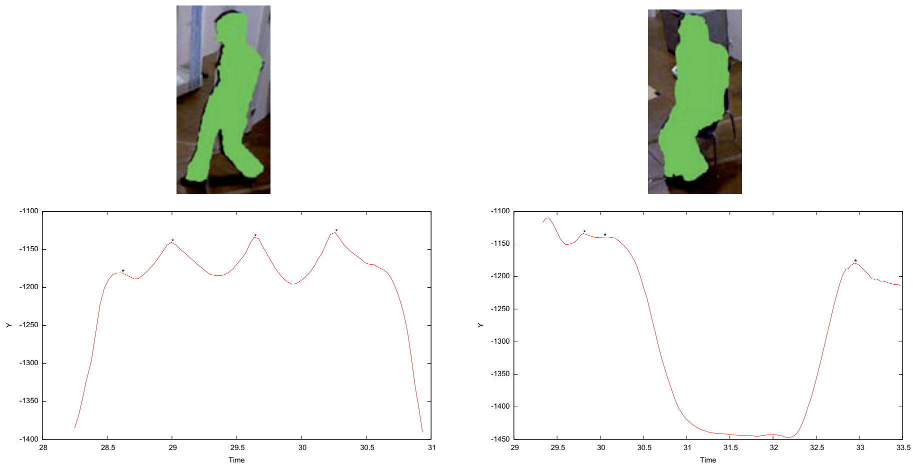

Figure 3. Tracking of the center of mass in two different activities.

3. Preventing Falls

As we said in introduction, the length of steps is clearly related to the degradation of the gait and it is a good indicator to evaluate the fall risk of a person. We extract this gait parameter from the vertical trajectory of the center of mass of the walking person. In Figure 4 the curve is an example of the center of mass trajectory for a walking person from which we extract the length of steps. This curve is then filtered by Kalman filter [7]. We define the length of steps as being the distance between two local maxima of the curve. We set up an experiment to validate the accuracy of the length of steps obtained with RGB-D camera. We placed pads soaked with ink under the tip and the back of shoes and several subjects walked on paper, marking it. This technique allows us to obtain the real length of steps, to be compared to the length of steps provided by the camera algorithm. Five subjects performed two situations, first the subject had to walk in a straight line normally and then he had to walk making small steps to better fit elderly people walk. The mesured lengths were compared to the real lengths obtained with paper sheets. This comparison has been made on 106 lengths of steps, 39 normal steps and 67 small steps. The average error is 5.31cm for all steps, which represents an error of 11.78%. More precisely, we obtain for normal steps an average error of 6.38cm, which represents an error of 10%. For small steps, the average error is 4.69cm which represents an error of 12.80%. In order to correct a possible bias related to calibration issues we performed a linear regression and defined a linear model of the error. After correction of the error, we obtained an average error for all steps of 3.14cm, which represents an error of 7% on the 106 lengths of steps. More precisely, for normal steps the average error is 3.98cm, which represents an error of 6.04%. For small steps, the average error is 2.73cm which represents an error of 7.55%.

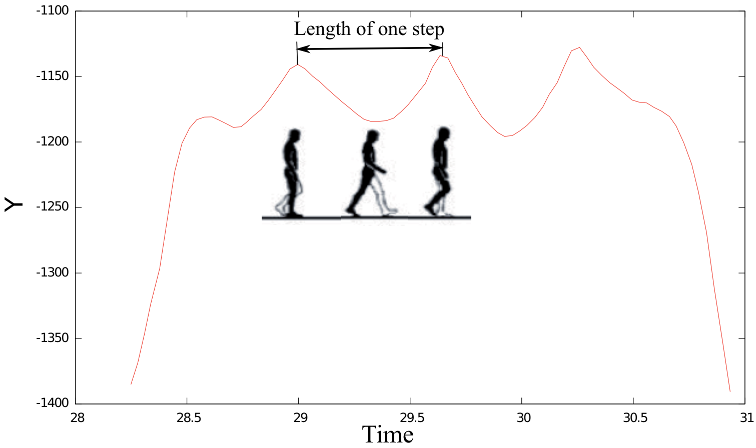

Figure 4. Lengths of steps extraction from the trajectory of the center of mass.

4. Conclusion

To conclude, we propose a simple low cost gait analyzer system. The system relies on a trained HMM. Good results for detecting and preventing falls have been obtained in laboratory conditions and since the model is independant of surroundings, we believe that it's general enough to work in other conditions. The next step is to deal with the problem of occlusions and to validate the approach in real living conditions either at home or in the physician office. Such a system is interesting to objectify the global analysis of elderly frailty at home or during physician examination.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-83

Integrative Implementation of Ambient Assisted Living Focused on Efficiency and Flexibility

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Abstract. The society and health systems have to face new challenges due to the increasing proportion of older people in the total population. The demographic change leads to an increase of the imbalance between beneficiaries and providers. According to forecasts, the proportion of over 60 year olds especially in rural areas will grow up to 45 percent by 2025. Concepts must be developed especially for person with a low family support potential. These have to consider the individual health state and have to enable an independently, self-determined life. Furthermore, under the inclusion of the latest technologies, their daily life should be assisted by a system based environment (in the private and public sector) with the intention to preserve their mobility. Therefore, the main target of the service provider and the service recipient should allow the older people, despite their individual health restrictions, independence but also supported and medical controlled life in their familiar home environment. This ensures in a holistic and integrated way that the gap between the domestic private sphere and the healthcare system can be closed. The requirements of this conceptual gap lead to the subject of the research project A²LICE composed of the University of Applied Sciences Zwickau and Chemnitz University of Technology and will be presented in the paper.

Keywords. Ambient Assisted Living, Smart Home, Efficiency, Flexibility.

Introduction and Research Priority

The young research field of Ambient Assisted Living (AAL) is engaged in the exploration of new concepts, services and products that combine modern technology and the social environment with each other. The most compelling objective is to improve the quality of life of all ages with the assistance of appropriate technical systems (e.g. sensors, actors, visualization technologies). However, there have been a large number of research projects which deal with sophisticated new technologies and assistive environments that track the claims of high end solutions. However, this usually leads to the fact that the results obtained fail, by factors such as the legal transferability, the acceptance of users and most of all the investment costs and interfaces to other systems, in reality.

The main objective of the project A²LICE ("Ambient Assisted Living in Intelligent Controlled Environments") focuses on the implementation of such a marketable solution which deals with these problems. Marketable in that way means to hit the on the top shown objectives in Figure 1.

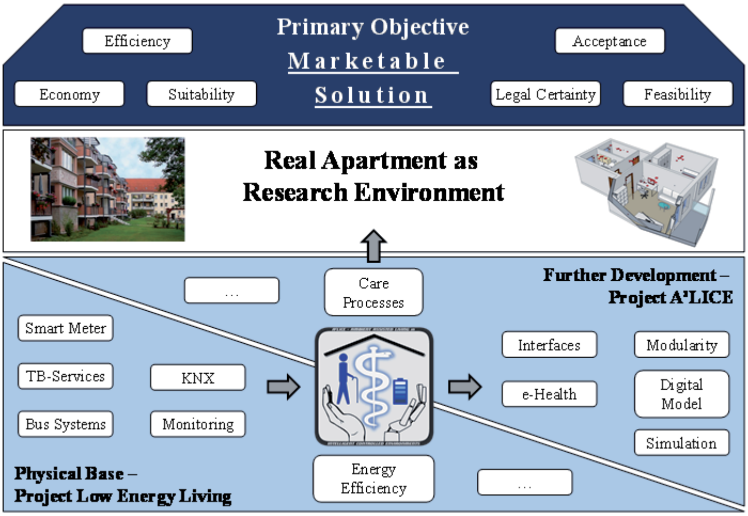

Fig. 1. Conceptual frame of the project A²LICE.

The project is funded by the European Social Fund (ESF) and is processed in a group of junior researchers from the University of Applied Sciences Zwickau, Chemnitz University of Technology and the University of Leipzig. It deals with the closure of the above-mentioned conceptual gap between institutional care and (municipal) housing industry in the health care chain within the claim of a marketable ambient assisted living environment [1]. The research approach and the technical base for the current work are formed by the previous successful project "Low Energy Living" of the WHZ [2]. The basic idea is to use the technical solutions from the focus of energy efficiency in private households and expand it with affordable as well as existing sensors and actuators to implement an ambient assisted environment.

1 Focus: Efficient Implementation

The research project Low Energy Living (LEL) was from 2009 to October 2012 and pursued the assignments to investigate, design and implement measures with the aim of increasing energy efficiency in the context of municipal housing companies within the domain heat, electric and energy supply. The LEL project builds up the infrastructural base for the A²LICE project and consists out of twenty apartments of a regional housing association which already include the systems researched in LEL. In addition to the practical integration of innovative building control system the focus was to create a feasibility study on the so called “smart living in apartment buildings” with the future goal of establishing efficient technologies as standard equipment in these types of buildings. The basis of the explored control system is a powerful, multipurpose, flexible and sustainable bus system based on KNX [3] as the successor of the European Installation Bus EIB [4]. The KNX installation is connected with numerous other components and systems such as PLC controllers and smart meters. The technical equipment of the reference objects include modern technology, such as remote-readable digital electricity meters, decentralized ventilation systems, a decentralized heat pump system, heat meters, heat cost allocators and also server and gateways for networking (see Figure 2). The focus lies on the establishing and implementation of marketable technologies [2].

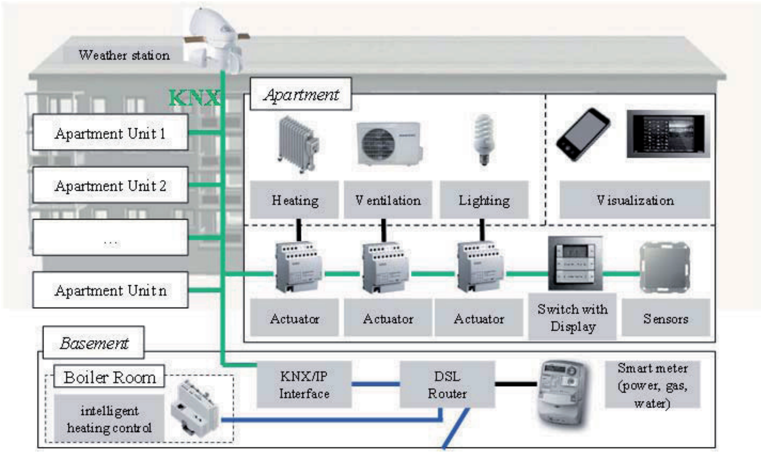

Fig. 2. Technical equipment of reference units [2].

Some of the apartments are equipped with touch panel PCs, which acts as interface between the building automation and the end user. This interface is more than a visualization component it also provides essential functions such as setting the desired temperature profiles, switching of sockets, display energy consumption of individual appliances and the so-called Stay/Leave function ("Kommen/Gehen"). These and other features make first approaches for Ambient Assisted Living (AAL) and the project A²LICE. In this context there will formal and informal health care providers be involved in addition to the researching universities. They have to set up business processes and scenarios that can be mapped to the existing sensors from the LEL system. Furthermore and in addition to the LEL data, vital signs (for example weight or blood pressure) should be measured with additional (medically) sensors and also should be integrated into the overall monitoring concept. Thus, it is possible to illustrate scenarios along the whole supply- and care chain. As an essential part of the chain the integration of telemedicine monitoring with the link to medical and care services should be realized. To make these technical systems stable for long-term adaptation, the principles of flexibility and adaptability are becoming increasingly important. Above all, these are crucial for the continued research work and are offered in the following chapter.

2 Focus: Flexibility through Modularity

The flexibility consists of the ability of a system to respond quickly to dynamic changes due to low operating costs and physical adaption [5]. The adaptability further includes the potential ability to respond reactively or proactively to structural, organizational and technical changes with appropriate functional and dimensional adaption measures at a strategic point of view. From this point the Chemnitz University of Technology dealt with the evaluation and adaptation of methods of versatile planning and design of technical systems into the private environment of AAL.

To promote adaptability it is necessary to implement appropriate properties. They are called enablers and consists out of the properties of universality (independent in function and use), mobility (largely unrestricted spatial mobility), scalability (expandability and reducibility), modularity (maximum internal independence of the functional units), compatibility (networking capability via interfaces) and neutrality (no influence on the capacities of other objects)[6]. In the best case, there are technical or constructive objects which can be connected with each other, freely installed in the room, expanded and reconfigured and are operating independently of others and for a number of different applications. Following this idea, the objects of the private sector are systematically divided into different hierarchical levels (residential unit, residential complex and residential quarter), which are linked in a decentralized supply chain and furthermore be linked with the individual needed service provider.

Regarded to the core idea of the implementation of energy efficiency and AAL environment, these hierarchical levels objects, especially in the living unit, can be further divided into the areas of the implementation field's supply, security, home, comfort and lifestyle, rehabilitation and prevention, health care and social communication. In these the required sensors, actuators, visualization and processing units as well as the furnishings are classified. This structured system allows the implementation of an appropriate framework of information technology. In turn, essential objects for the flexible-modular implementation can be identified and evaluated in terms of their changeability. The evaluation also includes the differentiated consideration of alternative objects. These may already exist on the market or are able to integrate due to freely programmable and controllable sensors and actuators with little effort by themself. However, the aim of the modularization is to package the objects according to individual use cases. Based on this, according the disease patterns and life circumstances, packets will be added or removed. Thus it is possible that an individual can adapt the unit according to its stage of life and physical as well as mental limitations. Based on different scenarios, the results from the modularization can be proved in a digital as well as real research apartment.

3 Approaches and Results

Working with scenarios allows a modular design of software and especially hardware. Various first tier scenarios were defined and mapped as process chains. This approach has several advantages. On the one hand dependencies can be shown up and also combined with each other. And on the other hand, the detailing of scenarios within their needed processes and activities till down to the elementary sensor level can increase the flexibility in planning, implementing and monitoring. In the project LEL, there where be various scenarios and processes developed and implemented due to energy efficiency, heat supply and increased comfort (heating control, energy monitoring,…). In the project A²LICE the health and nursing care. The main focus in the explored scenarios is to monitor activities based on collected sensor and smart meter data. Basically there are two different types of monitoring that can be distinguished. The first category contains emergency scenarios which results from a generally inactivity of the end user. It is a method to recognize situations in which a person performs no measurable activity in long term than usual [7]. If it happens, an automatic emergency call to the relevant person will be send. The second category is more complex and includes a multitude of varied, sequential or parallel processes which can be assigned to more than one scenario. So called “Activities of daily Living” (ADL) form the basis for these special monitoring scenarios. The quality of life and thereby the subjective health of elderly is influenced by the degree of their independence in living. As a result of illness and disability, usually translated functional limitations in one affected [8]. This loss of function can be divided into activities of daily living (ADL) and instrumental ADL (IADL) [9]. To detect and visualize it, complex methods of recognizing human behavioral pattern are required [10]. Each ADL consists of a set of typical actions that can occur in different temporal sequences. One or more sensor can be assigned to each of these actions, as shown in Figure 3. These assignments are n to m associations and one sensor can indicate several activities which in turn can connect to different activities of daily living [11]. The challenge is to select the "right" ADL with a very high probability from the pool of possible activities of daily living.

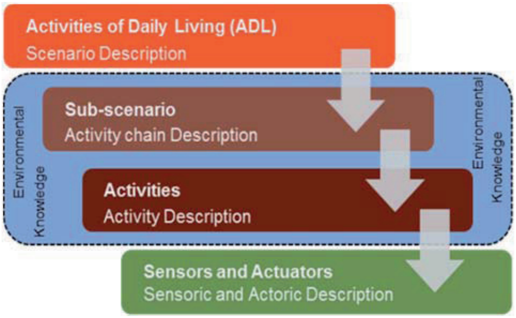

Fig. 3. Detailing the scenarios with ADL.

In order to calculate these probabilities, the scenarios are subdivided according to the processes in figure four. Each scenario is depicted with an exemplary description with reference to a flowchart. Based on this structure a (software) reference model will be developed. By the layer-based detection of necessary additional information (environmental knowledge) the identification of the respective ADL is easier and more efficient. The monitoring of specific ADLs creates added value for the different user groups involved. This system allows recognition of activities and their monitoring over periods of time. Furthermore important information’s can be derived by analyzing this data to show up health conditions of the inhabitant. With the modularization based on the scenarios a combination of data from different domains is also possible. Here, for example, data from scenarios of heat supply (room temperatures, etc.) and data from ADL-identification scenarios (day-night rhythm, food intake, sleep, etc.) could be combined for more detailed statements about the apartment or about health conditions of the patient.

To make such statements visual and debatable the scenarios and ADL are mapped into a digital model from one of the available apartments of the housing association. This model combines all sensors, actuators and fittings. Research relevant objects can thus be activated and deactivated via different layers. Moreover, in a parallel simulation, the necessary data for the Energy and ADL monitoring are collected via virtual function units. This ensures an effective and holistic way to get useful data for exploring new processes and configurations and provides comprehensible activities. Furthermore, it provides a fast, free and non-destructive testing environment. Based on the data and object relations from the digital model the real, existing research apartment is currently being built. In this all the necessary objects for the real-time survey will be installed. This is permanently inhabited by a test person, which should refer to defined ADL's. Ostensibly, the apartment intended to show the feasibility and the value of the system.

4 Further Expectations and Conclusion

The adaptability and the variety of combined scenarios and processes enable an individual solution for the end users, which can be adapted to their needs and restrictions. At the same time different stakeholder along the medical supply chain (and moreover) benefit from the created values. The merger of the various application possibilities from energy data und care processes cause synergies that reveal many additional economic potentials. In turn these potentials are the basis for functioning and viable business models. At the moment there are no business models at the most areas of ambient assisted living. This gap is one main cause for the slow innovation and implementation of ambient assisted living solutions in practice. From the technical point of view there are nearly no limits in the area of assisting technologies and provided functions. Beside this, there are deficits concerning to the acceptance of the end user and financing the expensive solutions. The A²LICE project pays attention on both of the mentioned restrictions. The focus on adaptability offers main opportunities to counteract missing acceptance and creates new possibilities for financing the developed solutions. Additionally the networking applications in the care and research in science is an essential part of the project. Here the focus is on the combination of theoretical, technology-oriented research and practical application in housing, health and care sector.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-90

Footstep Localization based on In-home Microphone-array Signals

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Abstract. This paper describes a system able to detect footstep locations. Through acoustic information retrieved from a wireless sensor network with small and relatively cheap microphone arrays. A dataset was recorded in order to validate the accuracy of the detection. Results on this dataset show that a best median of errors of 31cm per time moment are achievable, but results heavily depend on the positions of the microphones relative to the footsteps.

Keywords. footstep location estimation, steered response power, global coherence field, gait analysis

Introduction

It is shown that a person's gait is related with there health, e.g. for early detection of dementia [1]. This work focuses on detecting footstep positions for later estimation of gait related parameters (i.e. such as walking speed, direction, stride length) by acoustic information, acquired from relatively cheap electret microphones. Acoustic sensing has the advantage that it is passive (i.e. no transmission of reference signals is needed) and contactless. For this work the setup of a wireless acoustic sensor network (WASN) has been chosen which differs from work using only one microphone array [2]. Such networks contain multiple so called nodes each holding at least one microphone. These WASNs have advantages over other kinds of setups. For instance the nodes can be small while maintaining large spatial sampling. The nodes can be placed uniformly in a room without inconvenient cables, which is ideal in an home environment. The computational load (which can be significant) can be distributed among nodes so that cheaper hardware can be selected [3].

This paper starts off with a general system description (section 1) and a selection of appropriate state-of-the-art algorithms for each part (section 2). Then an experimental setup and the data collection are described in section 3. In section 4, results on this dataset are presented. Finally conclusions are drawn in section 5.

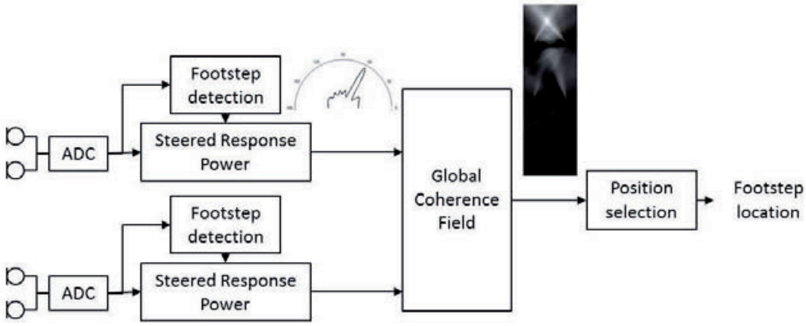


Figure 1.: Block schematic with example intermediate results.

1. System Architecture

The proposed system consists out of 4 linear microphone arrays, further referred to as nodes. For esthetical reasons, these nodes should be rather small. In this work, nodes with 3 electret microphones with an inter-sensor distance of 6.8 cm are used, experimentally determined as a trade-off between beamwidth and node size. These nodes are then placed at ground level with a negligible microphone height of 4.5cm, making the localization a 2 dimensional problem. Furthermore, all node positions and orientations are considered to be known. A visualization of all tasks to be performed along with examples of intermediate results is shown in Figure 1. A first stage detects whether or not the sound contains a footstep. Through other alternatives have been studied for this purpose [4], this work uses an energy threshold for footstep detection. In a second stage each node is capable of estimating the sound energy coming from a certain direction. Multiple techniques exist but here the steered response power (SRP) is selected for reasons explained in section 2.1. The third stage combines the directional energies of all nodes to a map representing the spatial energy in 2D space. This is done by a global coherence field (GCF), further discussed in section 2.2. The last stage selects one XY coordinate out of the 2D GCF map, a step which is further discussed in section 2.3.

2. Methods

2.1. Direction of Arrival Estimation

Since sound travels at a finite speed, information about the direction of arrival (DOA) can be found in the time differences of arrival (TDOA) between different microphones in a node. The most simple way of measuring these TDOA is by a cross correlation, but this approach has a time resolution of only one sampling period. This problem can be resolved by using the so-called steered response power (SRP) algorithm [5]. SRP is based on a well-known delay and sum beamformer. To obtain time resolution the microphone signals are first chopped in frames (8000 samples which corresponds to 0.25 s at the used 32kHz sample rate, overlapping by 7000 samples), then the beamformer is steered in multiple directions at once (ranging 180° with 1° resolution). In each direction the retrieved energy of a frame is measured. In this work an enhancement on SRP is used, namely SRP phase transform (SRP-PHAT). PHAT basically pre-transforms the microphone frames to have an unity spectral density. This operation decorrelates the different microphone signals over time, making the directional energy peaks narrower. The SRP-PHAT algorithm is further described in [5].

2.2. Global Cohenrence Field

Global coherence field (GCF) is a method for combining the directional energies of all nodes to a map containing energies at different XY positions. Unlike others, GCF takes all directional energy into account and not just the direction of the maximum energy. The main idea is to define an XY grid (points edging by 2 cm) and project the directional energies of all nodes onto this grid. This way intersections of high-energy directions will stand out. GCF is further described in [6]. Unfortunately, the collected data contains noise correlated over all microphones (presumably due to electromagnetic interference on the low level electret microphone output). But since these power contributions are quite stationary the noise effects can be estimated by a (local in time) average of the GCF map taken on noise only frames as follows:

$$GCF_{average}(k) = (1-\lambda)GCF(k) + \lambda GCF_{average}(k-1) \quad (1)$$

Subtracting this average map from the current map removes effect of the noise. The parameter λ (ranging from 0 to 1) symbolizes the time on which the average is taken. Prior tests show that $\lambda = 0.95$ (corresponding to a time constant of 20 ms) produced good results.

2.3. Source Position Selection

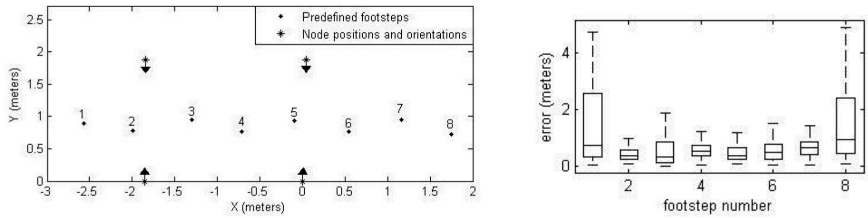
The GCF produces a map indicating the sound energy at different XY coordinates. The last step is to select one XY point out of this map as the footstep position. This is done by taking the weighted mean position of all points exceeding a threshold of 95% of the maximum, neighboring the maximum.

3. Experimental Setup and Data Collection

The experiments were performed on data recorded in an office setting. Two test subjects were asked to walk 8 times on a predefined path containing 8 steps, yielding a total dataset of 128 (=2x8x8) steps. The nodes (plus front directions) and the footstep positions are shown in Figure 2a.

4. Results and Discussion

Figure 2b shows boxplots of the errors for each footstep position. The median of errors range from 31 to 92cm. The figure indicates 2 important effects. Firstly that the errors are smaller for footstep positions enclosed by the nodes. This was expected since both signal-to-noise-ratio (SNR) and signal-to-reverberation-ratio (SRR) are larger and indicates the importance of a well chosen setup of the nodes. Secondly it is seen that the lower 50



(a) (b)

Figure 2.: a) Node positions/orientations and predefined footstep positions. b) Median of errors per footstep position.

percentile of errors is more dense than the upper 50 percentile indicating outliers. This is an important conclusion for future design of a post processor. Furthermore, following notes are important to contextualize these results:

1 This experiment is conducted on one floor type using only 2 types of footwear (2 test subjects), limiting the acoustics a footstep produces. The proposed system should be able to handle all sorts of footsteps acoustics, but the presented results can not be generalized.
2 The results presented here are based on a small set of footsteps. A larger data collection should be made to accurately validate the system.

5. Conclusions

This work focused on estimation footstep locations using acoustic information retrieved from a WASN. A system flowchart was presented and state-of-the-art algorithms were selected for each subtask. A dataset was recorded. The minimum and maximum observed error over the 16 instances per footstep position number are shown by the boxplots. Subsequent these experiments showed that the proposed system is able to detect footsteps with a best median of errors of 31cm. But also showed that these results are only achievable when nodes are located nearby the footstep location, making a well-chosen setup of nodes necessary. The experiment also showed that there are outliers in the position estimates for a frame, which will be of uppermost importance in designing a post-processing algorithm.

Acknowledgements

This work was preformed in context of following projects: ALADIN (IWT-SBO project contract 100049), IWT doctoral scholarships (contract 111433 and 121565) and FallRisk.The iMinds FallRisk project is cofunded by iMinds (Interdisciplinary Institute for Technology), a research institute founded by the Flemish Government. Companies and organizations involved in the project are COMmeto, Televic Healthcare, TP Vision, Verhaert and Wit-Gele Kruis Limburg, with projectsupport of IWT.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-95

Ubiquitous Fall Detection and Activity Recognition System for Bathrooms

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Abstract. Falls are the most frequent external cause of death for older adults, where bathrooms are a particulary dangerous environment. We propose an autonomous, ubiquitous, low-cost fall detection system based on ultrasonic and piezoelectric sensors, which takes into account privacy concerns as well as bathroom-specific hazardous environmental influences to technology. The system was implemented and tested in a real-world scenario.

Keywords. Ambient assisted living (AAL), ultrasonic range finders, piezoelectric sensors, activity recognition, fall detection, ubiquitous computing.

Introduction

Current demographic changes pose great challenges to society in general and health care systems in particular. One of these challenges is an increasing demand for assistive systems and technologies to sustain independence and allow people to keep living in their own familiar environment. The major requirements are to reliably detect unusual situations and to quickly react to medical emergencies. According to statistics for Germany [1], falls are the most frequent external cause of death for people over the age of 60. For these older adults, the bathroom is one of the most dangerous places: low vision aids are typically not worn in the shower, the floor can be slippery when wet, and the impact on tiled floors is harder than on most other floor materials. At the same time, it is one of the most challenging environments for technical fall detection systems, as rapid temperature changes and high humidity are problematic for them and the use of cameras is undesirable due to privacy concerns. In this paper we propose a fall detection system[2], which meets the special requirements of such an environment.

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[2]The system was developed during the project ”Village Arbergen for self-dependent living”, which was funded by the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR) and as a cooperation of the Institute of Cognitve Neuroinformatics, the Bremer Heimstiftung, the Bremer Kontor GmbH, and FORUM Huebner, Karsten & Partner.

Table 1. Device models, technical specification and prices of the ultrasonic sensors and the controllers for operating them (prices from http://www.segor.de, http://www.segor.de and http://www.lipoly.de, http://www.lipoly.de; last visit 2013-06-12).

Model	Specification	Price
Ultrasonic Range Finder MaxBotix XL-MaxSonar®-WRC1™ MB7067	range: 20 – 645 cm; resolution: 1 cm; operation between -40°C and +64°C; IP67 water proof; operates at 42 kHz; cone diameter: approx. 80 cm @ 260 cm	90 EUR
Arduino Mega 2560	ATmega2560 @ 16 MHz; flash memory: 256 KB; SRAM: 8 KB	47 EUR
Arduino Ethernet Shield	connection speed: 10/100 Mbit/s	35 EUR

1. Related Work

Fall and emergency detection systems can typically be separated into two categories: wearable devices and stationary systems. Wearable devices are usually worn around the neck or the wrist or are carried in the pocket. Some devices require active user interaction while others automatically detect an emergency. A common example of the former type consists of a button which has to be pressed in case of emergency. The latter type typically uses tilt-switches, accelerometers [2], gyroscopes [3] or a combination of these sensors to detect a fall or an emergency. While they are subject to research, devices of both categories are on the market and are widely-used in private as well as in nursing homes. For stationary emergency and fall detection systems, sensors are placed in the environment. Types of sensors include pressure-sensitive floors, vision-based systems (e.g., cameras for silhouette extraction [4], IR sensors [5], or depth maps [6]), acoustic sensor arrays [7], or a combination of multiple sensor technologies [8]. Especially in bathroom environments, these systems have certain drawbacks: sensitivity to rapid temperature changes, high humidity, or water vapor, along with privacy concerns. Other approaches measure floor vibration [9] or use ultrasonic range finders mounted in the ceiling [10].

We aim to address the above problems by developing a non-invasive, unobtrusive and autonomous fall detection system that requires no user interaction, can detect emergencies in bathrooms and is able to automatically make an emergency call.

2. Approach

The proposed system consists of a number of sensors and a set of micro-controller boards installed in the bathroom. Two types of sensors are used: multiple water-proof ultrasonic range finders for measuring distances and one piezoelectric element for measuring vibrations.

The ultrasonic sensors are located in the ceiling facing the floor. They are arranged in a grid pattern to allow for their cone-shaped detection areas to overlap (see Figure 1). Given the room height of 260 cm, the measurement cone of one ultrasonic sensor has a diameter of 80 cm at floor level. Hence approx. 2 sensors are needed per square meter. For our experimental bathroom (250 cm x 210 cm = 5.25 m^2), 10 sensors are needed to cover the whole floor of this particular bathroom. The combined output of this sensor grid create a height profile of the bathroom. If a person is inside the room, this profile will change, providing information about both location and posture (e.g., standing or lying). Hardware specification and prices are given in Table 1.

Table 2. Device models, technical specification and prices of the piezoelectric element and the hardware for operating it (prices from http://www.segor.de, http://www.segor.de and http://www.conrad.de, http://www.conrad.de; last visit 2013-06-12).

Model	Specification	Price
Piezo Sensor PLS 3112	1.3 kHz; 48 nF	1 EUR
Universal Preamplifier Kemo® M040N	signal amplification: 40 dB; frequency range: 20 – 20,000 Hz	12 EUR
Arduino Uno	ATmega328 @ 16 MHz; flash memory: 32 KB; SRAM: 2 KB	24 EUR
Arduino Ethernet Shield	connection speed: 10/100 Mbit/s	35 EUR

The piezoelectric element is located beneath a floor tile (see Figure 1). It responds to strain by generating a small electrical potential and thus can be used to detect vibrations which are generated either by normal activities (e.g., walking or showering) or emergency events like falls. Hardware specification and prices are given in Table 2.

Two Arduino[3] boards are used to operate the sensors (cf. Table 1 and 2), read the data and transmit them via LAN to a separate computer which handles data recording, signal processing, and alarm triggering (e.g., making an emergency call). The overall hardware costs for this particular bathrom are below 1600 EUR (sensors and operational hardware: 1100 EUR; evaluation computer: 400 EUR; cables and mounting material: 100 EUR; constituted on June 2013). In comparison a vision-based system costs at least 4000 EUR (price for two semi-professional infrared cameras[4]).

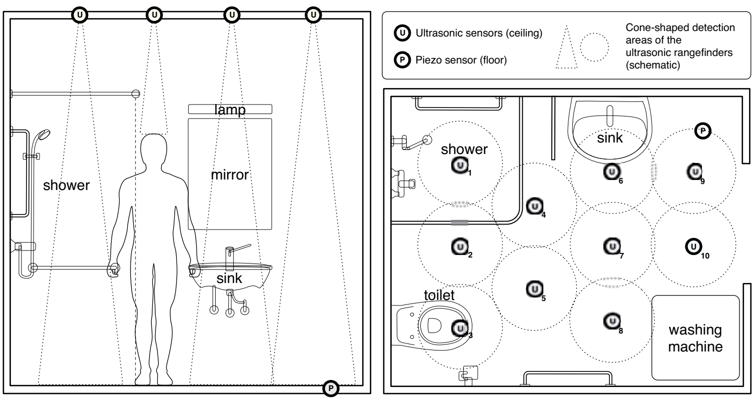

Figure 1. Side view (left image) and plan view (right image) of the bathroom.

The aim of the classification process is to infer, from the measured data, the location and posture of a person in the bathroom and the activity currently being performed. The former can be deduced from the ultrasonic, the latter from the piezo data. Sequences of sensor readings (3 to 7 seconds) are recorded and for each sequence a feature vector is calculated. The ultrasonic feature vector consists of min, max, median, and standard

[3]Description of the Arduino platform: http://www.arduino.cc, http://www.arduino.cc; (last visit 2013-06-12)

[4]Price from http://www.edmundoptics.com, http://www.edmundoptics.com; (last visit 2013-06-12)

deviation for each individual sensor. The piezo feature vector consists of the magnitude spectrum calculated from a fast Fourier transform. These vectors are used as input for the two corresponding classifiers. Classification is performed using a probabilistic support vector machine for each sensor type which calculates the probability of the provided data sample belonging to a certain class of events. For actual emergency detection, the classification results of subsequent time windows of both sensors are combined, generating a joint hypothesis regarding the probability of an emergency.

3. Evaluation

The proposed system was implemented and installed in four apartments. In a first step, both classifiers were trained and evaluated individually, where the aim was to evaluate the performance of the classifiers with respect to position detection (ultrasonic sensors) and activity recognition (piezo sensors) respectively. In a second step, both classifiers were combined and evaluated regarding their performance with respect to the detection of falls in a simulated bathroom usage scenario. For the first step, training and test data consisted of a number of short sequences of sensor readings. Evaluation was performed using 10-fold cross-validation. For the second step, test data consisted of 20 sequences with a duration of approximately 1 minute. All falls were simulated by a young, healthy subject.

For each case (standing and lying) and each ultrasonic sensor (1 to 10) we recorded 20 sequences, each with a duration of 7 seconds where a test subject was either standing or lying directly beneath one sensor. Table 3 (top left) shows the performance for the standing case, Table 3 (top right) shows the performance for the lying case. As for the task of detecting a fall, only a reliable distinction between standing and lying is required. We trained a classifier with the two combined classes *subject standing* and *subject lying*. Table 3 (bottom left) shows the performance of this classifier. In a last step we recorded an additional number of 40 sequences for an empty bathroom and trained a classifer for the classes *empty bathroom*, *person standing* and *person lying* with these new sequences and a subset of the previously recorded data. Table 3 (bottom right) shows the performance of this classifier.

We performed a number of prototypic activities in the bathroom (3 seconds per activity, each performed 20 times) and for each recorded the sequence of piezo sensor readings. The activities were: *bag* (subject dropped a heavy bag in the middle of the room), *brush* (subject droped a toothbrush next to the sink), *fall* (subject sat on the toilet, fell forward), *stomp* (subject stomped at the ground a single time), *dstomp* (subject stomped at the ground twice in quick succession), *toilet* (subject forcefully closed the toilet-lid), *walking* (subject walked from the door to the toilet), *zero* (the bathroom was empty, no activity was perfomed). Table 4 (left) shows the performance of a classifier trained with eight classes directly corresponding to the performed activities. As only a reliable distinction between normal activities and falls is required, we trained a classifier with three combined classes *no activity*, *normal activity* and *fall*. We recorded an additional set of 60 falls of different kinds and 40 sequences of opening and closing the bathroom door. Table 4 (right) shows the performance of the classifier trained with these datasets.

The trained classifiers were used in conjunction for fall detection. Testing data consisted of a set of recorded bathroom usages which were 1.) normal bathroom usage 2.)

Table 3. Evaluation results for the ultrasonic sensors. Top left: results for *subject standing*. Top right: results for *subject lying*. Bottom left: results for classifier distinguishing between *standing* and *lying*. Bottom right: results for classifier distinguishing between *empty bathroom*, *standing* and *lying*.

Ultrasonic data - subject standing											
		beneath sensor									
		1	2	3	4	5	6	7	8	9	10
detected beneath sensor	1	20	0	0	0	0	0	0	0	0	0
	2	0	20	0	0	0	0	0	0	0	0
	3	0	0	17	1	2	0	0	0	0	0
	4	0	0	0	17	0	0	0	0	0	0
	5	0	0	1	2	16	0	0	1	1	0
	6	0	0	0	0	0	20	0	0	0	0
	7	0	0	0	0	1	0	19	0	0	0
	8	0	0	1	0	0	0	1	18	1	0
	9	0	0	1	0	1	0	0	1	18	0
	10	0	0	0	0	0	0	0	0	0	20
correct classification rate: ~ 0.93											

Ultrasonic data - subject standing											
		beneath sensor									
		1	2	3	4	5	6	7	8	9	10
detected beneath sensor	1	14	2	1	1	0	1	0	1	0	0
	2	3	14	2	2	1	1	0	0	0	0
	3	0	3	16	0	0	0	0	0	1	0
	4	0	0	0	17	1	0	0	0	0	0
	5	2	1	0	0	14	1	0	0	0	0
	6	1	0	1	0	3	16	0	0	2	0
	7	0	0	0	0	1	0	10	2	4	0
	8	0	0	0	0	0	0	4	17	0	0
	9	0	0	0	0	0	1	4	0	12	2
	10	0	0	0	0	0	0	2	0	1	18
correct classification rate: ~ 0.93											

Ultrasonic data - standing vs lying			
		subject	
		standing	lying
detected	standing	191	13
	lying	9	187
correct classification rate: ~ 0.95			

Ultrasonic data - empty vs standing vs lying				
		empty bathroom	subject	
			standing	lying
detected	emtpy bathroom	40	0	0
	subject standing	0	92	7
	subject lying	0	8	93
correct classification rate: ~ 0.93				

Table 4. Evaluation results for the piezo sensors. Left: results for classifier trained for individual activities. Right: results for classifier trained with the classes *no activity*, *normal activity* and *fall*.

Piezo data - specific activity recognition									
		bag	brush	dstomp	fall	stomp	walking	toilet	zero
detected	bag	16	1	0	0	0	0	0	0
	brush	0	19	0	1	0	0	0	0
	dstomp	0	0	16	3	1	0	0	1
	fall	1	0	2	15	2	0	0	0
	stomp	0	0	3	3	14	0	1	0
	walking	0	0	0	0	0	20	0	0
	toilet	0	0	0	0	0	0	20	0
	zero	0	0	0	0	0	0	0	20
correct classification rate: ~ 0.88									

Piezo data - fall detection				
		no activity	normal activity	fall
detected	no activity	20	2	0
	normal activity	0	150	6
	fall	0	8	74
correct classification rate: ~ 0.94				

normal bathroom usage, object fell to the floor 3.) bathroom usage, subject fell from the toilet and 4.) bathroom usage, subject fell while standing up. These cases were labeled according to the two classes *normal bathroom usage* and *bathroom usage with fall*. The classifiers were combined by applying them to two distinct, subsequent time windows which corresponded to the sequence: *fall* (detected by the piezo sensor) followed by *person lying* (detected by the ultrasonic sensor). The joint classifier detects a fall when the minimum of the two classifier responses exceeds a threshold. Table 5 shows the confusion matrices for the combined classifier and the results for different thresholds.

Table 5. Evaluation results for combined classifiers for different thresholds.

Fusion: ultrasonic and piezo data		
threshold: 0.50	fall	no fall
fall detected	10	0
no fall detected	0	10
correct classification rate:		1.00
false positive rate:		0.00
false negative rate:		0.00

Fusion: ultrasonic and piezo data		
threshold: 0.70	fall	no fall
fall detected	9	0
no fall detected	1	10
correct classification rate:		0.95
false positive rate:		0.00
false negative rate:		0.10

Fusion: ultrasonic and piezo data		
threshold: 0.90	fall	no fall
fall detected	8	0
no fall detected	2	10
correct classification rate:		0.90
false positive rate:		0.00
false negative rate:		0.20

4. Conclusion

It was shown that the position and posture (standing versus lying) of a person can be detected using ultrasonic sensors. Furthermore activities can be recognized and the distinction between normal activites and falls is possible. It was shown that the combination of both classifier responses, taking into account the temporal sequence of a fall situation, is suitable for detecting falls with high performance. The next steps will be to extend the number of training cases in terms of quantity and variety and to perform a long term evaluation of the system.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-101

A Wearable Assistive Device for AAL Applications

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Abstract. MuSA, Multi Sensor Assistant, is a wearable device designed for elderly people monitoring. The system provides healthcare services as a fall detector, a user alarm button, heartbeat, breathing rate and body temperature measurement. The full integration of MuSA in the ambient-assisted living framework CARDEA allows to provide the user with remote health monitoring, supporting independent and autonomous life at home. The paper illustrates the main concepts behind the MuSA device and presents details of single functionalities. Field tests have been carried out to ensure that the low-cost approach provides adequate quality of the system response.

Keywords. AAL, Assistive Technology, Multi-parameter, Wearable Sensor, ECG, EDR, Fall Detection, Health Monitoring, Wearable Monitoring Health Systems.

Introduction

Due to population ageing, a growing number of people is experiencing frailty and disability. Institutionalization-based policies are quickly becoming economically unsustainable: home care and assisted living strategies hence represent an essential component of present and future care policies. Among main assistive functions in the home environment, aimed at fostering autonomy and independent life, is the early risk detection, which in turn involves continuous health monitoring. A number of solutions have been conceived for monitoring personal activities and vital signs; among them, Wearable Monitoring Health Systems (WHMS) have the potential to implement a consumer-operated personal prevention paradigm and account for early risk detection [1]. A variety of prototypes and commercial products have been designed, with the common aim of providing real-time information about a person's health, either to the user himself or to a specific caregiver.

In literature many research works about wearable devices are presented. For example, CHRONIOUS system [2] has been conceived to monitor chronic health conditions, in particular obstructive pulmonary disease and kidney disease. This device comprises a 3-lead ECG (Electrocardiography), a microphone, a pulse oximeter, respiration bands, a 3-axis accelerometer and a humidity sensor. MagicIC System [3] is a garment composed by textile sensors capable of ECG and respiratory activity and by a motion detection board. SoM [4] aims to detect psychomotor abnormalities in elderly lifestyle. Monitoring is performed in a holistic manner through accelerometers. Chuo et al. [5] developed a wireless body sensor that incorporates multiple sensors on a single node in order to improve user comfort. A flexible unit is attached to person's chest and is able to measure simultaneous parameters such as body motion, respiration, heart-rate.

MuSA, Multi Sensor Assistant, developed at the University of Parma, is aimed at personal activity and vital signs continuous monitoring [6,7]. MuSA is composed by a module attached to a belt and by an elastic-strip to be worn on chest (Fig. 1). It includes a tri-axial accelerometer, exploited to analyze motion and recognize fall events, an ECG unit, from which heartbeat and breathing rates are extracted, a body temperature sensor and a user alarm button. MuSA design specification included: ease of use, small size and light weight (not to interfere with elderly mobility in the daily living activities), data security, reliability and affordability, and low-power consumption. Even if suitable for stand-alone operation too, MuSA has been explicitly conceived for cooperation with an Ambient Assisted Living system. In particular, MuSA is fully embeddable into the home automation system, named CARDEA, a powerful and versatile Ambient Assisted Living (AAL) system, developed at University of Parma [8]. Thanks to real-time data acquisition and processing, MuSA is able to provide CARDEA with meaningful, synthetic information (i.e., without requiring further processing and minimizing power-hungry communication). Data coming from MuSA enter the wider CARDEA knowledge base, enabling data fusion and possibly contributing to activity profiling and behavioral analysis. Moreover, the articulated communication and alarm strategies available into CARDEA are readily accessed by MuSA, thus easily implementing monitoring and surveillance routines.

1 MuSA

MuSA is specifically designed for assistive purposes and is compliant with ZigBee 2007 PRO standard protocol, and the Home automation standard profile. The MuSA board is based on a TI CC2531 SoC [9]. The overall system is composed by a small module (78x48x20 mm, which weights 70g, including a 3.7 V Li-Ion battery) and by an elastic chest-band with ECG electrodes.

MuSA was initially conceived as a fall detection device with a user call button. Further functionalities have been implemented: a single-lead ECG system is used to evaluate heart rate and respiration rate using EDR (ECG Derived Respiration) technique [10] and a NTC thermistor is used to measure body temperature. These analog signals are acquired and then processed by MuSA itself: abnormal behaviors or deviation from “safe” ranges are autonomously detected and related alarm messages are forwarded over the network via a low-power radio communication.

Fig. 1. MuSA and the elastic chest belt with electrodes.

<u>Motion Analysis</u> - Fall accidents are among the main cause of elderly people injury or death. To detect falls (and perspectively to contribute to behavioral analysis aimed at preventing falls) a motion analysis tool is needed: MuSA exploits a tri-axial MEMS accelerometer to evaluate human body position and orientation. The implemented fall-detection algorithm is based on both a posture and acceleration analysis, in order to attain high accuracy and reliability; details are given in [11].

Heart Rate - In the current MuSA/CARDEA view, monitoring of heart activity is assumed to promptly identify elderly's abnormal heart rate rhythms (i.e. arrhythmia, tachycardia, etc.). In the longer perspective, heart rate information will be fused with motion and environmental data, in order to comprehensively profile user behavior. Since non-obtrusive design and continuous monitoring are key-features of MuSA, a simple electrocardiogram (ECG) scheme has been implemented by using a single-lead (I Einthoven) derivation. Electrodes fit an elastic chest belt. On-board circuitry includes, in a first stage, an analog front-end, mainly composed by a differential instrumentation amplifier and an analog low-pass filter. The CC2531 processor then is exploited to filter the ECG signal in order to emphasize QRS complexes. Heart rate algorithm aims to detect and count R-peaks in the ECG signal. In order to look for local maxima, a zero-crossing signal is worked out from the ECG derivative. Through simple threshold comparisons, R-peaks can thus be reliably recognized: despite the simplified approach, a fair accuracy has been estimated, allowing to keep low the computational demand.
Breathing Rate - Another useful vital sign monitoring concerns breathing. Healthy person's respiration rate depends on both age and physical activity. By using this analysis different respiration abnormalities can be estimated (apnea, hyperpnea, tachypnea, etc.). Respiration signal was at first acquired using a piezoelectric sensor integrated to the same elastic chest belt. Unfortunately, the non-perfect signal periodicity, together with motion-induced artifacts, makes the algorithm implementation unreliable. Moreover, the piezoelectric and its housing into the chest belt sensor increase the overall cost, and negatively affects the belt comfort. A new, sensorless solution has thus been implemented, based on the known correlation between ECG signals and respiration acts. The EDR (ECG Derived Respiration) method has been chosen [10]. It is based on small ECG morphology variations, during the breathing cycle, caused by movement of relative heart position with respect to chest electrodes and by the change of lung volume that leads to dielectric changes. In particular, our study exploits the amplitude modulation of the ECG signal: apex of the heart extends towards the abdomen due to lungs filling during the inspiration, while the heart relaxes during expiration, this reflecting on an intensity variation of the ECG sensor response.

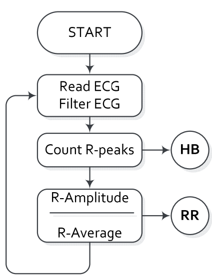

Fig. 2. Heartbeat and Respiration Rate algorithm.

The implemented algorithm, used to derive the respiration signal from ECG, has been described in more details by Shivaram, et al. [12].

The algorithm features real-time processing of a single-lead ECG, and is therefore suitable for the limited computing power available (Fig. 2). In short, ECG signal can be seen as composite R-wave amplitude, composed by the sum of the amplitude modulation due to respiratory movement of the thorax and different noise components.

Being hearth and breathing rates quite different, it is possible to discriminate both effects. After a proper signal filtering, the implemented algorithm detects every R-wave peak, stores its amplitude and computes a running average of the current and previous amplitudes. The ratio of these two values provides a real-time approximation of the respiration signal.

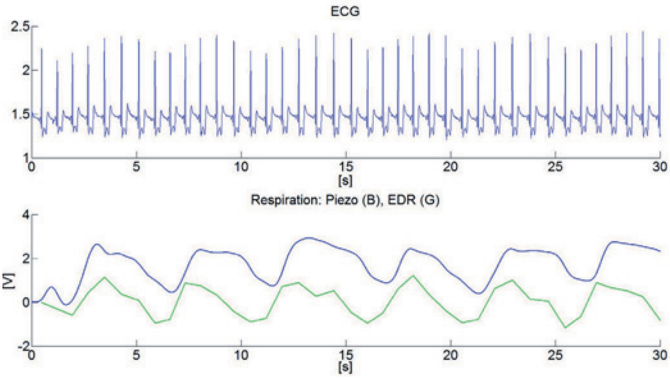

Fig. 3. ECG (a); piezo (blue) vs EDR (green) respiration waveforms comparison.

It is worth emphasizing that our aim is not an accurate estimation of the actual respiration waveform, but just to infer the current breathing rate. With this respect, EDR provide an accurate enough way to inexpensively estimate such rate, as shown in Fig. 3, which compares a piezo-sensor outcome and the EDR signal of the same respiration activity. From the EDR-inferred waveform, a simple peak count provides the breathing rate estimate.

Body Temperature -Another relevant health indicator is the body temperature. Changes during the day are to be correlated to the actual activity as well: hence continuous, combined monitoring of the parameters introduced above and of the body temperature can be significant. A temperature probe has hence been incorporated into MuSA, availing of the same hardware platform. A temperature range between 35-42 °C, with a 0.1 °C accuracy has been attained. The sensing element is a relatively inexpensive NTC thermistor. A multi-stage acquisition circuitry has been designed and implemented, accounting for linear characterization of the voltage-temperature relationship in the given range and accurately tailoring power consumption, also to prevent thermistor self-heating. In this case too, successful validation of the sensor has been carried out by comparison with a reference instrument (a mercury thermometer).

MuSA firmware has been designed to accomplish, at the same time, all the task illustrated above. It is based on a finite-state machine description: first, MuSA joins the CARDEA network, then it initializes peripherals and services needed for internal operation (Serial Peripheral Interface, SPI, Analog to Digital Converter, ADC). Then, MuSA loops reading analog values coming from the various sensors. Subsequently, each value is processed in order to detect meaningful conditions (fall, user call, out-of-range heart- or respiration-rate, abnormal body temperature). Related messages are eventually sent to CARDEA through the ZigBee radio link and MuSA goes back to the sensing state.

2 Results and Conclusions

Heartbeat and respiration rate have been tested on a set of ten healthy volunteers, between twenty and thirty years old. First results stated an accuracy of 99.4% for the heart-rate algorithm and about 87.5% for the respiratory rate. Such relative difference can be explained by considering that ECG analysis is based on a well-established set of references and ECG signal features are relatively independent of the specific individual characteristics. EDR signal, instead, is inherently more subject to person-to-person variability, so that tuning of the algorithm parameters is somehow more difficult. Nevertheless, the attained accuracy is adequate to the application at hand.

Although these tests are not meaningful in a statistical manner, they point out the effectiveness of the implemented approach. In the near future, it is necessary to conduct intensive series of field tests on elderly users in order to evaluate the algorithms performance.

MuSA, as described above, is already a complete device able to provide a significant amount of information about the user's health. Anyway, it is possible to exploit the technological resources already implemented on the device in order to expand its functionalities. The first feature is the activity recognition: relevant information can be derived from the MEMS accelerometer and from them distinguish a static from a dynamic activity or, furthermore, recognize a particular action [13-15]. The second feature is the indoor localization. Many suitable technologies are available [16] but here, the IEEE.802.15.4/ZigBee protocol will be used. The indoor localization is based on the evaluation of two parameters. The Received Signal Strength Indication (RSSI) parameter estimates the distance from the relationship between transmitted and received signal strength; the Time of Flight (ToF) indicates the time that a signal takes place to propagate from the transmitter to the receiver [17]. Thus, any message sent from MuSA, worn by the user, to the CARDEA routers, scattered in the house, can be processed to identify its location. The router that measures the highest RSSI and ToF parameters, confirms the presence of the senior in that room or in a specific area of the room.

In this work, the evolution of MuSA, multi-sensor wearable device toward low-cost healthcare features has been described. The medium-term target is to devise and implement data-fusion strategies (encompassing both kinetic, physiological and environmental data), suitable for accurate profiling of user's habits, to detect variations ascribable to impairment or mental conditions, and health-status. Integration into the AAL system CARDEA provides the ground for such an evolution.

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Assistive Robotics

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-109

COCHISE Project: An Augmented Service Dog for Disabled People

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Abstract. Aside from the recent progresses in robotics, autonomous robots are still limited in assisting disabled people. On the contrary, the animal, especially dogs, have demonstrated real skills to support the human being in many everyday life situations, such as rescue (avalanches, earthquakes...), smell detection (drugs, explosives or even cancers), handicap assistance (blind, deaf, motor or cognitive disabled people)... However, each system, the robot or the dog, has its own limitations: a step or a hole can fatally immobilize the machine and a cat may easily distract the animal. Due to the limitations and complementarities between a service dog and an assistive robot, the idea of the Cochise project is to develop a hybrid system animal/robot that will take advantage of both to be more efficient. In the present study, this approach is applied to assist people with motor disabilities. The robot is used to "augment" the service dog by increasing its control from the human being. This machine is a mediator that translates and transmits the dog state to the human user, on one hand, and enables the person to trigger predetermined behaviors of the animal, on the other hand.

Keywords. Service dog, assistive robotics, motor disabilities, human-robot interaction, dog-robot interaction.

Introduction

Many studies have shown that a robotic device may influence the behavior of different animal species. For instance, a "cockroach-robot" can trigger the movement of a flock of cockroaches or other bugs [1, 2, 3, 4]. In addition, robots can be accepted as biological parents in order to take the role of a "mother-robot" that protects her young [5]. It is also possible to control the movements of a rat by directly stimulating of its brain [6].

Another field in robotics tends to replicate animal life for therapeutic purposes. One of the most famous implementations is the PARO robot [7]. This is an interactive fluffy seal that has been successfully used with elderly people in retirement homes and children in hospitals. Attempts have been made to replicate dogs with the objective of substituting assistance dogs with assistive robots, in order to facilitate human-robot

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interaction [8, 9, 10, 11], in particular with the AIBO robot from Sony [12, 13, 14]. Even though more children consider a live dog, as compared to a robot-dog (AIBO), as having physical essences and emotions, many of them interact and conceptualize AIBO like a real dog [15]. The learning motivation is also higher if preschool children are interacting with AIBO than a stuffed dog [16]. Children with autism are more engaged verbally and physically when they interact with a robotic dog (AIBO) than a toy dog (KASHA) [17].

Despite being inspired by animals, the behavior of the dog-like robots is still very limited and therefore difficultly accepted as companions. At present, the best approach to implement this concept is to design robots which are more task specific [18]. This reality suggests that it is premature to use an entire autonomous device to substitute a pet. On the contrary, a hybrid system that takes advantage of the dog's flexibility/adaptability and the robot's reliability/consistency could be the perfect way to assist people in a determined task.

At the 12th International Association of Human - Animal Interaction Organizations (IAHAIO 2010), a Japanese team presented a robot that played with an assistance dog, by throwing a ball to the animal and having it bring it back. However, in spite of the numerous studies on the human-dog relationships, none of them applies on the "augmented assistance dogs" through a robotic device.

1. Methodology Used

Cochise is a multidisciplinary project merging competencies from assistance dog handlers, roboticists and experts in human-machine interfaces and computational architectures. The methodological approach consists in taking advantage of the multitalented skills of the dog (affective relationship, sensorial capabilities, motor skills...) and using the robot to correct the intrinsic unpredictability of the animal's behavior. In practice, the robot has two specific roles, which are:

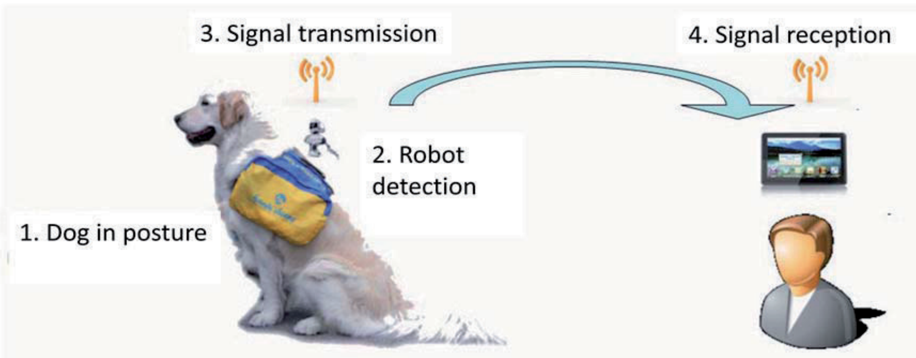
- To provide an alarm signal to the human being (the master and/or a third party) if the dog faces a determined problem.
- To preserve dog obedience in an autonomous way or by a remote control from the human user.

In order to find a solution for the alarm and obedience problems, it is necessary to list the specific behaviors of the dog. This list, called an ethogram, enables us to identify some identifiable states of the animal's behavior, such as barking, lying down on its back or on its side, sitting down, running around, dropping its head... Each specific behavior is an alarm signal that must be correctly interpreted in order to ensure a proper response. A nomenclature of the technical solutions related to each dog signal is laid down in such a way that a sensorial device matches a characteristic behavioral parameter and an appropriate alarm signal. Other signals can come from physiological monitoring of the animal or an analysis of the environment by a camera or a GPS position, for instance, and must be transformed into discriminable information that is broadcasted to the human user.

2. *Ongoing Work and Results*

2.1. The Alarm Signal

Triggering an alarm from the robot (carried by the dog) consists in sending a signal to the master or a third party. A signal may be sent to the dog's owner when the dog violates an instruction or does not follow the correct behavior. A signal will be transmitted to a third party, for example, if the animal fails its mission to watch its master and keep him/her inside a limited area. The alarm is broadcasted through the robot by "yapping" or other such specific behavior. The robot ensures the dog monitoring by measuring and analyzing different parameters with diverse sensors (Fig. 1).

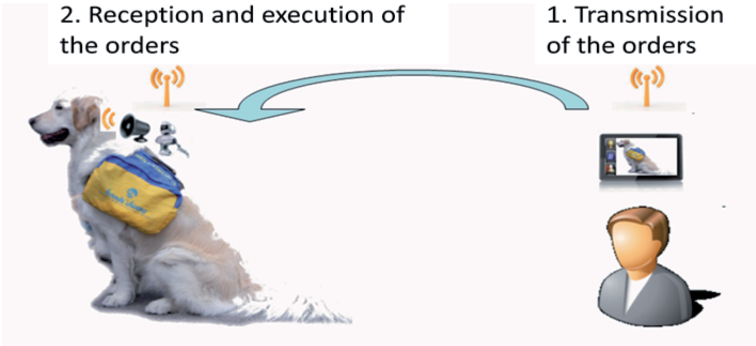


Alarm implementation		
Types of signal	**Types of technology**	**Data processing & interpretation**
Dog barking Posture : sit, lie …	Microphone, Accelerometer, Gyroscope, Contacts, Pressure sensors	Form recognition, Signal processing, Multi-sensor fusion
Environment	GPS, Camera, IR barrier	Cartography
Interface	Computer, Cell phone, Tablet, Specialized peripherals…	Customized multimodal restitution

Figure 1. The alarm implementation.

2.2. The Obedience Control

Once the alarm is received, the human being (master or third party) must be able to remote control the dog through the robot, or to request the robot to execute a specific task. In this latest case, the robot has to work autonomously. The machine becomes a substitute of the master, by giving a direct order to the dog and rewarding or punishing it whether or not the animal behaves in the desired manner. The obedience control requires the implementation of an electromechanical device that stimulates one or another dog sense (Fig. 2).



Obedience implementation		
Types of signal for the dog	**Types of technology**	**Functionalities**
Hearing	Loudspeakers	Display of remote or prerecorded voices, ultra-sounds
Smell	Servovalves	Control of duration and/or intensity
Touch	Vibrators, Actuators (compression, light nociceptive stimulation, caress), Resistance (heat)	Control of force, velocity and intensity
Taste	Relays, Motors	Kibbles delivering
Sight	Laser pointer, Pico projectors	Visual steering control

Figure 2. The Obedience Implementation.

2.3. Technical Implementation

The activities detection is the first tool of a set that will be experimented. It will allow the discrimination and classification of four types of dog behaviors (walk, run, lay and sit down) to trigger the appropriate answer through the robot. Other tools that will be implemented are GPS tracking, video streaming, and giving orders by remote control. Due to its numerous advantages, a smartphone is used for the communication between the animal and the owner. It is a small and powerful embedded processor that has many built-in devices such as GPS, camera, speaker, sensors, and communication capacities GSM, Bluetooth, Wi-Fi… For instance, in order to detect the dog activity, the following three phone sensors are used: 3-axis accelerometer, 3-axis gyroscope, and 3-axis magnetometer.

Figure 3. The dog with a smartphone on its back.

The smartphone is placed on the dog's back. The orientation of the sensors is shown in Figure 3: Y-axis to the dog's head, X-axis to its right side and Z-axis in the upright position.

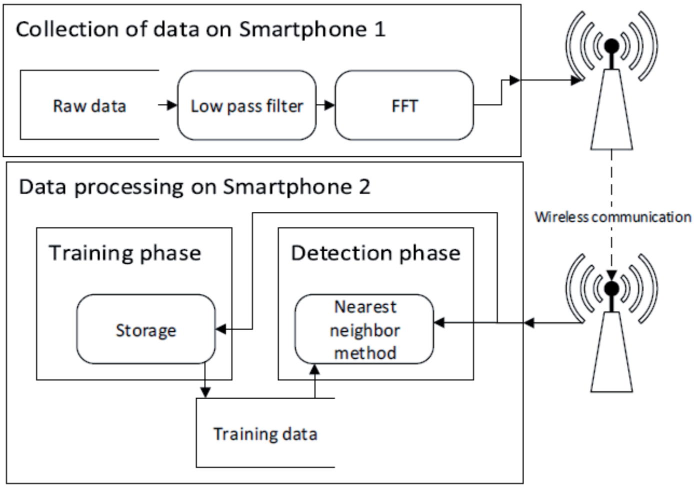


Figure 4. Data flowchart.

Figure 4 describes the data flowchart of the activity detection. In order to extract the periodicity of the movement, data are filtered with a low pass filter and a Fast Fourier Transform (FFT) is achieved. Then, the signal amplitude and frequency are extracted. This processing is done locally in real time by the smartphone 1, on the dog's back. Every 2 seconds the data are wirelessly sent to the smartphone 2, in the dog's owner hand, which executes the detection. The same technology will be used to transmit an order from the disabled person to the animal.

3. Economical and Societal Impact

The animal is a great companion for the human being. When the human-animal relationship is really strong, the animal becomes a partner that completes services for its master. In particular, the human being takes advantage of the dog's skills in the domestication context. The service dogs for the assistance of disabled people represents a high demand, which increases constantly in developed countries (more than 1200 assistance dogs are already operational in the French territory only).

Optimizing the dog working performance and improving the communication of the master-dog couple, thanks to an assistive robotic device, is an important societal issue that involves a potential of thousands of dogs. Extending the scope of working dog actions is a second relevant issue regarding the human, social, economical and technical consequences.

Among working dogs, assistance dogs, who are in charge of helping handicapped people in their everyday life activities and facilitating their social integration, are the perfect candidate for pilot studies involving a "mediator robot" and to open up other potential applications.

4. Conclusions

The Cochise project has two main objectives: improving the knowledge of the animal-machine interactions, on one hand, and developing a prototype that can soon be available on the market, on the other hand. In practice, this study aims to improve the collaboration between the human being and the dog, in an assistive framework. The technological exploitation of assistance dogs represents a societal issue due to the fact that a robot, which is capable of working in synergy with an educated dog, may simplify many issues related to rescue, working dog situations or, just, companion dogs. The overall benefit of this project is to allow the increase of the human presence alongside the animal, despite a possible remote position of the handicapped person.

Acknowledgements

This project is funded by the French National Research Agency (ANR-012-BLAN).

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-115

Health Professionals' Perceptions of the Robot "Giraff" in Brain Injury Rehabilitation

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Abstract. This exploratory study examined nurses' perceptions of using the robot "Giraff" in their work in brain injury rehabilitation. The robot is a mobile robotic that is driven remotely via a computer and pc-mouse. All nurses at a rehabilitation clinic in Stockholm, Sweden received training in how to handle the "Giraff". After the training session they were asked to answer a questionnaire regarding their perceptions of using the robot in their work. The results indicated that the robot "Giraff" could be useful to check on the patient, handle alarms and unforeseen situations and be funny to use. The potentials of the robot reported prompt for further research into the use of mobile telepresence robotics in brain injury rehabilitation. In a forthcoming study we are going to interview patients, occupational therapists and nurses` to assess their experiences in using the "Giraff".

Keywords. Assistive technology, elderly people, mobile robotics, video communication.

Introduction

Mobile robotics provides virtual face-to-face communications for people in different locations and allow a remote caller to "walk around" in the user's environment. Mobile robotics are not novel, but their use has been limited to research projects and they are generally not practical or reliable enough to be used in real life [1]. Very little real user experience has been studied and most evaluations have been done in laboratory settings [2]. Only a few studies have investigated acceptance from potential users which is important factor in assessing the practicality of using robotics in real-life settings. For example, Beer and Takayama [3] found that elderly people acknowledge benefits such as being able to physically see who they were talking and that this benefit could reduce social isolation and travel costs.
The ongoing developments of mobile robotics raise the question of how robotics can be used and improve the quality of brain injury rehabilitation. Although, robotics such

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As the newly developed mobile robotic the ”Giraff” (www.giraff.org) can offer assistance in brain injury rehabilitation, the patient´s acceptance and the professional´s willingness to make use of new technology in their work are important considerations. Kristoffersson et al. [1] examined health professionals´ attitudes about the ”Giraf” using a video. They found that previous experience with technology impacts how well a robot is accepted. Coradeschi et al. [2] found that willingness to use new technology could also depend on motivation to use technology and whether the device is fitting into existing working habits. Thus, the first step in this project was to examine the nurses' and the assistant nurses' attitudes to use the robot ”Giraff” in their work in a hospital training apartment (TA) in a Swedish rehabilitation clinic.

1. Method

This exploratory study was approved by one of the Regional Ethical Review Boards in Stockholm, with journal number 2012/855:32. Our hypothesis was that the ”Giraff” could be a useful tool for health professionals in their work.

The Training Apartment within the Rehabilitation Clinic

The patients stayed in TA for a four days' period for evaluation for independent living and to receive training in daily activities before returning home [4]. The TA was equipped with alarms for the stove, the refrigerator, the freezer, the washing machine, the coffee machine and the water as well as reminders for medication, doors, windows, and Television. The patient wears an alarm watch that is connected to the inpatient ward with medical staff available 24 hours a day. There was a clinical need for improving technology for communication and safety monitoring between the inpatient ward and the TA particularly in the late evenings and at night since the TA was located far off from the inpatient ward. The robot ”Giraff” was installed in the TA and connected with the inpatient ward 24 hours a day for safety monitoring, guidance in daily activities and communication.

Training methods associated with the robot ”Giraff”

The robot is 163 cm tall, with a one-way videoconferencing system including a wide-angle lens web-camera, screen, speakers and a microphone. The ”Giraff” is powered by motors which can propel and turn the device in any directions. A standard computer (Windows Compatible), a mouse, a headset and a web-camera are needed to operate the robot. The ”Giraff” is steered by pointing with the mouse cursor on the real-time video feed received from the robot and pushing the left mouse button. When the robot is not in use it should always be charged in the docking station facing the wall.

In total 38 nurses and 10 night assistant nurses at the in-patient ward received education and training in how to use the ”Giraff” by the author and a trained occupational therapist. The nurses came to the TA in groups of three or four persons. The session began with information about the TA and the ”Giraff”. After the presentation the groups received training how to interact with the ”Giraff”. 1) To start the ”Giraff” application, 2) to log on to the ”Giraff” server, 3) to call the patient, 4) to undock the ”Giraff” from the docking station and drive. After the introductory lesson the groups undertook a role-play consisting of various practice tasks. For example, the nurse who drove the "Giraff" might check the pill box or find a lost television remote control, and direct the "Giraff" back to the docking station.

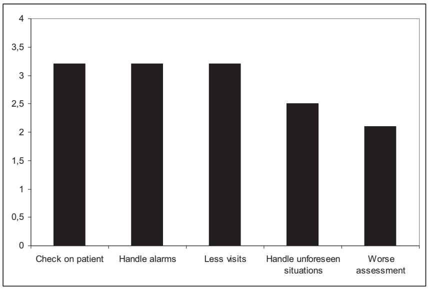
Data collection and data analysis

After completing the training session the nurses were asked to fill in the "Giraff questionnaire" which focused on the nurses' expectations of the usefulness of the "Giraff" in their work (5 questions) and their thoughts of using the robot to communicate and interact with the patient and issues regarding integrity and monitoring (6 questions). For these questions, a 5-number scale was used where "1 = Not at all" and "5 = to a very high degree". There were also questions on how frequently they use a computer, Skype and computer games. For these questions a 3-number scale was used where 3= frequently, 2= a little, 1= never. The nurses also rated how skilled they were in using computers since studies have found that previous technology experience has an impact of how well a robot is accepted. Data from the questionnaires was analysed using descriptive statistics [5].

2. Results

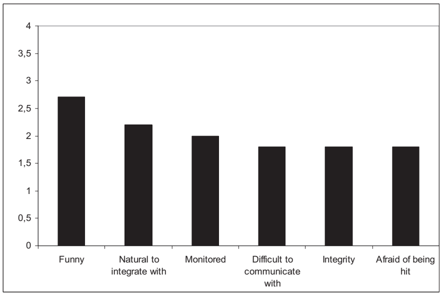
There were 22 nurses and 5 assistant nurses that filled in the questionnaire. The majority of them were female (25 female and 2 male). The mean age was 40.8 years (27-66 year). Answering frequency was 56% (58% for nurses, 50% for assistant nurses).

The nurses rated that the "Giraff" could be useful in their work with tasks like handling an alarm from the patient or checking on the patient´s wellbeing. They stated that it could also decrease the number of real visits in TA (figure 1). However, the nurses' opinions of the robot were negative. They noted that he patient could perceive the daily visits via the robot negatively. They also thought that the "Giraff" could be a threat to the patient's integrity and that the patient could feel that he/she was being monitored (figure 2).



0=Not at all; 4=To a very high degree

Figure 1. The nurses' expectations of using the "Giraff" in their work.



0=Not at all; 4=To a very high degree

Figure 2. The nurses' opinions of the "Giraff".

Moreover, 15 nurses rated that they had they had good computer skills, 9 nurses had sufficient skills and 3 nurses had low skills. Most of the nurses used a computer frequently. However, 11 of them had never used Skype and 14 had never used computer games (Table 1).

Table 1. The nurses' use of computer, computer games, Skype (n=27)

	Computer	Computer games	Skype
Frequently	23	5	6
Little	3	8	10
Never	1	14	11

3. Discussion

The nurses rated that it could be relatively difficult to communicate and to interact with the patient in TA via the robot. One explanation could be when the nurses would like to move the "Giraff" or adjust its speed they had to look away from the patient to find controls and click buttons. Other studies have also found that it may be difficult to focus on the conversation as attention needs to be directed between steering the robot and carrying on a conversation [6-7]. Furthermore, the nurses noted that the patient's integrity could be affected and therefore it is important to decide who should be allowed to enter, when and why? Previous research has pointed out that it is important to not misuse technology and ethical aspects of monitoring people should always been acknowledged [8-10]. In order to assure the patients that they were not monitored when the robot was not in use, it should always be recharged in the docking station facing the wall.

Communication via the robot can also result in an unequal communication where the nurses have control over the robot and the patient is put into a more or less defensive role. The nurses can move around freely and get view of the immediate surroundings and conditions out of control of the patient.

The nurses rated that the patients could be afraid of being hit by the robot. One explanation could be that the nurses experienced that it was difficulties to maneuverer the robot. When designing telepresence mobile robotics it is important that the device is easy and uncomplicated to use for all users.

A limitation of the present study was that the response rate for the "Giraff Questionnaire" was low. Nurses were asked to complete the questionnaire and send it back after the training sessions. However, due to heave workload on the ward compliance rate decreased. In future studies it is recommended to schedule the evaluation within the training schedule.

4. Conclusions and Planned Activities

There seems to be a potential for the use of the robot "Giraff" in brain injury rehabilitation. However, if the robot should be used in rehabilitation, there are additional requirements of reliability and safety other than the professionals' perception of using a robot in their work. Additional research is needed to investigate the usability of the robot involving multiple users and several categories of the users. A forthcoming study will investigate the nurses' perceptions of the "Giraff" on a long-term basis in order to explore if their perceptions of the robot have changed when the novelty effect wears off. Moreover, interviewing patients, occupational therapists and nurses` and others likely to benefit from using the "Giraff" will be important in planning the future of this device.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-120

Episodic Memory Visualization in Robot Companions Providing a Memory Prosthesis for Elderly Users

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Abstract. The goal of home care robots is to help elderly people to age in their own homes. Ageing people who are otherwise quite healthy may suffer from memory loss and consequently decrease their independence because the memory loss might endanger their health and safety. For example they may not remember if they have taken their medicine or what task they were currently engaged in. Equipping a robotic companion with a visualization tool for episodic memory is an excellent opportunity to have a robot provide memory prosthesis. In the EU project ACCOMPANY we study how memory visualization can support the user in remembering past events from the human-robot interaction history. Potentially, this ability to explore interaction histories could enable elderly persons as well as third parties (e.g. technicians, carers, family and friends) to monitor, maintain and improve the robot's abilities, services and ultimately its usefulness as a care robot.

Keywords. Cognitive psychology, human-robot interaction, database management, information retrieval.

Introduction

The EU population is projected to undergo a significant change in its age structure, from four people of working-age to each person aged over 65 to about two people by 2060. As a consequence, strictly-age-related long-term public expenditure in the EU is projected to increase on average by 4.1 percentage points of GDP [1]. Policy makers are adopting various strategies such as to allow older people to live at home for as long as possible and receive care from relatives [2] although the relative proportion of younger people available to provide such support is decreasing. Moreover, fragile elder people showed health deterioration and mortality rates of 50% in their first year of admission to care facilities [3]. Home care robots aim to help and assist the elderly to age at their own homes, improving their quality of life and supporting their daily activities.

Dementia is defined as memory impairment and Alzheimer's disease is the most common cause of dementia. The increase of prevalence of dementia with age is confirmed to people suffering from Alzheimer. It has been predicted that world-wide the

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number of people with dementia will increase from 66 million in 2030 to 115 million in 2050 [4]. Dementia is progressive and evolves through different stages [2]. Early stage of dementia (2-4 years) is characterised by memory loss causing behavioural change, i.e. problems is short-term memory or episodic memory causing struggle to recall recent events occurring a few hours or days ago, which is sufficient to disturb people's everyday life. A home care robot's memory visualization built up from the human-robot interaction history can serve as cognitive prosthetics assisting users who are likely to be forgetful.

The purpose of this article is to explain the concept of memory visualization and its challenges. We introduce the initial implementation framework with the use of the Care-O-bot 3 (COB3) robot in a smart environment (UH robot house). Then, we provide a discussion of the possible advantages provided by memory visualization and benefits of, and challenges faced, in the current implementation. We conclude with some future work and provide possible directions that this can lead to.

1. Related Work

In HRI a lot of research on the ability to remind users of activities to be performed (prospective) or prior events (retrospective) has been done. Autominder was an initial attempt to make reminders more intelligent and dynamic, and was implemented on the Nursebot embodiment [5]. Intelligence and dynamics was also one of the aspects of the system proposed by the Robocare project [6].

More recently, work has been carried out focusing on persuasive technology. For example, KSERA [7] focuses on both the ability of the robot to draw on information not readily available to the user and its ability to persuade, in order to safeguard the health of the user. The robot Hector developed in the project CompanionAble [8] aims to assist and remind elderly people with dementia through multimodal interactions and smarthouse integration. The project Florence [9] introduces a robot as an autonomous lifestyle device for ambient assisted living, including a reminder service application that allows the elderly to share information with carers. It is relevant to mention some related projects which do not use robots but focus on providing cognitive prosthesis, such as the COGKNOW [10] and HERMES [11] projects.

The LIREC project investigated the visualization of a robotic companion's long-term Episodic Memory (EM). The robot‘s interaction history was stored in, and retrieved from, the robot's EM, and visualization of user past experiences could be achieved through an embedded touch interface. Pictures of the environment were captured in a particular moment during the robot's goal execution and linked to its EM, which was used to create interaction histories for the purposes of event visualization [12]. Based on the positive feedback of users towards memory visualization in the LIREC project, we revisited, reimplemented and significantly improved the design for the ACCOMPANY project.

2. System Design and Implementation

The COB3 robot system provides a number of modules that can be accessed in order to provide detailed information regarding the state of the robot, as well as providing the ability to issue mid level commands for the robot to execute. Examples of these commands are move to the kitchen or raise the tray. The COB3 raw data is collected and processed, with the resulting values stored in a relational database for access by the remainder of the system. The scheduler uses this data as well as the UH robot house sensor data in order to execute sets of stored robot competencies, called here either sequences (where sets of robots actions are carried out) or behaviours (where rules are associated with these action sequences).

As the robot house environment changes, the values recorded by the sensors are stored within a relational database. These values are read by the scheduler to determine which sequence (or robot behaviour) needs to be started. These sequences can be simple timed events, or far more complex scenarios involving the use of multiple sensors as well as the users location or robots location.

At this stage, the structure of the action history data is relatively simple. The environmental sensory state becomes part of the visualization history. Memory visualization is fully integrated into the complete sensory and action architecture (see Figure 1) and can be generated both on behavioural execution or on a timed basis. Users can tag/label memorable events, i.e. important as well as unclear/problematic events which can then later be shown selectively.

When an action sequence (that part of the behaviour which runs on the robot) is executed, a record is added to the history log table with the behaviour name, the location

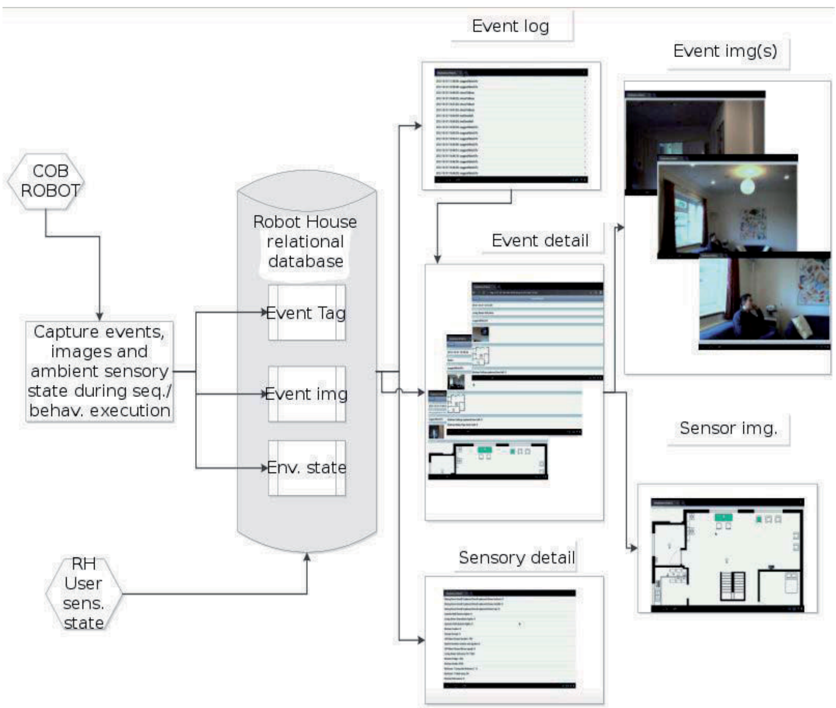

Figure 1. Captured Memory Visualization Data. The COB3 robot when executing behaviours has the facility to record images, sensory values and events. These events are triggered either singly by main behaviours, or by each sub-behaviour of a larger behaviour, or on a timed basis (e.g. every 5 seconds). Each event is stored in the robot house database together with its associated image and sensory history. These items can then be reviewed using the memory visualization interface (shown here running on an Android tablet).

of the robot, and the current time stamp. This initial data is recorded separately to ensure that a record of the event is entered in a timely fashion. Collecting of other relevant data is then started, which can take several seconds to complete. Currently, this additional data always consists of an image from the onboard camera, and a snapshot of the state of the robot houses sensor network.

When the user opens the visualization interface for this data (see Figure 2) the system retrieves a list of all actions that have been recorded. This list is ordered chronologically, with the oldest actions appearing first. When a user selects an action, they are presented with the recorded information. Currently, for all actions this consists of the image from the COB3 camera, and the sensor data. The data for the sensor network is presented twice, first as an image with icons to represent the on/off state of each sensor, followed by the raw sensor data that was stored.

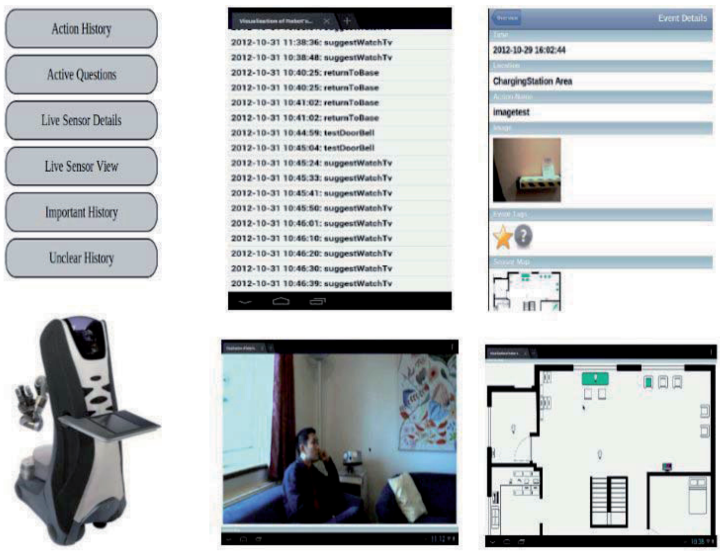

Figure 2. Top: Visualization interface, actions list and action information. Bottom: COB robot, onboard camera image and sensor house snapshot.

3. Contributions and Challenges

The users obvious benefit from the visualization of a robot's memory is that a user can look into past events from their daily normal activities. A robot's memory can serve as a cognitive prosthetic assisting users who are forgetful and need frequent reminders in everyday activities. Even a user without memory problems may benefit from reviewing past events that were notewhorty, e.g. in order to reflect on the functionality of assistance provided by the robot.

Morevoer, HRI researchers working with elderly users have been adopting methods of co-imagination to allow users to share their personal images in order to generate social conversations [13] to improve their cognitive health.Along that direction the role of a human moderator was later replaced by a remotely controlled humanoid robot. Researchers claimed that generating social conversation among these users can improve their cognitive health and elderly users participating in such social events can prevent or delay their dementia. Such research reveals that sharing personal stories and images can stimulate more social conversation in elderly users and thus improve their memory. Our system shows a first step towards enabling users to tag events that are meaningful and/or personal to them.

Nowadays, technology allows easily to create, record and store digital material. However, the management of such information is still extremely difficult and, as previously reviewed [14], there are issues regarding the structuring of the captured data, i.e. recording everything that happens in a persons life can raise concerns that clutter may obscure valuable content and that information overload may occur. Thus, better interpretation and visualization is required.

Although advantageous in searching and browsing information, event structure in our computational memory is based on actions that the robot carries out, and such a definition of an event in long term HRI can be over-simplified as they are bound to the direct reaction of the robot based on the given sensory input (although these reactions can also be based on user preferences and requirements). To improve such situations, richer scenarios and more contextual information will be needed, allowing it to use such information to plan and act in real-life HRI situations. A key problem of this approach is that during long-term interaction a large amount of data will be produced, and it will most likely become impractical for the users to search through. Thus, the challenge remains on how to filter and organise the memories efficiently and according to the personal relevance and meaning they provide to the user. The current solution, based on manual tagging simply presents an initial feasible approach. Future work could investigate how information on the state of the user (e.g. physiological states, user behaviour and activities), the robot (e.g. states and goals of the robot), and information of the environment could be used to classify and store only memorable events.

4. Conclusions and Future Activities

We have illustrated the initial implementation of a robotic companion's memory visualization feature and pointed out potentially useful aspects. In future work we will seek feedback from our user groups on the proposed memory visualization feature being particularly interested to find out if it could help the user's recollection of past events and how useful users may find this feature in their daily life. Future research on storing, organising, retrieving and visualizing personal and meaningful information via a robotic companion could stimulate social conversation in elderly users. Moreover, memory visualization could be extended in future towards systems with an explicit narrative representation of events.

Acknowledgements

This research is funded by the EU FP7 Acceptable robotiCs COMPanions for AgeiNg Years (ACCOMPANY) under contract number 287624.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-126

Proposal for Robot Assisted Rehabilitation: A New Approach to Patient Exercise

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Abstract. Walking rehabilitation exercise using a robotic dog is proposed. Using a robot instead of an animal in animal assisted therapy overcomes the problems of infection, feeding and excretion, animal abuse, and the like. Patients operate the robotic dog AIBO using an acceleration force sensor, a touch panel, or a center of gravity sensor. Use of these human interface devices allows new functions such as sensing, recording, and processing of human conditions to be easily achieved using information communications technology. One of the key aspects of this proposal is the reversal of the roles of actor and object in assistive technology such as rehabilitation exercises. Patients operate the robot by themselves and the consequent feeling of self-efficacy should help to prolong the rehabilitation exercise. Preliminary experiments conducted at a nursing home and hospital supported this prediction and show the effectiveness of the proposal.

Keywords. Robot, Animal, Rehabilitation, Walking, Elderly Person, Nursing Home.

1 Background to This Study

Rehabilitation of a body paralyzed by a brain hemorrhage or other causes ordinarily consists of repeating exercises. These exercises can be painful for the patients and may cause them to react negatively to the rehabilitation program. Physical or occupational therapists can encourage them during the exercise, but in a rapidly aging society like Japan, such dedicated person-to-person care will become increasingly difficult to provide. Machine assisted rehabilitation is one approach to reducing the amount of labor involved in care; however, it is not always enjoyable for the patients. We propose the concept of robot assisted rehabilitation (RAR), in which a robot is used instead of a simple machine, with the aim of increasing the willingness of patients to engage in machine-mediated exercise.

The medical effects of human-animal interactions have been studied for a long time and have led to animal assisted activity (AAA) and animal assisted therapy (AAT). However, there are limitations to the practice of AAT in hospitals or nursing homes. These limitations arise from the fact that an animal is a living creature and, therefore, presents the problems of infection, feeding, excretion, and the requirement for a handler. In addition, we must be careful to avoid animal abuse.

The first aspect of this study is the replacement of the animal with a robot[1-4]. This resolves the abovementioned problems. We call this practice “robot assisted activity/therapy” (RAA/RAT), and “robot assisted rehabilitation” (RAR) when its purpose is specifically rehabilitation. Recent advanced mechatronics technology makes it possible to endow the mechanical robot with lifelike behavior. There have been several reports on the interactions of robots and humans[3–6]; however, none has specialized in rehabilitation. The introduction of a robot not only overcomes the limitations of AAA/AAT but also brings in new applications based on information communications technology. For example, we can control a robot like a living creature as mentioned, sense a human health condition through the robot, and record and transfer the data taken at every instant.

As with AAT, the positive effects of RAT on humans are categorized as physical, mental, and social. In the early stage of our RAR study, the robot moved autonomously based on previously programmed instructions or was otherwise controlled by a human on site. Even in this case, in which the patients are passive in terms of the robot-human system, the extraordinary stimulus properties of robots were seen to maintain the patient's positive attitude toward the rehabilitation exercise for longer than normal.

The second aspect of this study is the reversal of the actor and object in the assistive technology[7]. More specifically, it is not that the machine carries out action for or on the patient; instead the patient controls the machine and thereby unconsciously engages with the rehabilitation program. In this case, the motivational force for continuing the rehabilitation exercise comes from the patient's feeling of self-efficacy as well as from the robotic stimulus.

In this paper, we discuss an approach to rehabilitation exercises for walking, using the arms, and manipulation with fingers, using a setting in which the patient either walks with a robotic dog or makes it walk.

2 Experimental Setup

The experimental trial system in which an elderly patient with dementia operates the robotic dog consists of three elements: the human interface device (HID), the control server, and the robot. The robots used are SONY AIBO dog-like entertainment robots with on-board wireless LAN equipment. All the components were available from the market. In order to ensure the patient's mobility and safety, data transfer between the elements is made mainly using conventional wireless systems like Bluetooth and wireless LAN.

Since the robotic dog is not merely a walking machine but behaves like a living dog and speaks simple sentences, it should be noted that the patients already feel some kind of empathy with it after petting it before rehabilitation. The control method needs to be very simple because the patients operating it were elderly and had mild dementia.

Three kinds of HID were employed: a swing around an acceleration sensor, a touch panel sensor, and a center of gravity sensor. The first and the last of these were NINTENDO HIDs which are sold as accessories for a TV games console and are safe, robust, and cheap. The signal sensed by each HID is sent to the server and converted to a gait signal which is sent to the robot. When the acceleration sensor is held by hand or attached to body trunk, motion of the patient triggers the robot's gait. The touch panel HID was driven in two modes. In one mode the patient's finger stroke on the panel is sensed as a back/forward straight line motion or as a clock/counterclockwise arc and the robot moves in the corresponding direction. In the other mode the patient points to the written characters "back", "forward", "right", and "left". A balance board with weight sensors at 4 corners is used as the center of gravity sensor, and the patient makes steps on the board. Whether the patient makes a step or not is determined from the measured movement of the position of their center of gravity calculated from the weights at the 4 corners. The conversion between the steps of the patient and those of the robot is tunable. In all cases, the numerical data sensed by the HID and the converted gait command is recorded every 100 ms on the server's disk so that it can be analyzed later.

3 Preliminary Results & Discussion

A total 20 patients living in the nursing home cooperated for this study. Their age and HDS-R (revised Hasegawa's dementia scale) were ranged from 70 to 95 and 5 to 25, respectively.

When using the acceleration sensor, the patient's motion causes the robot to move and the patient follows the robot. This feedback cycle could sustain continuous walking with the robotic dog, providing the conversion ratio from the signal intensity sensed by HID to the number of steps of the robot was adjusted appropriately. A substantial number of the residents in the nursing home have had the habit of walking with a living dog before moving in to the home, and the topic of their own dog came up routinely in dialogue during the walking exercise. Thus in-house walking with the robotic dog would appear to be helpful for reminiscence therapy. The gait speed of AIBO is not very high, so this form of rehabilitation therapy is good for patients that have difficulty walking.

Figure 1 shows the locus of a finger stroke on the touch panel. The guide line and circle are drawn on the panel for patient convenience. The extent of the fluctuation from the drawn line and circle depends on the patient's level of physical body function. The fluctuation is about 1–3 cm and is more than 3 times that of elementary school children. A number of the patients could control the robot more easily and made fewer mistakes when they pointed to command characters written on the control panel. This shows that even patients with dementia do not lose knowledge that has been repeatedly learned.

The use of the center of gravity sensor is shown in Fig.2 and Fig.3. Figure 2 shows its use with a patient who could stand (age 78, HDS-R 14), while Fig.3 shows the exercise performed in a sitting position. The patient shown in Fig.3 is 87 years old with HDS-R score of 8. She suffered from the fracture of the femoral neck and could not raise her knee during daily exercise. Using our system, the physical therapist guided the patient's attention to her knee by tapping and simultaneously lifting up her knee (see Fig.3 left) and after several repetitions, the patient recognized that raising and lowering her knees caused the robot to move. She then continued the up and down motion without the therapist's help (see Fig.3 right).

Center of gravity movements from the left to the right-front and from the right to the left-front cause the robot to turn right and left, respectively, so that the robot can walk in any direction. As shown in Fig.2 the patient tried to move the robot toward another resident who was beckoning the robot closer. Since it requires a configurational map to turn the robot at an arbitrary position, this exercise is also applicable to spatial perception rehabilitation training for higher brain dysfunction.

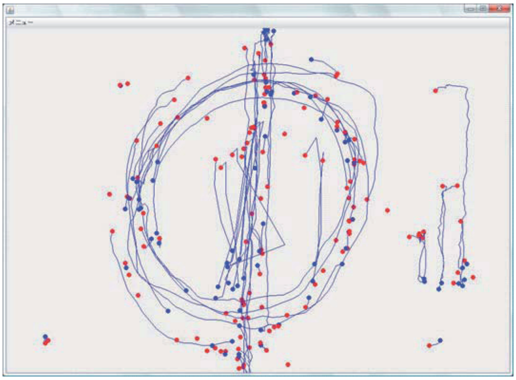

Fig. 1. Locus of finger strokes of 92-aged female. Red and blue dots are touch on and take off points, respectively.

Fig. 2. Patient controlling the robotic dog by stepping.

Fig. 3. Walking exercise with (left) and without (right) help from a physical therapist.

In all cases the important concept is that the patients do not feel forced or obliged to undertake the exercises, and they subconsciously do the exercises while enjoying operating the robot. These results suggest the proposed RAR is effective for bringing out the positive attitude necessary to start and maintain a rehabilitation program, particularly among elderly patients with mild dementia.

Since the proposed RAR includes a component that fundamentally entertains and it is easy to operate multiple robots simultaneously, considerate would be possible to use it in a game in which the residents control a particular robot and make it compete with other robots on a course to imitate dog racing. This would be valuable not only for patients with dementia but also for healthy people wishing to delay the effects of aging.

4 Conclusions & Future Prospects

Although more experiments are needed, the preliminary results show that a situation in which patients operate a robot on their own is an effective method to bring out a positive attitude toward rehabilitation. In addition, since data is recorded every 100 ms it is possible to review the locus of finger strokes or the movement of the center of gravity at a later time. The quantified fluctuation in finger stroke and magnitude of movement of the center of gravity are useful for planning the rehabilitation program for individual patients. Robot assisted rehabilitation has significant potential when carried out in conjunction with conventional rehabilitation.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-131

Robot-Mediated Interviews: Does a Robotic Interviewer Impact Question Difficulty and Information Recovery?

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Abstract. Our previous research has shown that children respond to a robotic interviewer very similar compared to a human interviewer, pointing towards the prospect of using robot-mediated interviews in situations where human interviewers face certain challenges. This follow-up study investigated how 20 children (aged between 7 and 9) respond to questions of varying difficulty from a robotic interviewer compared to a human interviewer. Each child participated in two interviews, one with an adult and one with a humanoid robot called KASPAR, the main questions in these interviews focused on the theme of pets and animals. After each interview the children were asked to rate the difficulty of the questions and particular aspects of the experience. Measures include the behavioural coding of the children's behaviour during the interviews, the transcripts of what the children said and questionnaire data. The results from quantitative data analysis reveal that the children interacted with KASPAR in a very similar manner to how they interacted with the human interviewer, and provided both interviewers with similar information and amounts of information regardless of question difficulty.

Keywords. Humanoid robots, interviews, children, human-robot interaction, disclosure, interaction dynamics, social interaction.

Introduction and Background

In recent years research exploring potential applications for social robots has increased, from entertainment and educational aids [1-4] to therapeutic and assistive tools [5-7]. Recent studies have explored the possibility of using social robots to recover information from young children [8-10]. When police officers are conducting interviews with young children that have been through a stressful or traumatic ordeal it can be difficult for the interviewer to maintain their composure without subtly and unintentionally indicating their thoughts and feelings despite their extensive training. The information that a child reveals in an interview can sometimes be quite shocking or surprising. The document referred to by UK police officers states "the interviewer should not display surprise at information as this could be taken as a sign that the information is incorrect" [11] p196. Maintaining such emotional discipline can be quite difficult for a human interviewer but would be easy for a humanoid robot whose expressions are explicitly controlled. It is also important that an interviewer does not appear to assume that someone is guilty "So far as possible, the interview should be conducted in a 'neutral' atmosphere, with the interviewer taking care not to assume, or appear to assume, the guilt of an individual whose alleged conduct may be the subject of the interview" [11] p66. Using a robot to interview a person could eliminate any of the subtle unintentional signs in body language that a human interviewer may give away, as the body language of the robot can be fully and precisely controlled by the interviewer. In addition a person's perceived authority can sometimes have an effect on a witness, particularly with regards to suggestibility [11] p56. Using a robot could address this problem because the robot is clearly not an adult and may not be viewed in the same way.

In this article we build on and extend our previous research which showed that children interacted with KASPAR very similar to how they interacted with a human interviewer [9]. However, our previous work did not control for the difficulty of the questions being asked, which may or may not influence how children respond to human or robotic interviewers. The article reports on results from a follow-up study investigating how the difficulty of the questions affects the interaction and the information that the child reveal to a robot compared to a human. When children are being interviewed it is often for a very good reason and some of the questions that they may be asked could be quite difficult for them to answer. Therefore, ascertaining how children respond to different types of question, and more difficult questions, is an important step in establishing if robots could be a useful tool for mediating interviews with young children. Exploring the possibility of robot-mediated interviews may reveal whether robotic interviewers could be a valid addition to existing methods of interviewing children by professional staff such as police or social services. The overall goal of our research is to provide professionals with a robotic tool that can be precisely controlled and used as an interface to interview children in an enjoyable and comfortable manner, rather than replacing human interviewers.

1 Method

This study was conducted in a primary school in Hertfordshire (UK) with 23 children, 20 (8 male, 12 female) of which produced useable data[1]. The children were aged between 7 and 9 with an average age of 8 years 10 months and had not interacted with KASPAR before. The robot used was a small child-sized humanoid robot called KASPAR (Figure 1). KASPAR has a proven track record working alongside typically developing children [12, 13], and children with special needs [5, 7].

The interviews took place in an unused classroom that contained a small lockable cupboard that the children could not see into, which was used as a control room for KASPAR. A monitor with a wireless connection to camera #1 was used to observe the situation and make KASPAR respond appropriately (see Figure 2). The interviews were always led by the lead investigator either in person or remotely via KASPAR to maintain consistency between the interviews. The children were unaware that KASPAR was being controlled by a human triggering the correct questions and responses from a pre-recorded list. A second research assistant unknown to the children took the children to and from the interviews and remained in the room during the interviews, but was as non-reactive as possible. Immediately after each interview the children were asked by the research assistant to rate the difficulty of the questions they had just been asked along with other details about the interview.

[1] Due to technical difficulties and attendance three of the sessions were not included.

Figure 1. KASPAR Robot.

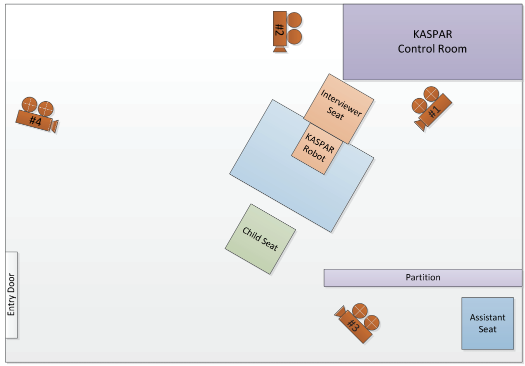

Figure 2. Room layout.

2 Procedure, Interview questions and Questionnaires

The interviews were conducted on three days over a two-week period using a two-phase counterbalancing method. Each child experienced two interviews, one with KASPAR and one with a human experimenter, a week apart[2]. The same interview structure was followed on both occasions to ensure comparability. The interviews began with a short introduction and some simple rapport building questions that would establish the child's name, age and whether they have any siblings. This was followed by a question asking the children if they had, or would like pets, in preparation for the main topic of pets and animals. The majority of questions were open questions or were followed by a descriptive question to encourage the children to elaborate on the details to maximise their freedom to express themselves. Research and practice indicates that the most detailed and reliable answers are secured from open questions [14] p27. The interviews concluded by thanking the child for their time and participation. To compare the two different conditions we adhered to a rigid structure with pre-defined utterances. The structure and questions for the interviews were derived from the guidance of a document used by the UK police called Achieving Best Evidence (ABE), a recognised standard approach to interviewing children [14].

The main interview questions were specifically designed to vary in difficulty because we sought to investigate if the children's responses to a robot would differ to their responses to a human when faced with questions of varying difficulty. To ensure that the questions were appropriate and at a suitable level for the children, their class teacher rated a selection of questions. From the list of questions 10 were selected to be used in the interviews as they represented a range of levels of difficulty. In addition, the children were asked to rate the difficulty of the questions at the end of the interview. This was particularly useful because each child is different. For example, if one child had recently visited a zoo it is likely that they may find some questions easier than another child that has not visited the zoo. Also, a child that is only just 8 years old may find some questions more difficult than a child that is 9 and a half years old.

[2] There were five exceptions due to late consent form submission, these children had their interviews one day apart. The results from these sessions were consistent with the data from the rest of the study and were therefore included in our final dataset.

3 Measurements

The primary sources of data for measurement in this study were:

Questionnaires - Immediately after each interview the child was asked to rate the difficulty of the 10 main interview questions as easy, medium or hard to answer, and their opinions of the interview experience. The difficulty measure allowed us to assess if the question difficulty was affected by the interviewer, whilst the general interview experience questions accessed how interesting they found the experience, how difficult they found the interview, how much fun they had participating, and how long they thought the interview took.

Communicative content - All of the interviews were fully transcribed then analysed in detail for word counts, filler word counts, keyword counts and key point counts. The word counts were the words spoken throughout the duration of the interview excluding filler words. The filler word count was the amount of filler words the children used (e.g. “err”, “errm”, “hum”). The keyword count was the total number of keywords the children used, these related to the questions the children were asked. The key point count related to the content of what the children were saying. A key point was defined as a specific piece of information that we recovered from the child relating to the question they had been asked. Some of these categories were also analysed proportionately.

Video coded data - The video data was collected from four cameras recording the interviews. Cameras #1 and #2 were behind the interviewer to the left and right of the interviewer to capture the eye gaze of the children (see Figure 2). The video data was coded using the Observer XT software to measure the various durations of the interview. The durations we measured were interview duration, child response duration, child pause duration, interviewer response duration, response time child > interviewer, response time interviewer > child, eye gaze duration. These measures allowed us to analyse the temporal aspects of the interviews.

4 Results

Results in Table 1 revealed that the most significant differences related to how interesting the children found the activity and how difficult they found talking to the interviewer. The children found the activity more interesting with KASPAR but they also found it harder. The other statistical differences relate to the behavior of the interviewer rather than the children. The human interviewer used more words and spoke for longer, but responded to the children more quickly. Overall there were no differences in the amount of information the children revealed or the amount of eye contact towards the interviewers. Proportionately the children used more keywords with KASPAR than with the human interviewer. The children found that the questions varied in difficulty and overall rated 4 questions as easy, 3 as medium and 3 as difficult. This indicates that we were successful in designing a study with a range of question difficulties. The interviewer did not influence the perceived difficulty of the questions, and overall there were no differences between KASPAR and the human interviewer.

Table 1. Results of measures.

Measure	KASPAR Mean	Human Mean	Mean Diff.	t(p)	Standard Dev.
Question difficulty	1.72	1.74	-0.02	0.53 (0.601)	0.743
1=boring - 5=interesting	4.18	3.40	0.78	3.44 (0.003)*	0.980
1=hard - 5=easy	3.40	4.08	-0.68	2.29 (0.034)*	1.090
1=no fun - 5=fun	3.80	3.60	0.20	0.89 (0.385)	1.077
1=long time - 5=quick	3.65	3.65	0.00	0.00 (1.000)	1.085
Overall key points	32.60	35.90	-3.30	1.90 (0.072)	10.222
All Key words	33.70	37.40	-3.70	1.48 (0.157)	14.306
Proportionate all key words	0.16	0.14	0.02	2.17 (0.043)*	0.043
Child word count	241.30	308.05	-66.75	2.03 (0.056)	158.647
Proportionate word count	1.61	1.74	-0.12	0.63 (0.539)	0.965
Proportionate filler word count	0.04	0.03	0.00	1.02 (0.321)	0.026
Interviewer word count	150.40	180.00	-29.60	11.3 (0.000)*	17.272
Interview duration	359.92	338.82	21.10	1.03 (0.314)	76.079
Child response duration	139.46	167.19	-27.72	1.88 (0.075)	75.184
Interviewer response duration	52.43	66.34	-13.91	8.84 (0.000)*	8.566
Response time Child > Interviewer	89.20	27.94	61.26	9.27 (0.000)*	36.410
Response time Interviewer > Child	32.66	32.73	-0.07	0.02 (0.987)	16.161
Child pause duration	37.46	39.22	-1.76	0.31 (0.764)	23.198
Total Eye Gaze duration	110.76	98.39	12.38	1.59 (0.128)	36.422
Proportionate Eye Gaze duration	0.32	0.31	0.00	0.27 (0.791)	0.124

5 Discussion

Our findings confirm that the questions presented to the children varied in difficulty with an even distribution of easy, medium and hard questions. The results suggest KASPAR neither positively nor negatively influences the behavior or information the children provide. Furthermore how difficult the children found the questions did not vary between interviewers. These results support to our previous work on robot-mediated interviews [9]. The most significant differences were how interesting the children found the activity and how difficult they found speaking to the interviewer. The children found the activity more fun with the robot, which is to be expected because talking to a robot is more novel than talking to a human. However, the children found talking to the robot more difficult, we believe that was due to the robots text to speech synthesised voice. Although no statistical differences in the information the children provided were found, there was a significant difference in the amount of keywords the children used in proportion to how many words they use in total. This could indicate that the information the children disclose was more refined and focused on the particular topic of interest. The statistical results relating to the interviewers were due to speech disfluencies from the human interviewer (e.g., adding words and saying words twice), and constraints of the robot (finding the correct response key).

6 Conclusions and Future Work

The results from this study are consistent with the findings of our previous research [8, 9], and indicate that children were willing to interact with a robot in an interview scenario and did so in a similar way to how they interacted with a human interviewer regardless of question difficulty. These results continue to support our hypothesis that humanoid robots such as KASPAR could be useful tools for interviewing young children[3]. Children responded to both easy and difficult questions from a robotic and a human interview in a similar manner. Further research needs to be conducted to investigate if the responses of children vary more when they have a vested interest in keeping information from the interviewer or when they are asked questions of a more sensitive nature. Our next step will be to enhance the capabilities of KASPAR to increase the flexibility of the system rather than having pre-set questions. Developing a user friendly adaptive system is an important step in enabling professional interviewers, rather than researchers, to utilise the system, which is our goal for future work. The feedback from professional interviewers can then be used to establish if robot-mediated interviews could be used for real world applications such as police or social services' investigations.

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[3] **Acknowledgements:** The authors would like to thank Sophie Mayhew, Maria Jesus Hervas Garcia and the staff and children who helped with and participated in this study.

Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-137

Evaluation of the Acceptance of a Social Assistive Robot for Physical Training Support Together with Older Users and Domain Experts

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Abstract. According to recent studies a strength of socially assistive robots (SARs) is the ability to motivate users to perform tasks in a multimodal manner. Within this paper the evaluation of a SAR based prototype for support of physical therapy of older users at home is described. By performing a user study with a training system consisting of a social assistive robot (NAO[2]) in combination with the Microsoft Kinect[3], the acceptance of human robot interaction (HRI) within the field of physical training as well as the impact on user motivation was evaluated. Results regarding motivational abilities of a SAR and the user acceptance towards the system are given.

Keywords. Human Robot Interaction, Physical Training, Acceptance of Socially Assistive Robots.

Introduction

Physical inactivity is a risk factor for development of chronic diseases and leads to a higher risk of falls in daily life. Even slight physical training is sufficient to counteract this progress. Regular physical activity reduces the risk of falls of people aged 65+ by nearly 30% [1]. The success of the undertaken therapy is largely dependent on the patient's training compliance and competence, which in daily practice results in a high variance of the training results.

It was shown that socially assistive robots (SAR) are capable of motivating users to perform certain tasks by facilitating human like interaction such as gestures, eye contact and speech together with common motivation strategies [2]. In the presented project a SAR based prototype system for physical training support and motivation at home was developed and evaluated within a user study. The following research questions were used to drive the evaluation.

RQ1: To what extend is a social assistive robotic solution for physical training support at home **accepted** by a target group of older users?

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[2]http://www.aldebaran-robotics.com/
[3]http://www.microsoft.com/en-us/kinectforwindows/

RQ2: To what extend is a social assistive robotic solution **able to motivate** users to perform training at home regularly?

1 State of the Art

Presenting physical exercises via video is a widely used approach and has the advantages of low prices and high accessibility (e.g. via Youtube, video recorder), but lacks the ability to control the quality and quantity of the executed exercises.

Several Exergaming systems target this shortcoming by augmenting video display of physical training with movement measurement based on parameters such as acceleration, pressure or visual detection to track body movements and to provide feedback about the performance of exercising [3], [4], [5]. Systems like Nintendo Wii and Xbox Kinect have permeated the mass market and are used for gaming exercises in context of increasing physical activity levels or computer-based rehabilitation [6]. The game character increases the motivation to perform more physical activities [3] and is effective to enhance adherence and several markers of health status [7]. The project 'Motivotion60+'[4] is such a training system that was specially developed to motivate older people.

One recent trend is the development and application of socially assistive robots (SAR) that interact with people, participate and give support in everyday life [8], [9]. The goal of using HRI to realize physical training is to facilitate human robot interaction to motivate the person to interact with the robot for a period of time which encourages the achievement of e.g. physical therapy goals. Research projects like KSERA [5], SERA[5] or COMPANIONABLE[6] work on HRI optimization for an application of SARs in the home environment of older people.

2 The Prototype System

The prototypical training system, see figure 1, composed of the SAR NAO and a Kinect sensor has been developed to accomplish the following tasks:

- presentation of physical exercises
- detection and interpretation of user movements
- motivation of the user to perform the exercises.

The physical exercises, including a verbal description of each exercise are presented by NAO, the SAR trainer. NAO offers verbal and visual real-time feedback about the execution quality and quantity as well as improvement suggestions, a concluding training feedback and motivates the user to perform exercises.

The central component is the social assistive robot NAO from the French company Aldebaran with a weight of 4.5 kg and a height of 58 cm. The humanoid physique of the biped robot, 25 degrees of freedom and multimodal input- and output-channels like loudspeaker and microphone, various sensors for position- and movement-recognition

[4]http://www.motivotion.org/site/
[5]http://project-sera.eu/
[6]http://www.companionable.net/

as well as the capability of showing emotional expressions qualify NAO for presentation of physical exercises and for motivation tasks [10].

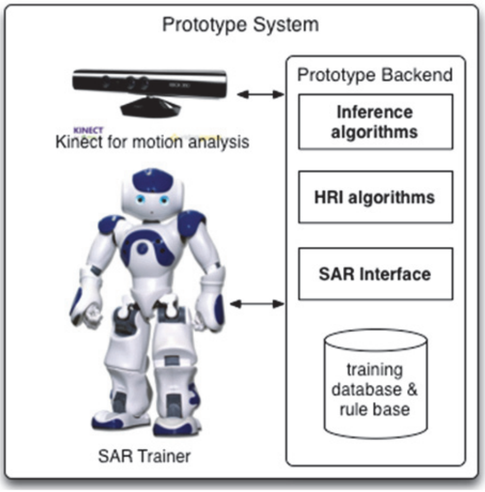

Fig. 1. Prototype design of training system (Image source: Microsoft, Aldebaran).

The core element for data acquisition is the Kinect sensor, a motion sensing input device by Microsoft, with an RGB camera and a depth sensor. With the OpenNI[7] framework and appropriate middleware components depth data from the Kinect sensor, represented as 3D joint positions, are available.

3 Methods

Two experiments were conducted to evaluate acceptance, motivation and adoption of the system in real-life. Within these experiments physical exercises were conducted with the older users together with the robot by mimicking the movements of the robotic assistant. Experiment 1 (EXP1) was conducted within single user test sessions and with an earlier stage of the prototype that did not involve training feedback, whereas experiment 2 (EXP2) was conducted in a group session with 14 participants with the final prototype.

During the user study quantitative results regarding the acceptance of the robot as trainer were generated by the use of standardized questionnaires (Godspeed [11], PANAS [12]) and specifically introduced ad-hoc questionnaires [13] based on Heerink et al. [14] during interviews before and after the demonstration of test scenarios. In addition to open questions within the questionnaires, the method “thinking – aloud” [15] was used during the performance of the training session to generate additional qualitative data.

3.1 Test Setup

EXP1 was conducted in a room mimicking a room of a real user’s apartment, EXP2

[7]http://openni.org/Documentation/

was conducted in a gymnasium that fitted the group size.

In both settings, the SAR is positioned opposite the person to establish eye contact while presenting the exercises. The distance between NAO and the person(s) imitating the shown exercises is about 2.4 to 3 meters. The execution poses of the exercises were sitting, standing or in a supine position depending on the motor abilities of the users.

3.2 User Involvement

An end-user study was undertaken together with 30 users whereof 16 older users (n=16) with an average age of 77 (avg age=77), 13 female and three male, took part in EXP1 and a group of 14 users (n=14) (7 female, 7 male) and an average age of 69 (avg age=69) took part in EXP2.

The inclusion criteria to participate in the study have been being at least 65 years old and cognitively healthy, which was evaluated by means of the WHO quality of life questionnaire [16]. Furthermore the physical abilities should permit to conduct simple physical exercises. The involved users had only minor motor problems; one user was not able to walk without a walking frame.

4 Results

Specific questions about motivation were inquired after the demonstration of training support within EXP1. Fig. 2 shows the relevant questions and illustrates the results. Fig. 2a shows that 71% of the trial participants think that NAO was motivating them "very much" or "a lot". As an expected result within Fig 2b 70% of the trial participants say, that a human trainer would motivate them more than NAO. However Fig 2c depicts that 78% of the participants rated NAO to be the better motivator than standard training plans, which they use in daily life.

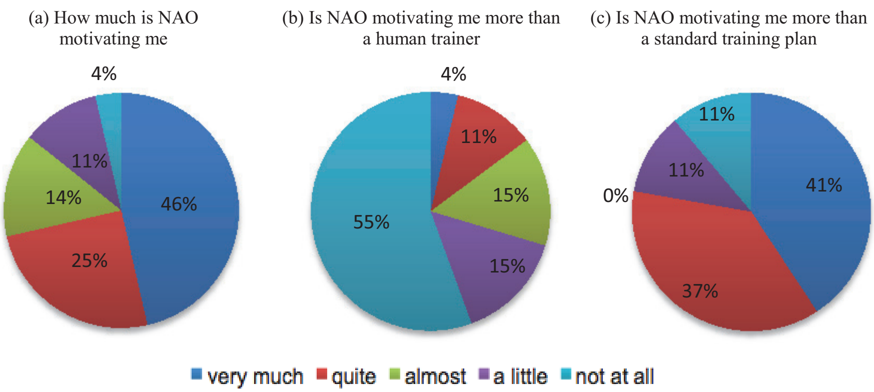

Fig. 2. NAO's motivational skills.

Fig. 3 shows results of a comparative questionnaire conducted after EXP2. As shown in Fig. 3a most participants prefer conventional systems for their regular training at home. As reasons they stated that the accuracy of displayed exercise movements is higher in the video version and they can use video and paper together. Fig. 3b shows that they found the video solution and the robot to be nearly equally motivating with a small preference for the video version. Fig 3c shows that over 3/4 of the users would prefer the robot if they could choose one system to take home.

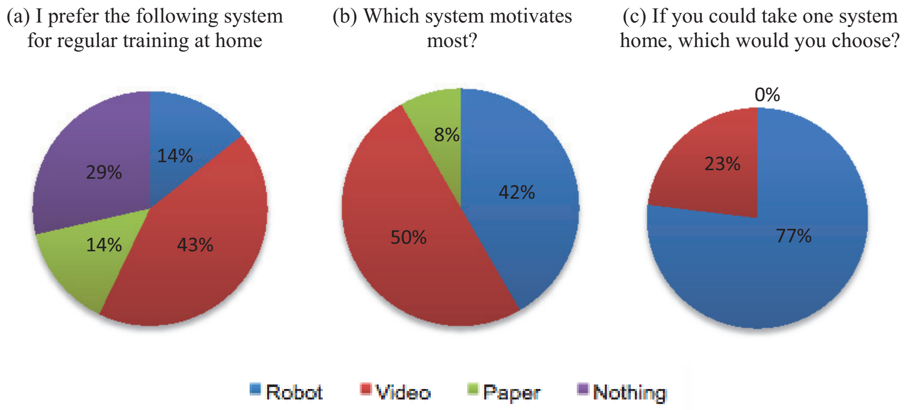

Fig. 3. Comparative analysis of different ways of training support.

5 Discussion

Research question 1 – “Is the system accepted by the users?” – can be partly answered given the results. A full analysis of acceptance related factors was not yet undertaken but clues are already given in the presented results. Although users prefer video or paper based systems for training at home and although they find video based systems approximately equally motivating, the majority of users would choose the robotic solution if asked which they would want to take home. This suggests that they did feel confident in handling the system at home and also accepted the robotic solution for physical training support.

Research question 2 – “To what extend is the system motivating?” - can be answered in that the users find the system highly motivating, but not significantly more motivating than comparable similar systems such as video based systems and less motivating than a human trainer. During the qualitative interviews the ability of the robotic system to automatically approach the user and remind them of performing exercises was commented positive and rated as one benefit of the system over current video based solutions.

For reasons of limitations of the degrees of freedom of the used robotic agent, some of the physical movements could not be shown absolute correctly by the robot. The participants noticed this fact but stated, that it would be good to train with the robot, as they would easily remember the correct movements by themselves and would be motivated to make the training together with their SAR trainer (see also [17]).

6 Conclusions

The results of the conducted user study point out, that a SAR for physical training is motivating and accepted by the end users. The proposed solution provides a training environment in which, under the guidance of a coach or therapist, success of training in terms of raising the motivation to actually perform the prescribed exercises can be increased.

Future studies are suggested to evaluate the results on longer term at home usage. Currently this seems not to be feasible from a technological perspective for issues of reliability and technical support. Further studies are planned with secondary users such as coaches and therapists to evaluate their willingness to involve a SAR in their training- or therapy-concepts.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-143

Prompt-fading Strategies in Robot Mediated Play Sessions

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Abstract. Play is the primary way for children to acquire cognitive, social and relational skills. However, children with disabilities risk to be deprived of their freedom and their right to play in spite of the efforts made by adults in the familiar, educational and rehabilitation context. This work investigates the adults' role in letting children with Cerebral Palsy acquiring play skills through a playful interaction with a robot. The originality of this research lies in evaluating the prompt fading technique in a playful environment given that this strategy has so far, in fact, only been applied to contexts of rehabilitation and learning.

Keywords. Play, Children with Cerebral Palsy, Prompt-fading, IROMEC. Social Robots.

Introduction

Play constitutes the primary way to acquire cognitive, social and relational skills [1] and it is recognized as a fundamental right for every child [2].

Children play on the basis of an instinctual drive, and change over time the contexts, objects and the complexity of their play activities in relation to the new challenges posed by their peers imitation and appropriate interactions with adults.

Children with disabilities find instead several difficulties in beginning, developing and carrying out play activities in a natural way [3]. This is due to many causes: first of all to their impairments that limit their ability to act upon the world, concerning objects and use them; but also to environmental factors, in the double sense: because environments and instruments are usually not enough accessible for them and because inclusive contexts in which adults are competent in implementing effective playful practices that promote cooperation among children with different capacities are not so frequent. Furthermore, the dominance of rehabilitation activities should be added, at least in the early (but critical) years of life of children with disabilities. Aimed at recovering the damage and activating residual competences, they end up invading the whole life of children and their families so that the clinical objectives dominate educational and rehabilitation projects. The value and the importance of the natural expression of playfulness and the role of play in childhood life in general is underestimated [4].

The relationship with the adult is very important in play development, although the ludic activity builds and changes over time also because of an autonomous boost and thanks to the experience and the relationship with peers. In the case of children with

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disabilities, the role of adults becomes even more crucial: their capabilities in facilitating the play competence [5],[6] can be the real turning point to allow an activity that otherwise would become unreachable or repetitive.

The study presented here investigates how rehabilitation professionals can elicit play competence for children with motor impairments (in addition or not with cognitive impairments) through the mediation of robot companions. Possible intervention strategies for adults in play activities for children with disabilities have already been proposed in literature [7] as well as an assessment of the effectiveness of robots in therapeutic and educational contexts [8].

The originality of this research lies in evaluating the prompt fading technique in a playful environment given that this strategy [9] has so far, in fact, only been applied to contexts of rehabilitation and learning. A reduction in the overall number and in the intensity of prompts given by the professionals is to be expected as the evidence of the successful acquiring of play competence by the child. A second expected result is if and how rehabilitation professionals and children "appropriate" the robotic technologies – i.e. if they adapt technologies for their purposes going beyond the uses envisaged by the designers [10]. Appropriation is considered as a positive design outcome because it shows that the technology has been domesticated during its use, that the users understand the possible interactions and are comfortable enough with the technology to use it in their own ways. As a consequence, in the case of the robots involved in the play sessions, the expectations are that either children or therapists will not always play to the scenarios implemented on the robot, rather they will go beyond them and find ways to make the activities more entertaining and adapted to meet the needs and preferences of the single child who plays with them [11].

1 The Experimental Study

Eight play sessions were conducted with 4 children affected by Cerebral Palsy[2] of a chronological age between 4 and 8 years and diagnosed of mild or moderate cognitive impairments. Each child was participating individually with support offered by two therapists. The children involved had no previous experience with assistive technologies. The robots used for the experiments were IROMEC, Wall-e and I-SOBOT,[3] which all allowed interaction through touch switches suitable for children with severe motor disabilities. The play scenarios used for the experimentations were based on those devised during the project IROMEC [12]. Two switches allowed the control of the robot's movements. Children could make the robot rotate by pressing on one switch and make the robot move forward in a given direction by pressing the other one. Before the play session an assessment of their sensorimotor abilities was conducted for each child so to inform the characteristics of the switches that could better fit to their impairments. Children were instructed by two therapists on how to interact with the robot. During the play sessions one therapist sat close to the child to

[2] The play sessions were conducted at the rehabilitation centre "Centro Santa Maria Nascente" of the "Fondazione Don Carlo Gnocchi IRCCS-Onlus" in Milan. The authors wish to thank Manuela Romanò, Antonio Caracciolo and the others therapists of the rehabilitation centre who participated to the play sessions.

[3] The results presented in the paper regard only a comparison between play sessions were IROMEC was involved. During the eight sessions children played using I-SOBOT and WALL-E but the results are not considered in terms of the prompts given by therapists.

supervise and help him or her by explaining the rules and offering verbal and physical support where it is needed and keeping the child's attention focused on the activity. Another therapist was the child's playmate and prompted children verbally by encouraging them to play.

The prompts given to the children were categorized on a scale of intensity from the strongest (a complete physical guidance) to the mildest (limited verbal prompts). The decrease along the scale is considered as evidence that children were acquiring a play competence.

1.1 Methods

The play sessions were video-recorded and the therapists were asked to keep a diary. An analysis of this material allowed for a classification of the prompts given to the children not just in terms of intensity but also in terms of the goal the therapists wanted to achieve with each contribution.

This allowed to single out two categories of prompts:

a) prompts aimed at helping the child in understanding how to play. This category involves all the prompts necessary to support the child in understanding how the robot works and also the prompts necessary to understand which sensorimotor action was necessary for the interaction. In many cases this action needed physical support by the therapists to be performed (i.e. how to physically activate the switch; the cause-effect relationship between the activation of the switch and the movement of the robot; helping them to understand their errors in controlling the robot);
b) prompts aimed at generating a playful and engaging experience (i.e. keeping children's attention focused on the activity by relying on the emotional involvement; making the child be interested in the robot with the use of other toys).

All the prompts given by therapists were tagged on the videos related to the first and the last sessions, by two independent observers, and were attributed to one of the two categories through the use of the software VCode & VData [13], as explained in the picture below.[4]

Fig. 1. The central part of the image shows the play session analyzed. On the top right each coloured row corresponds to a category of prompts. Prompts are singled out in the timeline below.

[4]Inter rater reliability of observers was tested with Cohen's kappa using a random segment of a video session. Kappa= 0.617, with parameters corresponding to the macro-categories of data

1.2 Results

The table below shows a comparison between the mean number of prompts given to children in the first and the last session. In the case of category a) six sub-categories are singled out on a degree of intensity from the strongest (a complete physical guidance) to the mildest (limited verbal prompts), whereas category b) contains only the latter three sub-categories because no physical prompt for playfulness was given.

Table 1. The table shows the average number of prompts given to children, related to understanding how to play and to playfulness, for the first and the last play session.

Prompts for Understanding how to play	First session	Last Session	Prompts for Playfulness	First session	Last session
Complete physical guidance	6	2	/	/	/
Restricted physical guidance	5	2	/	/	/
Prompts & physical modelling	3	2	/	/	/
Prompts & gestures	6	3	Prompts & gestures	3	1
Verbal prompts	12	10	Verbal prompts	17	18
Limited verbal prompts	11	11	Limited verbal prompts	32	31
Total	43	30	**Total**	52	50

The results show a difference between the trends of the prompts belonging to the two categories.

- The results concerning category a) show an overall decrease between the sessions (from 43 to 30). Breaking this result down to the sub-categories of intensity it is possible to observe how physical prompts (of higher intensity) tend to decrease in number while verbal prompts (of lower intensity) show no particular difference.
- The results concerning category b) show a high number of prompts both in the first and the last session, without significant changes. It is also possible to observe how in terms of sub-categories these prompts not only remain constant but in one case are increased.

2 Discussion

The trend described in table 1 shows for what concerns the category a) a fading of the prompts given by therapists, between the first and the last session; this could suggest that the play sessions involving robotic toys have been effective in supporting children with cerebral palsy in acquiring play competence: they learnt to interact with the robots in the proposed way.

Nevertheless, results of category b), on the other hand, could suggest that the play activity has not been sufficiently engaging, since the prompts needed by children remain constant between the first and the last session to maintain their attention focussed on what they were doing.

These data appears to be coherent with other researches related to the IROMEC robot, -i.e [14]. IROMEC showed little added value for children with cerebral palsy in the context of occupational therapy because of a limited matching between the children's needs of play and the characteristics of the robot itself as a toy.

The distance between children's play needs and the play situations allowed by IROMEC could explain why children require many prompts to be engaged in the activity even after eight play sessions.

Further explanations of the need of prompts are to be found in the video analysis data presented. Between the first and the last session the adults try to enhance the play situation. They try to enrich it, to build more stimuli and ideas to make children's attention more focused on the activity; in terms of play theory, it could be said that they try to enhance the play scenarios available on the IROMEC, that mainly belong to the sensorimotor level, by translating them to a symbolic and imaginative level. For instance they invent novel play situations where children have to make the robot reach different objects in the room; they use other toys such as a car to make a sort of competition; they build a play activity based on letting children find physical add-ons and coating elements for the robot. Nonetheless, we argue that these changes in the play situations, compared to what could be expected as a result of the use of interactive technologies, are not a consequence of an appropriation in the strict sense of the robotic technology. In fact, the interaction with the robot remains the same and what changes is the play situation with the support of the therapists.

Some other play scenarios available for the IROMEC robot could allow for more complex and rich interaction than what is achieved by children in the play sessions described here, but those kind of activities require a degree of physical interaction that could not be accessed by children with Cerebral Palsy with the actual robot. The difficulty of IROMEC in matching children's play needs has been tackled by designing covers and add-ons [15] that allow a perceptual crossing so that users can recognize it and interact with it not only for its particular form, behaviour, or pattern of movements, but for how its behaviour is perceived by the users. This means that changing the aesthetics of the robot could affect how children see it and how they feel that they can play with it. This could result in an enhancement of their engagement and on the playfulness of the play situations.

The results obtained in this study show that the technology's role is secondary in making children with Cerebral Palsy acquiring a play competence compared to the efforts of the therapists who guide the interaction. In fact, it is only due to their experience and ability that children learn how to control the robot and need less prompts belonging to category a) but also remain interested in play even if they constantly require prompting by adults. The results of prompts related to playfulness are indeed surprising: the number of prompts for playfulness is and remains high throughout the study. If the playfulness is the child's pursuit of play for its own sake and on the child's terms, then such high levels of prompting should not be required because play and toys should have a power of attractiveness in themselves. This may point to weaknesses in the robot design and/or the play environment provided to the child. The robots used in the described sessions do not make it possible to have the robot prompting the child – a solution that would allow for "independent" play, or at least without the direct support of an adult in many physical actions.

For this reason, further technological development should support adults' actions so that they can build a ludic relationship that meets the expectations of children and shows a clear match between the play needs of children and the characteristics of the robot as a toy.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-149

Differentiation in Service Robot Behaviour based on User Ability

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Abstract. Sustaining independent living of elderly is both desired by citizens and a target for societal policies which results in a growing demand of home support. Service robots have the potential to offer a solution to this growing demand. In the European ACCOMPANY project an existing robot, the Care-O-bot 3®, will be further developed, to support these older citizens at home. However, the problems elderly face are person-specific due to the diversity in age related loss of abilities between individuals and the diversity in living environments. To explore the dimensions determining appropriate robot behaviour in providing care support at home to the elderly, the roles of caregivers in existing care provision were assessed in the Netherlands, UK, France, and Italy. Secondly, focus group meetings were organised with elderly persons (N=39), formal caregivers (N=44), and informal caregivers (N=24) in the Netherlands, UK, and France. From these results 3 consecutive scenarios could be created. Further, the results indicated the importance of the development of appropriate robot behaviour alongside the functional capabilities need for individual adaptation and the need to further explore the concept of companionship, a diversity of support strategies that need to be implemented and finally ethical considerations regarding the interaction between user and robot.

Keywords. Elderly Care, Ageing In Place, Service Robot.

Introduction

The ageing population is increasing and the number of elderly people who prefer to postpone living in a care facility for elderly persons is growing. Sustaining independent living is not only desired by elderly people, but also a target for societal policies. Currently, the caregiving process at home involves mainly human care provision. Due to changing demographics and the economic need for cost stabilisation, future care at home for elderly citizens cannot be provided by human care givers at the level it is now. It is generally acknowledged that service robots are likely to offer a large potential to answer the growing demand of support by providing support to elderly people to stay in their own homes for longer. Many service robot developments are ongoing and the first service robots for day to day support of the elderly are becoming available.

Also within the FP7 European ACCOMPANY project [1] the functionality of an existing service robot, the Care-O-bot® [2], will be further developed aiming to support older citizens to sustain independent living. While current developments of service robotics for elderly at home are mainly focused on the technical feasibility and

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functional performance [3], the focus in the ACCOMPANY project is also on how to develop appropriate robot behaviour while delivering its functionality. This behaviour is deemed to be essential for acceptance of the service robot and its success in actually supporting elderly persons at home. Besides the importance of the functionality of the robot, also the social and empathic behaviour of the robot should also be taken into account [4, 5].

The target group of the ACCOMPANY project are elderly persons (with the exclusion of elderly people with cognitive difficulties). Due to practical limitations, it was decided to focus within the ACCOMPANY project on just two different groups of elderly people. The first group includes elderly persons requiring mild support (e.g. an arm when walking, a third hand for stability, and sense of safety when performing physical tasks). This group lives at home and is still able to perform most tasks. They seek light support in many tasks to remain independent and have to deal with this given an ongoing decline in functioning. The second group includes elderly persons who are under rehabilitation treatment and require temporary support in day to day activities but who want to be self-supporting again as soon as possible (e.g. elderly persons recovering from hip replacement surgery).

In the first stage of the ACCOMPANY project the problematic activities elderly face at home were studied through focus group meetings with elderly persons, formal caregivers, and informal caregivers [6]. These focus group meetings resulted in three problematic activity domains: 1) mobility activities, 2) self-care activities, and 3) interpersonal interaction & relationship. At a general level elderly persons experience similar physical and mental decline everywhere. However, the problems elderly face are person-specific due to the diversity in age related loss of abilities between individuals and the diversity in living environments. One person may need just a little balancing support while standing, while another may need intensive support and needs to be dressed in the absence of a hand function.

Not only does the need for support vary strongly between users, also similar functionality may be offered by the robot with different intentions for the user. One user needs support to overcome temporary difficulties and the support of the robot is aimed at facilitating the rehabilitation process, while another user needs the same robot functionality because he/she is permanently unable to perform the activity him-/herself. A third user may sometimes need the support while at other occasions should be denied this support in order for the user to maintain their remaining functional abilities. The reasons for providing support differs between users, but may also differ within users due to changing preference or changing conditions. The behaviour of the robot should match the intention of the provided functional support and therefore a service robot should be able to display a range of behaviour in combination with the ability to perform supporting actions.

In the ACCOMPANY project, after a user needs assessment [6], robot functionality was selected from the domains that were reported to be critical in sustaining independent living of elderly citizens. The clarification of the selected robot functionality is provided elsewhere [6]. In this project the function of getting a bottle of water from the kitchen in one's own home (related to the activity domains mobility and self-care) was selected as a basic, first functionality. This paper reports on the second stage of the project. This stage results in the formulation of three use scenarios which will be implemented and evaluated in the remainder of the project. It explores the dimensions determining appropriate robot behaviour in providing care support at home to elderly users.

1 Method

To clarify the required range of behaviour service robots should have when delivering its functionality, the roles of caregivers in existing care provision was assessed in four countries covered by the ACCOMPANY consortium (i.e. the Netherlands, UK, France, and Italy). In addition a second round of focus group meetings were organised with elderly persons (N=39), formal caregivers (N=44), and informal caregivers (N=24) in the Netherlands, UK, and France.

In the analysis of elderly care provision in the four countries the range in purposes of the involvement of care staff was described and its implications for service robot development established. Also current views on how care provision, in particular home care, is provided and how this is differentiated between different care recipients was analysed (e.g. re-ablement in the UK, and care provision with 'the hands on the back' in the Netherlands). In the focus groups meetings the way in which support should be provided in maintaining the users' ability to perform the daily activities that were regarded as critical for sustaining independent living was discussed. The gathered qualitative results were translated into a set of dimensions considered to be important when developing service robot behaviour.

2 Results

The analysis of the care provision in European countries highlighted a number of different perspectives from which care provision is executed. It is a complex interplay between professional caregivers and informal caregivers, public funding and private funding. There are large differences between the conditions of care provision between countries and their regions. In France, the separation of home care (help and assistance) and home treatment (medical and nursing) activities causes many problems, especially regarding the coordination of care. In Italy each region autonomously manages and provides care services which results in differences, for example: in the south of Italy people receive by their municipalities one-third of the financial support for social and health assistance services received by those living in the north-east of Italy. Further, elderly care in Italy is often financed by private money. In UK recent policy developments have supported the move towards 'personalisation' in which older people are supported through a process of self assessment and have a budget allocated to allow them to buy their own care package. In Netherlands the budget for home care provision based on public funding is under discussion in light of the economic situation. The complex organisation of care funding makes it difficult to find an opening for financing robot support but if so, supporting basic ADL activities seems the only possibility.

From the national situations four approaches towards care provision were derived that could be adopted for the use of service robotics.

- Co-learner: The robot only supports the (problematic) activities partly. The robot learns from the user which part of an activity it should support and in which manner.
- Re-ablement coach: The robot intends to improve the capabilities of the user so he/she can finally perform activities ideally alone again. Item
- Assistive technology: The robot executes the entire activity alone. It acts like a butler or a servant and obeys the user.

- Care provision with ‘the hands on the back’: The robot guides the user through the (problematic) activities without providing actual physical support.

The analysis of the focus group discussions in France, the Netherlands and UK led to more detailed results regarding the relationship people foresee with a robot and their related expectations regarding robot behaviour. People do not want to be provided with robot care as a complete replacement of human care, but it seems care providers more strongly object to this than care recipients. Elderly state that the robot should be seen as a supportive option to human care provision. A user who is under rehabilitation treatment would need to have a service robot that assesses the user’s physical ability, offers just enough support on demand, and motivates the user to keep practicing. However, a user who requires mild support would need a different approach from the robot.

3 Conclusions

In the ACCOMPANY project three consecutive scenarios were defined in functional terms with the focus on the first basic functionality of getting a bottle of water from the kitchen in one’s own home.

Scenario 1

The user sits at the sofa in the living room. The robot approaches the user and reminds the user to take their medication and suggest to go to the kitchen to get the medication as well as a glass of water. The robot accompanies the user to the kitchen. The user takes the medication as well as a glass of water and places both on the robot. Together they walk back to the living room where the user takes the medication with the water.

Scenario 2

The user sits at the sofa in the living room and is thirsty. The user squeezes the tablet to get the robots attention. When the robot arrives the user chooses from the offered choices that he/she wants to drink something. The user and the robot walk together to the kitchen. When arrived in the kitchen, the user grabs a bottle of water from the fridge and places this on the robots tablet. Together they walk back to the living room. When the user is seated the robot places the drink on the sofa table in front of the user and observes the user to check if the user is drinking.

Scenario 3

The user sits at the sofa in the living room and wants to play a game. The user squeezes the tablet and the robot approaches the user. From the offered choices the user chooses to play a game with the robot. The doorbell rings and the robot alerts the user. The robot accompanies the user to the front door as requested by the user. After opening the door, the robot greets the visitors, who bought flowers, and the visitors and the user go to the living room. The robot goes back to its default position. The user then squeezes the tablet again and indicates that the robot needs to bring a vase. The robot fetches the vase and brings it to the user. After fetching the vase the robot places the vase on the table. The user wants to fill the vase with water and places the vase on the robot. The robot and the user go together to the kitchen where the user fills the vase and places it on the robot. The robot carries the vase back. In the living room the user places the vase on the table.

These three scenarios support the basic functionality of getting water from the kitchen. Although this basic functionality is related to the problematic activity domains mobility and self-care, it is not sufficient to improve the independence of elderly persons. Further the individual adaptability of the robot is insufficient integrated in the scenarios. Nevertheless, these scenarios do give a clear view on the complexity of the interaction between the user, the robot, and the environment in a realistic care-situation.

From the results described in this paper it is clear the behaviour of the robot should be further developed alongside the functional capabilities. From the user panel results three dimensions were formulated to be relevant for shaping the behaviour of the robot; companionship, support strategy and ethical considerations.

To shape the companionship dimension, the social behaviour and the empathic abilities of the robot should allow for a range of possibilities in the interaction and the behaviour of the robot to match the different settings of care provision and the personal preferences of its users. Potential users expressed surprising views regarding relationship to the robot. For example: Easy acceptance to chat with a robot about the weather while in contrast it was clearly no option to discuss more serious topics. The robots emphatic behaviour is being developed separately in the project.

The dimension support strategy is relevant depending on the functional abilities of the user. When people lack certain abilities to perform an ADL activity and there is no perspective of physical improvement, the robot could serve as a butler, or even a slave, supporting the user on demand and performing activities autonomously. This would enable the user to be independent regarding this ADL even though the activity was not performed by the user him-/herself. However, when the user is expected to be able to improve in performing an ADL activity, or maintain the current level of functional ability, the robot should not perform all activities but rather stimulate the user to remain active, and/or motivate the user to improve his/her abilities. This could ultimately imply that a robot refuses to perform an activity when asked by the user, and opts for stimulating this user to perform the activity him-/herself or to perform the task as a joint effort. Design of robot behaviour will be implemented in the final prototype of the robot.

The dimension ethical considerations prove to be an important, but subtle influence, in all this. The autonomy and dignity of the user is under this dimension, however also the perspective of the caregivers and even a societal perspective are of relevance. Trade-offs between privacy and independence are relevant here, but also the distribution of roles between robot and care givers. Societal policy regarding privacy in general, but also at a personal level (e.g. the possibilities to monitor drug compliance and sharing this information with their general practitioner), scared care providers much more that care recipients. Further in depth investigation of ethical issues is currently undertaken in the project.

Although the scenarios may seem a minor addition to the care of elderly at home, the fact that this has not been available before in an autonomous, but socially acceptable and empathic robot functioning in a non-structured environment, indicates there are major challenges to be taken. The complex interplay between behaviour and interfacing of the robot will be further explored in the upcoming evaluations in the accompany project.

Acknowledgements

The work described in this paper was partially funded by the European project ACCOMPANY (Acceptable robotiCs COMPanions for AgeiNg Years). Grant agreement no: 287624. Possible inaccuracies of information are under the responsibility of the project team. The text reflects solely the views of its authors. The European Commission is not liable for any use that may be made of the information contained therein. The authors are grateful to colleagues in the ACCOMPANY consortium (The University of Hertfordshire, United Kingdom; Hogeschool Zuyd, The Netherlands; Fraunhofer, Germany; University of Amsterdam, The Netherlands; University of Sienna, Italy; Maintien en Autonomie à Domicile des Personnes Agées, France; and University of Birmingham, United Kingdom; University of Twente, the Netherlands; University of Warwick, United Kingdom).

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-155

Development of a Bicycle Simulator System for Stroke Rehabilitation

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Abstract. In the rehabilitation training for stroke survivors, patients sometimes request training through riding a bicycle. However, sufficient space and therapists are required for the rehabilitation using bicycle. To solve these problems, a bicycle simulator for stroke rehabilitation has been developed. The system consists of a bicycle, a control computer, a visual system and a sound system. It can provide simulated traffic environment to the user and he/she can pedal on the bicycle in the virtual world for motor and cognitive functional training. Rehabilitation training on the bicycle simulator is not only to achieve functional recovery but also to improve patient's quality of life and independent life by ensuring the transportation.

Keywords. Stroke Rehabilitation, Bicycle Simulator.

Introduction

Stroke survivor's gait performance is reduced due to paralysis and weakness of the muscles strength. However, post-stroke people with non-severe after effect can ride on the bicycle and they use it as a personal mobility tool in the daily life, even if they cannot ride in safe. According to the interviews of the therapists, some stroke patient request to have trainings to ride on the bicycle. To provide such rehabilitation training, it will be required a sufficient space and therapists to ensure the training in safe. On the other hand, fixed exercise bicycle is commonly used for the rehabilitation after surgery e.g. heart surgery, hip joint replacement surgery today.

Riding a bicycle will extend post-stroke people's range of activities. It helps to keep a social connection and their independent life. Incorporating pedaling bicycle training into the rehabilitation and letting the patients regain their ability to ride on the bicycle will help their independence in the daily life. Therefore, a bicycle simulator for rehabilitation has been developed. It provides simulated scenery to the user and he/she can ride on the bicycle in the virtual environment for motor and cognitive functional training. Training on the bicycle simulator does not only aim to achieve functional recovery and fitness but also to improve patient's quality of life and independent life by ensuring the transportation.

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1 Bicycle Simulator

The bicycle simulators can be categorized into “for research” and “for education” types, according to the purpose of use.

In case of research, most common topic of bicycle research is a modeling of the bicycle dynamics. To evaluate the modeling and simulation, KAIST (Korea) [1] and Shanghai Jiao Tong University (China) [2] developed the simulator system. These simulators are equipped with a six degrees of freedom motion system, which moves the bicycle body and reproduces the acceleration feel to the user. Iowa University (USA) [3] developed the fixed base bicycle simulator for another research topic, traffic safety. This simulator has three visual screens, which are set around the bicycle and provide immersive riding experience. Chonbuk National University (Korea) [4] developed the simulator for elderly persons balancing training. The bicycle body is located on the load cells and records the movement of the center of gravity during the pedaling. Single LCD is located in front of the bicycle. Correlations of the training time and the level of body sway were reported. University of Medicine and Dentistry of New Jersey (USA) [5] developed the simulator for post-stroke training to improve individual fitness. The system consists of a single display, an exercise bicycle and vital sensors. The user’s heart rate is set to the avatar’s moving speed in the virtual environment. The user follows the avatar and train in sufficient duration and intensity to fitness.

In case of education, fixed base bicycle simulator has been developed and introduced in the market by Honda Motor Co., Ltd. [6]. Single LCD monitor is located in front of the compact bicycle body and other monitors e.g. left, right side and behind are equipped to check safe around the user. The software provides virtual environment and the user can ride the bicycle through the virtual traffic. The user learns traffic law and manners to correctly ride the bicycle.

2 Structure and Functions of Simulator System

The developed simulator system consists of a bicycle body, a control computer, an image generator, an image display, a sound generator and a base frame. Fig. 1 shows the system structure of the bicycle simulator.

The bicycle body uses a common shape real bicycle, which is mounted on the indoor training stand and fixed to the base frame. To measure the rotational angle of the steering bar and the rotational velocity of the rear wheel, the rotary encoders are installed to the bicycle. Front brake shoe contact pressure is also measured by pressure sensor. Sensor measured values are preprocessed by the microcontrollers and sent to the control computer by using USB. Fig. 2 shows the appearance of the bicycle simulator.

The control computer calculates the position and the attitude (heading) of the bicycle according to the sensor value. Dynamics of the bicycle is calculated based on simple bicycle model [7]. In this case, lean angle is not considered since the bicycle body is fixed on the base frame and it cannot rotate on rolling axis. The steering angle, wheel velocity, bicycle position, attitude and other parameters can be recorded by the control computer in real time.

The image generator generates the virtual view in the virtual environment. To generate the virtual environment, video game development tool UNITY [8] is used. The virtual environment is a 300m square city. This city is a combination of 5m square small fundamental road units and other objects e.g. buildings, trees. It is designed to create the different city and streets easily. The minimum lane width is 2.75m and the minimum road shoulder width is 0.5m. It is designed by following the Japanese government legislation on road design standard. The front view is generated as the user sees on the bicycle. It is calculated according to the bicycle position and attitude. Fig. 3 shows a bird's-eye view of the city and Fig.4 shows an example of the visual scene.

The generated front view image is displayed on the image display. To provide an accurate image as possible and to minimize the workspace, a 55inch size LCD is used. The user will be able to see the ground of 2.5m ahead. Virtual traffic environment prepares several scenarios e.g. making aware of the hemi-spatial neglect, relearning traffic rules and risky situations. The environmental noise and traffic related sounds are also generated and provided.

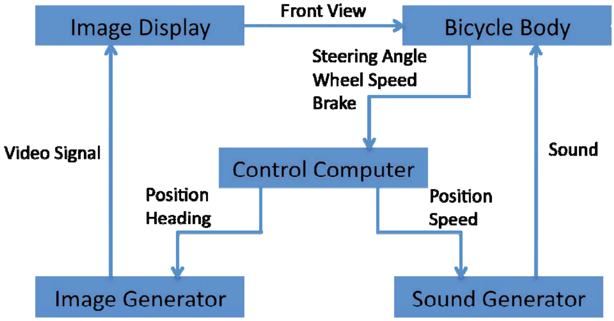

Fig. 1. Structure of the Bicycle Simulator System.

Fig. 2. Appearance of the Developed Bicycle Simulator System.

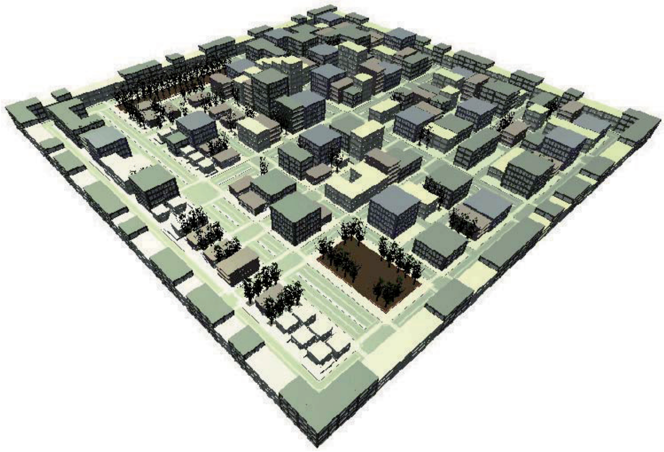

Fig. 3. Bird's-eye View of the Virtual Environment.

Fig. 4. Example of the Visual Scene.

3 Functional Tests Results

Functional tests and test pedaling by the therapists were carried out to confirm the performance of the bicycle simulator. The tester rode the bicycle simulator freely, the parameters of the bicycle motion were recorded and an interview was carried out. Trajectory of the bicycle is shown in Fig. 5. One physical therapist (PT) and two occupational therapists (OT) enrolled in the tests and gave us impressions as follows,

- From the viewpoint of physical therapy, training for improving physical abilities e.g. muscle strength and balancing was achieved. Exercise intensity and physical activity can be estimated by the pedaling distance and force on the pedals. Therefore, measuring force on the pedals system should be equipped. (PT)
- Load of the pedaling adjustable mechanism should be equipped. It is to provide an

appropriate load to the user. (PT)

- Observing user's reaction and recorded traveling data pedaling in the traffic environment will be the evidence to decide whether the user can use the bicycle. (OT)
- Support frame of the bicycle may make the bicycle difficult to ride for the stroke survivors. (OT)

Currently, improvement modifications are undergoing according to the therapist impressions. In the next step, experiments with normal healthy subjects, elderly subjects and stroke survivors will be carried out. The experiments are aimed to evaluate the effectiveness of the developed simulator system, including virtual environments, training scenarios and to correct the data for quantitative evaluation of riding ability.

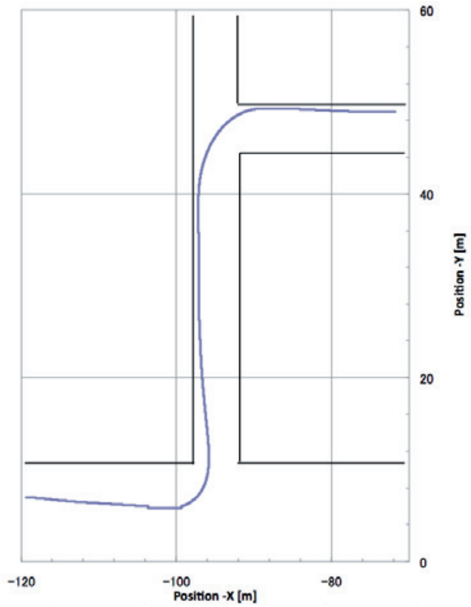

Fig. 5. Trajectory of the Bicycle in Experiment.

4 Conclusions

The bicycle simulator system has been developed, with the purpose to improve physical and cognitive function of post-stroke people. The therapists confirmed the functions and performance. In the future, the experiment with post-stroke people will be conducted and the effect will be quantitatively evaluated.

Acknowledgements

This research was supported by JKA and its promotion funds from KEIRIN RACE.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-161

Changes in Playfulness with a Robotic Intervention in a Child with Cerebral Palsy

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Abstract. Children with a severe motor impairment due to cerebral palsy have a free play deprivation due to their physical impairment. There is evidence that playfulness is affected in children with cerebral palsy. The objective of this pilot study was to investigate the effect of a home-based robot intervention that promotes free play, on the child's level of playfulness. This study was a pilot study for a future multiple baseline design (MBD) across subjects. The participant was a 4 year old girl with cerebral palsy who played with her mother at home. The 5 week intervention used a robot as an augmentative manipulation device for play. The playfulness level increased slightly during the intervention. Reflections for future studies are discussed.

Keywords. Robot, cerebral palsy, disability, playfulness.

Introduction

Free play occurs when an activity is spontaneous, intrinsically motivated, actively engaged and self-regulated [1, 2]. Free play provides children with the opportunity to discover their capabilities, try out objects, make decisions, comprehend cause-and-effect relationships, learn, persist, and understand consequences [2]. Playfulness has been defined as the main aspect of play, as the disposition to play [3]. It has been stated that the greater the playfulness shown by the player in a given activity, the closer to free play that activity is [1]. Playfulness is an indicator of free play.

Children with cerebral palsy that results in marked physical impairments have a free play deprivation. This is due to a lack of opportunities to interact and practice skills needed to control the environment [2]. There is evidence that playfulness is affected in children with cerebral palsy. Infants with cerebral palsy and developmental delays with at least moderate cognitive impairments are less playful than typically developing children [4]. Likewise, children with motor impairments including cerebral palsy have difficulties actively making decisions during play [5]. Children with motor impairment also spend less time concentrating on the play activity and their play is less complex than the play of typically developing children [6]. During play with objects children with disabilities and especially with motor impairments are highly dependent on their mother to play being the mother who manipulates the play material or toys [7].

Robots have the potential to help children with cerebral palsy engage in object play [8, 9]. Robots can allow children with severe motor impairments to interact with play

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materials that generally are part of typically developing children's play (e.g. buried objects, Lego bricks) [10, 11]. Robots have the potential to increase playfulness in children with cerebral palsy during occupational therapy sessions [12]. Lego Mindstorms ® robots are a low cost reliable alternative to traditional testing that can be used for estimating cognitive skills in children with severe motor impairments [13]. Research on robot-based play in children with cerebral palsy has shown that Lego robots may be successfully used to assist with play involving manipulation [14]. These robots are not intended for replacing the complexity of hand function but as assistive technologies that allow children to have a means for interacting with some objects in their physical environment. By using the Lego robots children have been able to do things such as pointing, pushing, pulling, carrying, organizing and measuring toys and objects by their selves. A gripper can be assembled and controlled as well. Generally robotic arm manipulators are expensive, heavy and difficult to set up. In contrast, Lego Mindstorms ® robots are portable, appealing to children and affordable; thus, they may be considered for long term use by parents and teachers at home or school [9]. Additionally these robots can easily be set up and operated by parents during play interactions with their children.

To the best of our knowledge, no study has investigated the effects of a robotic intervention on children's play at home, which is a naturalistic setting for the application of robots in the daily lives of children with cerebral palsy. Thus, the objective of this pilot study was to investigate the effect on a child's level of playfulness in a home-based robot intervention that promotes free play.

1. Methods

1.1. Participant

Ethics approval was obtained from the Ethics Review Board of the University of Alberta. A 4 year 7 month old girl with a diagnosis of cerebral palsy with spastic quadriplegia participated in this study with her mother. Her gross motor skills were level IV according to the Gross Motor Function Classification System (GMFCS) [15] and level IV according to the Manual Ability Classification System (MACS) [16]. She was able to sit on the floor without equipment for positioning, and was also able to creep on her stomach and crawl on her hands and knees very slowly. Her verbal language skills were limited, and her speech was only understood by those who know her very well. However, she was able to say yes and no and follow two-step instructions. She could hit the switches controlling the robot with her hands. According the Pictorial Test of Intelligence (PTI-2), her cognitive age was lower than 3 years [17]. According to her mother the girl tended to play with the same toys in the same way all the time and had problems focusing and engaged in an activity.

1.2. Design and Intervention

This study was a pilot study for a future multiple baseline design (MBD) across subjects. It was conducted at the participant's home where she played with her mother and her own toys. They chose 16 different toys (e.g. Ernie doll, walker toy, blanket, toy beaded necklace) to play with during the study. The mother-child dyad played on the floor. The toys were 1 meter from the participant. The 15 minute video recorded sessions were twice a week for 5 weeks. The study had two phases, a baseline and an intervention. During the baseline (two weeks), the girl and her mother played together with the set of toys. The child's playfulness was assessed through the Test of Playfulness (ToP) [1] by the researcher who was trained and calibrated on the test. The ToP is a standardized, reliable and valid measure for playfulness that consists of 29 items [1]. Once the level of playfulness was stable, the baseline phase was ended. The participant was then trained to make the robot move forward and turn according to a previous protocol [13] during 3 sessions over one week. Assessment of the robotic intervention started in the fourth week. The robot was available during the mother-child free play sessions.

1.3. Materials

The robot was a Lego MindStorms ® "rovertbot" vehicle with a shovel in front. These types of robots have been used in previous studies with children with motor impairment as a means for augmentative manipulation for play, cognitive development, and academic activities [9] [13]. The participant operated the robot using three switches (forward, left turn and right turn) through an adapted infrared remote control. The robot was programmed using the Lego Intervention System 2.0 programming language.

1.4. Data Analysis

Raw ToP scores were graphically plotted for visual comparison between phases. Statistically significant changes in level were determined using the 2-standard deviation (2 SD) band method. At least two consecutive data points of the intervention phase must fall outside the two standard deviation band of baseline measures for there to be a significant difference [18].

2. Results

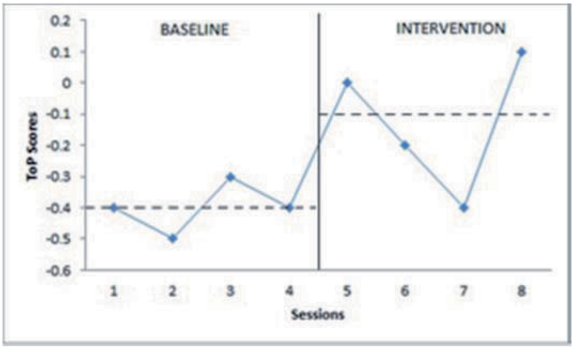

Figure 1. Mean ToP scores differences between phases.

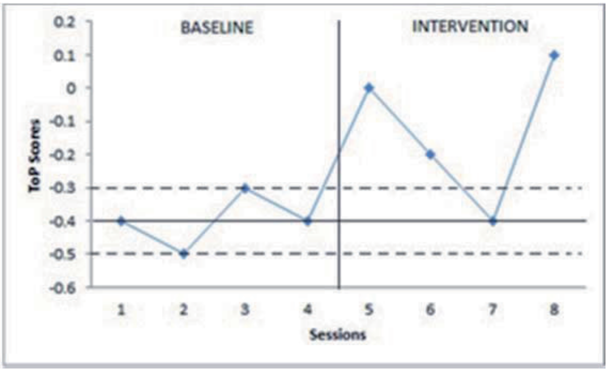

Figure 2. Changes according the 2 SD band method.

Figure 1 shows the visual analysis of the raw ToP scores. When the robot was introduced the child's playfulness increased (mean= -0.1) compared with the baseline (mean= -0.4), but the difference was small. The more negative the ToP score is, the lower the child's playfulness. Three data points fell outside the 2 SD band; thus, the child' playfulness significantly improved with the intervention (Figure 2).

3. Discussion and Conclusion

Playfulness is reduced in children with a severe motor impairment due to cerebral palsy [3] and this was evident in the study participant. In this study, the playfulness of a child with severe motor impairments increased with the introduction of a robotic intervention. Although the girl was interested in the robot, she did not use it during the entire 15 minute sessions. Her use of the robot during the free play sessions increased as the intervention progressed. The participant and her mother included the robot as part of their play in activities such as: 1) The robot pushed the walker toy pretending that the Ernie doll was walking towards the girl. When Ernie reached the girl, she hugged Ernie. 2) The robot picked up the beaded necklace, and took it towards her; then, she took it and put it on. 3) The mother hid the robot under the blanket and the girl hit the switches making it to move and uncover the toy. During these activities, the girl was operating the robot through the switches. Although the mother tried to modify their play by using the robot in combination with the other toys, the girl preferred to perform the same play activities she did during the baseline. For these activities, she was able to reach and grasp objects in an unskilled way despite her impaired manual abilities. She enjoyed familiar easy play activities such as wrapping Ernie with a blanket or hiding the toy beaded necklace, and during the intervention she tended to return to these activities. This preference may be explained by the fact that children with a motor impairment are often less persistent and prefer less challenging activities than able-bodied children [6]. In the seventh session maybe the girl felt pushed to play with the robot by her mother who provided a lot of prompting and the girl got frustrated.

Operating the robot demands cognitive skills that could be excessive for a child as young as 4 years old with a cognitive delay. The participant could make the robot move, stop and turn with prompting, but she was not able to use two switches to perform two different activations on sequential steps to accomplish a final result (e.g., sequencing:

turn the robot, then go forward). Previous research has indicated that the child's cognitive age as determined by the PTI determines success for operating a Lego robot. Five year olds typically developing children successfully carry out the highest task (sequencing) required for controlling the robot in two dimensions, while 86% of the four year olds and 25% of the three year olds were successful in this task [19]. Thus, it is not surprising that the participant in this study, who had a PTI cognitive age of 3 years old, had difficulty learning to control the robot. More differences in the playfulness scores may be observed for children with a more severe motor limitation who are older than five years old. They may find it easier to operate the robot, so they may use the robot more frequently during play than in this case.

In the planned MBD protocol the number of participants will increase giving more confidence in the strength of the results. Additionally, a second calibrated rater will assess 20% of the videos for inter-rater reliability, and a Rasch analysis will be done with the raw ToP scores for statistical analysis by the ToP's author. A longer intervention may be needed in order to provide more time for the child to practice the skills for operating the robot. Some instructions to mothers will be adjusted in order for mothers to not feel pressure to make the children to use the robot, but encouraging the child to play with the robot as another toy.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-167

The Neurophysiology of Augmentative Manipulation: A Method for Technical Implementation

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Abstract. The most well-known form of infant learning is motor experience. The strong relationship between motor and cognitive development suggests that the limited motor experience of children with physical disabilities can impact their cognitive and perceptual development. The assessment of cognitive skills of infants with physical disabilities is also compromised due to limited verbal communication and motor gestures. Robots have been used to give children with disabilities an opportunity to independently manipulate objects around them and to reveal their cognitive skills when they use the robots. However, little is known about the neural correlates that subtend robotic augmentative manipulation and its impact on the underlying mechanisms of neuroplasticity. Several technical considerations pose a challenge to such studies. This paper presents a methodology for the implementation of neurophysiological exploration of robot augmented manipulation. Preliminary results of an adult pilot study are presented. Advantages and disadvantages of this method for technical implementation are discussed.

Keywords. Augmentative manipulation, robots, neurophysiology, EEG.

Introduction

Motor experience plays a central role in cognitive and perceptual development. Through physical manipulation, exploration and interaction with the environment a child develops perceptual and social skills that will allow him/her to learn and act on the world [1,2]. Object manipulation is a critical part of motor experience that enables the child to acquire skills required for learning, symbolic and referential communication and understanding relationships between objects and their environmental interactions [1, 3, 4, 5].

The strong relationship between motor skills and cognitive development suggests that a lack of motor experience can result in cognitive and perceptual delays [6]. Children with physical disabilities can lose opportunities to develop and demonstrate skills and have limited ability to physically manipulate objects [7] compromising the quality of their play and learning skills [8].

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Several studies report the use of robots as augmentative manipulation systems by children with severe physical disabilities [9, 10, 11, 12, 13]. In these studies children independently controlled robots using switches adapted to their capabilities and needs. The characteristics of switches, such as simplicity, portability and safety, offer a means through which the child's independence and control over the task and environment increases [14]. By using robotic systems for augmentative manipulation, children's participation in academic and play activities, expressive language and level of engagement increased as reported by parents and teachers.

The outcomes of robotic augmentative manipulation systems use have largely focused on the perceptions of parents and teachers and the attainment of academic, play or therapeutic goals. The required cognitive and perceptual skills of direct manipulation of objects and of robotic augmentative manipulation are not equivalent. Little is known about the cognitive and perceptual benefits of augmentative manipulation using robots in early infancy. The use of neuroimaging techniques to support the study of augmentative manipulation can reveal its effect and implications. However, the nature of the manipulative task limits the use of techniques that are susceptible to movement artifacts such as fMRI and Magnetoencephalograpgy. The use of Electroencephalography and Event related potentials (ERP) provides an alternative for the functional analysis of brain function with the advantage of high temporal resolution and low cost. These neurophysiological measures are widely used to study cognitive development in typically developing children and have specifically been used to explore the substrate of early cognitive function. The integration of robotic systems and electrophysiological measurement creates technical challenges that are described in this paper. A method for technical implementation was designed and developed. A pilot study was first conducted with adult participants in order to test the technical implementation. This paper presents this technical implementation.

1. Method

1.1. Objectives

The main purpose of this study methodology is to identify the neural and behavioral correlates of early cognitive development. This methodology can also allow the exploration of whether robots can be used by infants with disabilities to reveal their cognitive skills. The purpose of this pilot with adult participants was to design and test the technical implementation of an augmentative manipulation system and the use of neurophysiological assessment.

1.2. Task

The A not B task with invisible displacement, developed by Piaget [4], was chosen for the future study, therefore was used for the current pilot. In this task children are exposed to an attractive toy hidden in a container. The container is moved to location ***A***. A screen is placed in front of the child and after a delay the child is allowed to search and retrieve the toy. Then this procedure is repeated. This time, after a screen is placed between the child and the container, an exact and empty container is placed on the opposite side, location ***B***. The child is encouraged to search for the object [15]. This task challenges children between 18 and 24 months, who often continue searching at the previously successful location, in spite of seeing the object being moved (perseveration) [16, 17]. Piaget's interpretation of this behaviour was that children at this age still associate the object with a previously successful scheme [4]. The ability to overcome this perseverative behavior results as the child engages in sensory motor behaviors acting on the environment. The nature of perseveration remains controversial. Other theories claim that preservation is a result of the child's difficulty inhibiting the reaching motor patterns in spite of cognitive understanding of the toy's location [18]. The strong relation between cognition and motor action in this task makes an accessible robot suitable for use with children with congenital physical impairments.

1.3. Robot Augmentative Manipulation System

For this study, participants had to find and retrieve the toys by using three conditions: 1) using a robotic arm for manipulation; 2) directing the researcher to the desired container and objects by using eye gaze; 3) reaching for and grasping the objects with their hands (as typically developing children would).

The half human size MiniMover- 5[2] robotic arm with six degrees of freedom was used [19]. The robot stepper motors enable base rotation, flexion and extension of shoulder and elbow, wrist flexion, extension, supination and pronation, and a gripper that can open or close. The robotic arm was programmed and controlled by a notebook computer running Microbot Control Center software[2]. The robot was programmed so that playback of a complete stored movement occurs when a switch is activated. Participants use three switches to activate the pre-stored robot movements.

1.4. Neurophysiology Recordings and Analysis: EEG and ERP

EEG and ERPs are non-invasive methods to study brain electrical activity in relation to behavioural responses and in situations in which the child cannot give a verbal response or no observable movement is present [20]. Electrical activity has temporal resolution on the order of 1 ms or better [21]. Cognitive processing can be studied in synchrony with the observed behaviour. EEG and ERP are also inexpensive compared to other neuroimaging methods [21].

EEG was recorded with the use of a high-density 256 channel Geodesic Sensor Net®[3] referenced to the central vertex electrode. Recording took place in an electrically shielded and sound attenuated chamber. Impedances were maintained under 50 kΩ and the signal was sampled at 250 Hz and filtered and amplified at a gain of 1000. Data analysis was conducted in NetStation® [3] and EEGLAB open source toolbox that runs in Matlab ®[4].

The use of neurophysiological measures in cognitive tasks relies on the use of software primarily designed to provide a template for the creation of computerized behavioral experimental tasks. Based on the designed experiment, participants were presented with a screen in which certain stimuli are presented. The participants' responses were collected and analyzed. E-Prime®[5] presentation software version1.2,

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2 Quest Technologies, Farmington Hills, Michigan

3 Electrical Geodesics Inc., Eugene, OR

4 Mathworks, Natick, MA

5 Psychology software Tools, Inc., Sharpsburh, PA.

the most widely used software for visual and auditory experimental stimulation [22] was used.

1.5. Participants

A pilot study with adult participants was conducted in order to test the functioning and reliability of the technical implementation before proceeding with the infant study. Participants completed one session in the EEG Lab of the department of Psychology, University of Alberta. Fifteen right handed graduate students at the University of Alberta participated in this adult pilot study. This paper presents the instrumentation including the design of a custom-made interface, and the methodological challenges based on the preliminary results of the pilot participants (4 females and 2 males; mean age: 29.3 years, range: 23-34). All participants had normal or corrected vision. None of the participants reported having a previous history of neurological or psychiatric disorders, or taking any medications at the time of testing.

2. Results

Typically, exploration of neurophysiological substrates of cognitive function are obtained by designing an experimental task in which stimuli are presented on a screen and the participant responds by using the keyboard, or a response box with a set number of switches. These responses subsequently flag the EEG ongoing signal, making it easier to then extract the segments of interest. In the case of robot augmentative manipulation systems, the tasks and stimuli are dynamic and three-dimensional in nature, therefore not suitable for screen based response experimental designs. In the case of the A not B task, several events of interest replaced the standard screen presented stimuli: (1) when the barrier is lifted marking the beginning of a trial, (2) when the participant hits a switch to choose either side A or B for robot retrieval of the object, (3), when either cup is lifted, recognizing both the lifting and which cup was lifted.

A custom-made interface is required that can translate the stimuli described above into input signals that E-Prime can detect and use as markers for the EEG signal. For this purpose a custom-built wooden platform was designed to monitor the responses of the participant using three magnetic switches wired into the platform, and two switches controlled by the participant. E-Prime extensions for Net Station flagged the EEG signal for each of these events. The participant switch responses were connected to the robot to replay the stored movements. (See Figure 1). The wooden platform was wired through a common DB-9 connector typically used for the switch response box so that, events were registered by E-prime as keyboard inputs (see Figure 2).

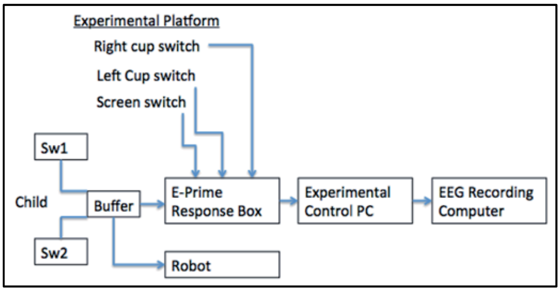

Figure 1. Platform and Robot set-up.

Fig.2. Experimental set-up.

Figure 3 Illustrates the electrophysiological set up with E-Prime® and NetStation®.

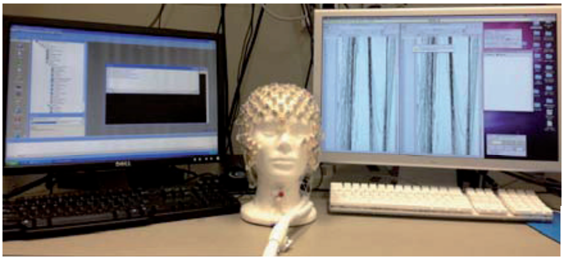

Figure 3. Neurophysiological measures set-up.

Participants achieved 100% rate of successful trials as expected. After signal processing and filtering, no signal noise caused by robot step motors was detected. An exploratory analysis of Event related potentials and EEG baseline to task comparison for the fifteen participants is underway at the time of submission. Final results will be available at the time of the conference.

3. Discussion

The main purpose of this adult pilot study was to explore the feasibility of implementing neurophysiological recordings in a robotic augmentative manipulation system study task while using a dynamic 3D task. The technical implementation presented several challenges that were solved by the design of a custom-built platform with hidden wired-in magnetic switches that were programmed into the stimuli presentation software as keyboard responses.

The acquisition of neurophysiology data of augmentative manipulation represents a first step for subsequent studies with infants and children with severe congenital physical disabilities that are underway. Even though the experimental setup can be challenging in exploratory studies, this constitutes a starting point for further investigation of robots and neuroimaging interactions.

Acknowledgements

The authors would like to thank Al Fleming for his invaluable contributions to the development of the instrumentation described in this paper.

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AT for Motor Limitations

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-175

Development of Input Device of Electric Wheelchair Considering the Characteristic of the Hand Function of Person with Severe Duchenne Muscular Dystrophy

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Abstract. Persons with the severe Duchenne muscular dystrophy (DMD) cannot operate the electric wheelchairs because of lack of muscular power and deformation of hand. To deal with this difficulty, the authors developed two new input devices. These devices were developed based on the evaluation of the hand function of persons with severe DMD. Thus these devices can be operated by slight force and movement of their fingers. Furthermore the shape of these devices is determined by considering the shape of the hands of persons with severe DMD.

Keywords. Electric Wheelchair, Input Device, Duchenne Muscular Dystrophy.

Introduction

An electric wheelchair is important mobility device to move independently, but there are people who cannot operate the joystick by disability. Muscular dystrophy is one of the diseases that causes the difficulty in operating the electric wheelchair. It is said that the patients' muscular power would decline gradually from proximal muscles to the distal one and no radical cure has been available yet. There are two major types of muscular dystrophy; one is *D*uchenne *m*uscular *d*ystrophy (DMD) and the other is *B*ecker *m*uscular *d*ystrophy (BMD). DMD has more rapid progress than BMD.

Previous research [1] focused on *B*ecker *m*uscular *d*ystrophy (BMD) and developed the force detecting interface which can be operated with the slight muscular power of the hand. But it was not available to person with severe DMD because the shape of the interface did not fit the hand deformed by DMD. It is said that the shape of hand and the muscular power are different for each person with severe DMD. Thus it is very important to understand the characteristics of each person with severe DMD and develop the appropriate input device for them.

The purpose of this study is to develop a new input device of electric wheelchair considering the characteristics of person with severe DMD. In this study, the authors evaluated the fingertip force, the range of motion and the shape of the hand of person with severe DMD and developed two new input devices of electric wheelchair considering the characteristics of them.

The experiment in this study was conducted under approval of Ethical Review Board of the National Rehabilitation Center for Persons with Disabilities in Japan.

1 Requirements of the Input Device for Person with Severe DMD

The authors observed and interviewed the daily living of 5 persons with severe DMD to grasp the requirements of new input device. Table 1 shows subjects' ID, age, stage of the functional classification of upper limb and experience of electric wheelchair each subject. The functional classification of upper limb indicates the degree of disability and the stage is the higher, the disability is the worse.

As a result of the observations and the interviews, three features among the subjects were found; that is, first, there is a limit of the range of motion of their upper limbs because of the decline of muscular power and arthrogryposis. Second, they often use their fingers instead of their arms in daily living. For example, they get their fingers creep instead of moving arm when they want to move their hand forward. Then hands of the subjects D and E are found to be deformed and the shape of them differs as shown in Figure 1 and 2.

Based on the above results and considering that the input device is used for operating electric wheelchair, the requirement of the input device was determined as follows. That is, the input device;

(1) can be controlled by slight power and movement of finger.

(2) has the shape to fit for the shapes of subjects' hands.

(3) can be set close to their hands.

(4) can control the direction and velocity of electric wheelchair.

Fig. 1. Hand of D.

Fig. 2. Hand of E.

Table 1. Detail of the subjects.

ID	Age	Stage	Experience of electric wheelchair
A	29	7	Using
B	26	7	Using
C	24	8	Used until 12 years old
D	25	11	Used until 16 years old
E	28	12	Used until 19 years old

2 Evaluation of the Hand Function

2.1 Problems of the Current Evaluation Methods of the Hand Function

There are two kinds of current evaluation methods of the hand function. One is Manual

Muscle Testing (MMT) [2], the other is Range of Motion measurement (ROM) [3]. MMT is used to evaluate the fingertip force. A measurer adds force to patient's finger directly and evaluates patient's resistance according to the six levels. The problem of MMT is that the method depends on the measurer's subjective evaluation and no quantitative result of the force is included. ROM is used to measure the range of motion of fingers. To measure the angle of joint, a measurer crooks patient's finger. The problem of ROM is that the method cannot evaluate patient's own ability because the measurer crooks by him/herself the patient's fingers. The authors suggest a new evaluating method of the hand function to solve these problems

2.2 The New Evaluation Method of the Hand Function

The joint coordinate system of finger was defined as shown in Figure 3. The origin of the thumb was set on CM joint and the origin of four fingers was set on MP joint. The evaluations were carried out for three fingers; thumb, index finger and middle finger. The fingertip force was measured by a 3-axis force sensor. The sensor was attached on the tip of universal arm as shown in Figure 4 to locate the sensor close to patient's fingertips. A subject was asked to press the sensor to each axis direction for 10 seconds and the mean value of the last 7 seconds was used as the fingertip force.

The range of motion of finger was measured by the motion capture method. Colored markers on the patient's fingers were recorded by 5 camcorders and the video data was analyzed by the analysis application software called Kineanalyzer (KISSEI COMTEC). As shown in Figure 5, four markers called "triplet marker" which are triangle shaped and with three different colored points were attached on the center of the nail and on the other three joints of a finger to make tangential planes on the fingers. A subject was asked to move finger to the direction of each axis 10 times and the mean value of the movable range of the center of the nail was regarded as the range of motion of the subject.

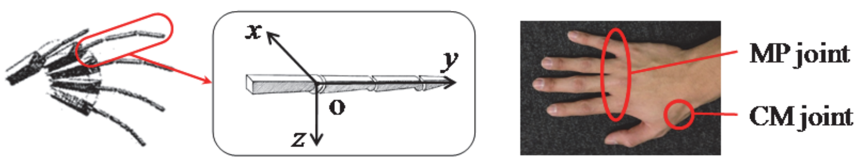


Fig. 3. Dynamic link model of hand and joint coordinate system.

Fig. 4. Measurement of the fingertip force.

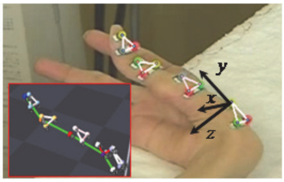


Fig. 5. Measurement of the range of motion.

2.3 The Evaluating Result of the Hand Function

The hand functions of 5 subjects were evaluated. The authors focused on their thumbs because the thumb's function tends to be remained more in particular than other fingers. Figure 6 shows the range of motion and the fingertip force of the subjects' thumbs. Horizontal axis represents the range of motion and vertical axis represents the fingertip force. The authors chose subject D and E to the model for the new input device because the fingertip force of subject D and E was weaker than that of A, B and C. Subject D has about 0.8 N forces in all directions. Although the range of motion in Y direction is narrow, the range of motion in X and Z directions remained more than 20 mm. Although subject E has weak force in Y direction, he has more than 0.6 N forces in X and Z directions. The range of motion of subject E left more than 20 mm in all directions.

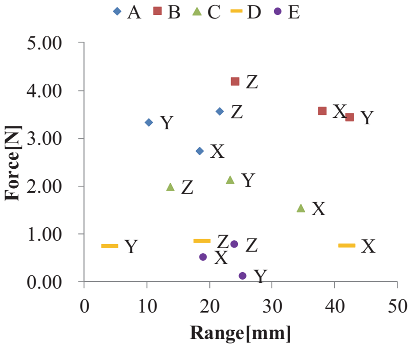


Fig. 6. Thumb's function.

3 Development of New Input Devices of Electric Wheelchair

3.1 The Prototype of the Input Device

The authors developed two types of the input devices for each of the two subjects. The shape of the input device was designed first and then the input method was considered.

There was a space between the thumb and palm because subject D remained the movement at the CM joint of the thumb and at the MP joints of the four fingers. According to the remained characteristic, the shape of the input device was designed like an egg so as to fit in the space. All the MP joints of four fingers of subject E were unmovable and there was a slight gap between the thumb and index finger. Thus the shape of the input device was designed like a sheet so as to put in the gap.

Subject D could move his fingers 20 mm broad or more in the two directions X and Z, thus a micro joystick was selected as the input method to pick up the movement of the fingers. The authors attached the T-shaped stick to the micro joystick and limited the range of motion as shown in Figure 9 so that it can be operated by less than 0.3 N and 10 mm broad. Although subject E also could move his fingers 20 mm broad, various motion values were found on subject E in the repetitive measuring. Thus there was choice of the micro joystick and the force sensor. In this study the authors finally choose the micro joystick because the force sensor was too expensive to adopt and its input value was not stable because of the influence of the electrical noise.

Fig. 7. Egg-shaped.

Fig. 8. Sheet-shaped.

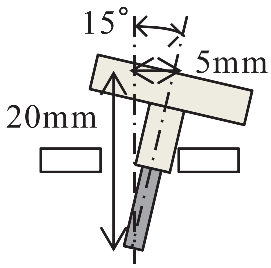


Fig. 9. Micro Joystick attached the T-shaped stick.

Improvement of the shape of input device The authors got advices about the prototypes from subject D, E, and also occupational therapists shown as follows;

- Egg-shaped device fit in hand well, but it was difficult to adjust the position and the direction of device because the size was larger than the appropriate.
- Sheet-shaped device could be held in right hand well, but it should also be fixed by left hand considering the stability.

Based on these advices, the discussion with them and considering that the device would be held by the subjects' hands, the authors redesigned the shape of the input devices. The redesigned device for subject D was smaller than before and it could be held and operated as shown in Figure 10. The device for subject E redesigned like a stick so that subject can fix the device by his four fingers of right hand, his left hand and his stomach and it also could be held as shown in Figure 11.

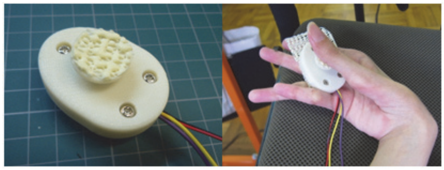


Fig. 10. Input Device for subject D.

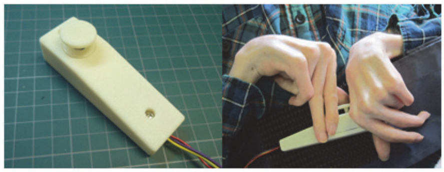


Fig. 11. Input Device for subject E.Evaluation of input devices.

3.2 The Purpose and the Method of Evaluation

The authors conducted evaluation experiments for subject D and E as below to find the operability, the usability and the utility as a controller of the electric wheelchair.
1. Subjects were asked to move the T-shaped handle of the device in a circular motion to find the range.
2. Subjects were asked to control a marker so as to overlap the target marker to evaluate the operability and the utility of the device. The two markers are displayed on the screen of a PC. The XY coordinate system was set as shown in Figure 12, and the signal of the micro joystick determines the position of the marker controlled by subjects. The position of the target marker provided the seven patterns as shown in Table 2. These patterns correspond to the actual movement of the electric wheelchair. The target marker did not move in task 1, 2, 3 and 4 and it moves regularly in task 5, 6 and 7. Subjects can start the tasks anytime they like because the tasks are get started when the controlled marker corresponded with the target marker. The positions of the two markers were recorded on the PC.

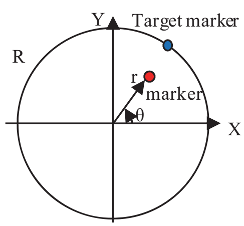
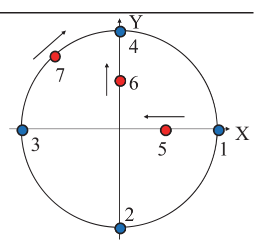


Fig. 12. Screen.

Table 2. Detail of the task (ω=36[degrees/s]).

Task	Target position (x , y)	time t[s]	movement of electric wheelchair corresponding
1	(R , 0)	10	Turn right
2	(0 , -R)	10	Move back
3	(-R , 0)	10	Turn left
4	(0 , R)	10	Move forward
5	(Rcosωt , 0)	20	Adjust the direction
6	(0 , Rcosωt)	20	Adjust the velocity
7	(Rcos(90(1+cosωt)) , Rsin(90(1+cosωt)))	20	Move without stopping



3.3 Result and Discussion

Figure 13 and 14 show the input ranges of subject D and E. Figure 15 shows the representative result of task 5. Table 3 shows the results of task 1 to 7. The achievements of the task 1 to 6 were evaluated by the mean value of distance between the controlled marker and the target marker. The task 7 was evaluated by the mean value of angular difference.

The input range of subject E was almost circular as Figure 13 shows and the achievement of the task was well. These results mean that the authors achieved the development of the input device which is appropriate for the fingertip force and the range of motion of subject E and the possibility that subject E can operate the electric wheelchair by using this device. But the lack of lower right of the circle and the sudden change of the value like 11 seconds in Figure 15 were observed. These may be caused by the slip of thumb on the T-shaped stick. It is necessary to change the material of the T-shaped stick or make a dent on it according to the direction of thumb.

The input range of subject D, the right half in particular, was found to be limited as Figure 14 despite the input device was designed to be operated in the range of 10 mm broad and the movement of thumb more than 10 mm was observed at the time of experiment. In addition trick motion tried to use not only the thumb but also the four fingers was observed. These may be caused by the decline of fingertip force of abduction direction because it had been a long while after the previous measurement. It is necessary to reconsider the input method which can be operated by the current fingertip force of subject D.

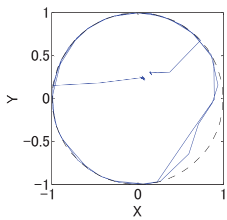


Fig. 13. Range of subject E.

Table 3. Result of the task.

Subject	Task1	Task2	Task3	Task4	Task5	Task6	Task7
D	No data	No data	0.002	0.002	No data	0.389	43.3°
E	0.0	0.006	0.001	0.0	0.142	0.151	8.0°

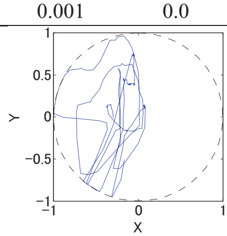


Fig. 14. Range of subject D.

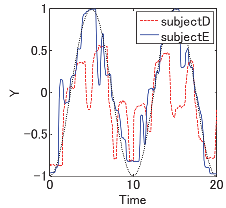


Fig. 15. Result of task 5.

4 Conclusions

This paper proposed an input device of electric wheelchair considering the characteristics of the hand function of person with severe DMD.

- The authors found the requirements of input device based on the survey of daily living of persons with severe DMD.
- The authors suggested a quantitative evaluating method of the fingertip force and the range of motion of finger and measured these of person with severe DMD.
- The authors developed two new input devices considering the fingertip force, range of motion of finger and the shape of hand of two persons with severe DMD. It is revealed that the input device which can be operated by person with severe DMD can be developed by considering the hand function of them.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-183

Evaluation of Physical Load While Propelling Manual Wheelchair on Cross Slope Road and Wave Road

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Abstract. A vertical and cross slope, waves (unevenness) of a sidewalk are significant barrier to the mobility of wheelchair users. In Japan, the Law for Promoting Barrier-free Transport and Facilities for the Elderly and the Disabled specifies that a cross slope in sidewalk is recommended to be 1% gradient or less and it is allowed to be no greater than 2% when it is unavoidable. However, it is necessary to clarify the evidence for the guidelines how changes in a cross slope gradient affect the accessibility and the physical load of wheelchair users. And the objective assessment of barrier-free road construction to resolve wave-road should be investigated. The objective of this study was to experimentally clarify the relationship between the cross slope of an actual sidewalk environment and the physical load of wheelchair users by the oxygen uptake and the wheelchair propelling force. Our experimental results showed that the physical load of a wheelchair user in the 2% cross slope was not so strong statistically compared with the level surface. On the other hand, the required force of a downhill side handrim was significantly greater than that of an uphill side handrim. This unbalance of propelling force caused by the cross slope would increase the physical load of wheelchair users especially with hemiplegia. The reduced oxygen cost index indicated that the barrier-free road construction was effective for improving the accessibility of wheelchair. Based on these findings, we propose the evidence of a wheelchair user's physical load while propelling a cross slope and a wave-road.

Keywords. Manual Wheelchair, Cross Slope, Wave Road, Physical Load, Mobility, Barrier-free.

Introduction

A vertical and cross slope of a sidewalk, and a wave-road are serious barriers for wheelchair users. Here, a wave-road means uneven sidewalks that the gradient of cross slope might be variable. In Japan, the Law for Promoting Barrier-free Transport and Facilities for the Elderly and the Disabled and it's guidelines [1] specifies that the vertical slope of a sidewalk should be recommended to be 5% or less and it might be allowed 8% or less when it is unavoidable. The cross slope of sidewalk is an important cross-sectional design element to drain water from the sidewalk laterally. Japanese guidelines specifies that the cross slope should be recommended to be 1% or less and it might be allowed to be no greater than 2% when it is unavoidable.

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The recommended upper limit of a cross slope is the same as the Americans with Disabilities Act (ADA) [2] specifies that accessible routes to sidewalks have cross slopes gradient no greater than 2%. On the other hand, in the UK, the cross slope of sidewalk should not be recommended more than 2.5%, and the figure of 2.5% could be regarded as the maximum acceptable. Where possible, it is preferable to have a cross slope between 1 and 2%. In any cases, it is necessary to clarify the evidence for these guidelines how changes in a cross-slope gradient affect the accessibility and the physical load of wheelchair users. And the objective assessment of barrier-free road construction to improve the accessibility of a wheelchair should be investigated.

Yoneda et al. [3] found the relationship between the physical load of wheelchair users and side slopes and steps from the view point of wheelchair propelling force. Hashizume et al. [4] clarified how changes in a vertical slope gradient influence the physical load of wheelchair users in actual sidewalk environments. Brubaker et al. [5] studied about metabolic demand for a single manual wheelchair user, and the average cost of propulsion was found to be 4.4liter /km on a level treadmill and 5.6liter /km on the treadmill leaning at a 2° (approx.3.5%) cross slope, corresponding to a 27.3% increase in metabolic demand. Richter et al. [6] found that the power required for propulsion on the treadmill considerable increased for the 3° (approx.5%) and 6° (approx.10%) cross slopes were on average 1.6 and 2.3 times greater than the level setting. They suggested that users had to push harder when on a cross slope and this increased loading was borne by the users' arms, which are at risk for overuse injuries, so, exposure to biomechanic loading can be reduced by avoiding cross slopes when possible. However the previous studies were limited inside of laboratory or carried out on a treadmill, and the evaluation conducted in actual sidewalk environments is still remained. Holloway [7] investigated the effect of sidewalk crossfall (cross-slope) gradients (0%, 2.5% and 4%) on wheelchair accessibility using the Capabilities Model.

The objective of this study was to experimentally clarify the relationship between the cross slope in actual sidewalk environment and the physical load of wheelchair users by the oxygen uptake and the wheelchair propelling force.

Methods

The dynamic wheelchair propelling force was measured by using a torque meter equipped on a wheelchair (Kyowa Electronic Instruments) to analyze the required force when propelling on a cross slope road and a wave-road. The oxygen uptake values and heart rate were measured with the portable metabolic analysis system VO2000 (S&ME) and the heart rate monitor system S625X (Polar) (see Fig.1). The oxygen cost index (OCI) liter/meter has been considered as the objective index of physical load.

The physical load in the indoor level surface was evaluated before the assessment of a cross slope road and a wave-road. In this experiment, four unimpaired adult male subjects that were 22±0.8years, 65.5±5.1kg, and 176.8±5.4cm (mean ±standard deviation) propelled the wheelchair for 600m distance with 60 strokes (pushes)/minutes, and approximately 3.6 km/h speed. The experimental results showed that the heart rate, the oxygen cost index, the workload (workload per meter), and the power were 113bpm, 0.0054l/meter, 7676J (12.8N), and 12.3W respectively.

These same subjects were asked to propel the wheelchair in a cross slope road, a wave-road, and a barrier-free road. The strokes and speed to propel the wheelchair was set to be free of each subject. The experimental conditions were following;

- *Cross slope road*; the effect of the cross slope was examined in the driving school road. The average cross slope of road's center path was approximately 0.4%, and that of road's lateral side path was approximately 2% corresponding to the upper limit indicated by the guideline [1]. Those two paths were an oval figure, and the subjects propelled the wheelchair counterclockwise. The distance of road's center path was 245m, and that of road's lateral side path was 232m. (see Fig.2, Fig.3).
- *Wave-road and Barrier-free road*; the difference between the wave-road (before barrier-free construction) and the barrier-free road that was smoothed the rough parts of the wave-road was evaluated. The average vertical slope of the wave-road was approx. 2%, and the average cross slope was approx. 3%. In the barrier-free road they were reduced to approx. 1.5% vertical slope, and approx. 1.6% cross slope. The subjects propelled the wheelchair in the wave-road and the barrier-free road with the same distance of 226m. (see Fig.1, Fig. 4).

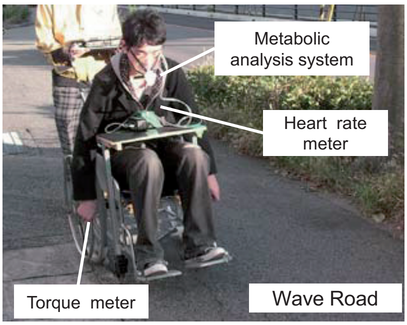

Fig. 1. Experimental wheelchair in Wave-road.

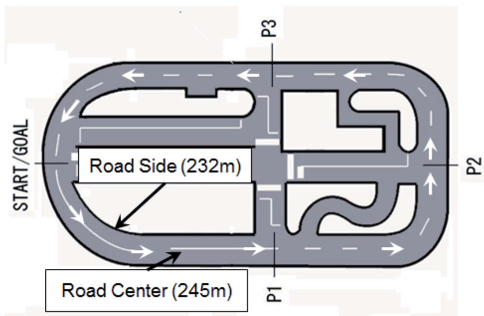

Fig. 2. Profile of Cross Slope Road.

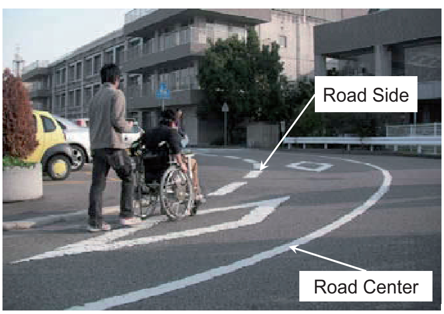

Fig. 3. Overview of Cross Slope Road.

Fig. 4. Overview of Barrier-free Road.

Results

The Effects of Cross Slope

In Fig.5 to 8, the results of road's center path (0.4% cross slope with 245m distance), road's lateral side path (2%, 232m), and indoor level surface (OCI and power: 600m, workload: 230m) were denoted by "0.4%", "2.0%" and "level 0%" respectively.

Heart rate, OCI, workload (workload per meter = N) and power were 139bpm, 0.0062l/meter, 4185J (17.1N), and 25.7W respectively in 0.4% cross slope. The results in 2% cross slope were 142bpm, 0.0080l/meter, 4366J (18.9N), and 28.0W respectively. The Borg Scale [8] is a simple method of rating perceived exertion and can be used to gauge subject's level of intensity in exercise. The Borg Scale was approx. 13 (somewhat hard) in 0.4% cross slope, and increased to approx. 15 (hard) in 2%.

Figure 6 shows the OCI of 2% cross slope was approximately 1.3 times greater than that of 0.4%. However, there was no significant difference of OCI in the cross slope conditions. Figure 8 presents that the average power of the both conditions in the 0.4% cross slope and the 2% showed a significant difference against the level surface (P<0.01: P value indicates the probability of statistically significant). Meanwhile the 2% cross slope showed no statistically significant effect to the workload (Fig.7) and the power (Fig.8) against 0.4% cross slope.

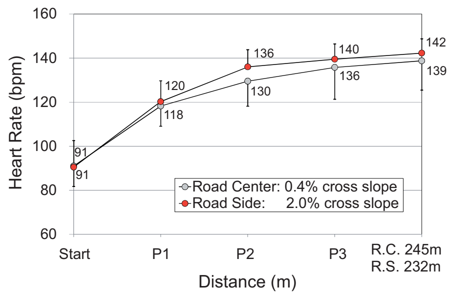

Fig. 5. Average Heart rate.

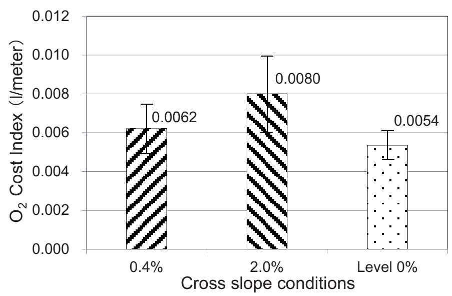

Fig. 6. Average O_2 Cost Index.

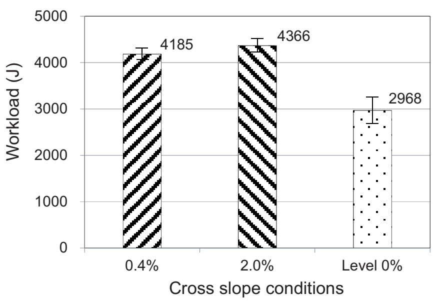

Fig. 7. Average Workload.

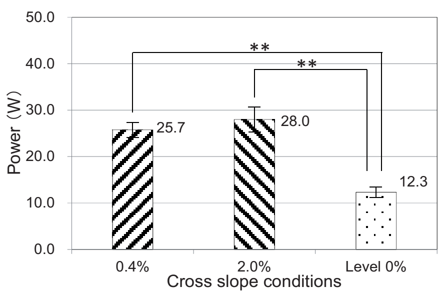

Fig. 8. Average Power (**P<0.01).

Table 1. Handrim Workload and Power for 0.4% cross slope, and 2.0% cross slope conditions.

	Workload (J)		Power (W)	
Condition	Left	Right	Left	Right
0.4% cross slope	1641 ± 102	2544 ± 145	10.0 ± 0.8	15.7 ± 1.1
2.0% cross slope	3239 ± 124	1127 ± 110	20.8 ± 1.0	7.2 ± 0.9

NOTE. Values are mean ± SD. While 0.4% cross slope: Left = Inside Handrim, Right = Outside Handrim
While 2.0% cross slope: Left = Downhill Handrim, Right = Uphill Handrim

Table 1 presents the subjects propelled the wheelchair counterclockwise in 0.4% cross slope, then, the power of the right (outside) handrim was approximately 1.6 times greater than the left (inside) handrim. While through the 2% cross slope, the left (downhill) handrim was propelled stronger than the right (uphill) handrim not to turn downhill in the direction of the cross slope. Then, the power of downhill side hand rim was approximately 3 times greater than that of uphill side.

The Effects of Barrier-Free Construction against Wave-Road

The average heart rate value at goal showed an increase of 152bpm in the wave-road (before construction) and 146bpm in the barrier-free road (after construction) (Fig.9). The Borg Scale in the wave-road was reduced from 15 (hard) to 13 (somewhat hard) by the barrier-free construction. The OCI of the wave-road (0.0123 l/meter) was reduced to approximately 2/3 by the barrier-free road (0.0082 l/meter) with a statistically significant ($P<0.05$) (Fig.10).

The workload 7069J (31.3N) in the wave-road was slightly decreased to 6690J (29.6N) by the barrier-free (Fig.11). In contrast, the average power increased to 42.7W after construction against the wave-road 35.9W, and statistically significant difference was observed between them ($P<0.05$) (Fig.12).

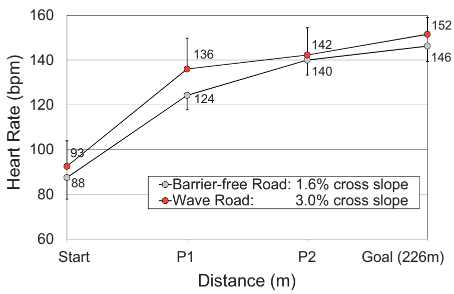

Fig. 9. Average Heart rate.

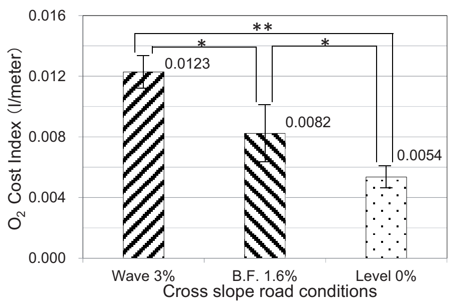

Fig. 10. Average O_2 Cost Index (*$P<0.05$, **$P<0.01$).

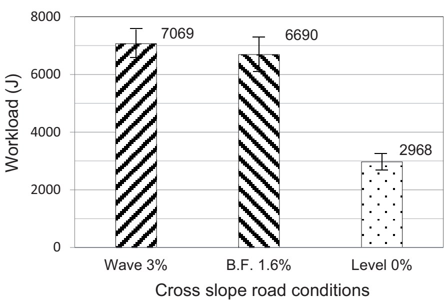

Fig. 11. Average Workload.

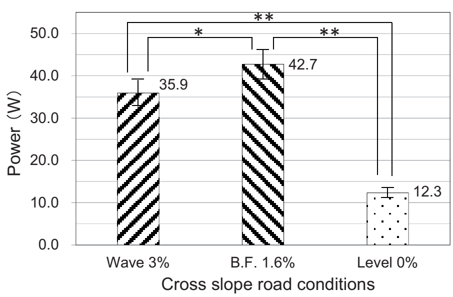

Fig. 12. Average Power (*$P<0.05$, **$P<0.01$).

Conclusions

The experimental results in the cross slope road indicated that the physical load of wheelchair user in the 2% cross slope was not statistically-significant difference compared with in a level surface, and were consistent approximately with the previous studies. Yoneda et al. [3] pointed to the absence of statistically significant between the 2% cross slope and a level surface by the assessment of the load factor and the kinematic pattern of propelling wheelchair. Holloway [7] also concluded that current crossfall guidelines of 2.5% in the UK seem reasonable, and that inexperienced users may struggle when these guidelines are exceeded. It is seemed the findings of studies give the evidence that the 2% cross slope gradient affect low impact for the physical load of wheelchair users. However, while no statistically significant, through the long or even short travels in actual cross slope sidewalk, wheelchair users are at high risk by the stacking of the physical load. And, the unbalance of handrim's push force caused by a cross slope can be a severe problem especially for a hemiplegia patient.

The reduced oxygen cost index indicated that the barrier-free road construction was effective and useful for improving the accessibility of wheelchair. Concerning the increase of the power on the barrier-free road, it is necessary to consider the average travel time taken 3min 6sec in the wave-road was significantly decreased to 2min 24sec in the barrier-free road. In the barrier-free road and the wave-road, total oxygen uptake were 1.8 liter and 2.8 liter respectively, and it was considered that the energy spent in the barrier-free environment was much lower than in the wave-road. Furthermore, the efficiency of wheelchair propulsion (introduced by Hashizume et al. [9]) in the barrier-free environment was increased to 18% from 12% in the wave-road. The increase of the efficiency was clarified the evidence that the barrier-free construction contributed the improvement of the accessibility of sidewalk.

Experimental analysis was conducted to clarify how changes in a cross slope affect the physical load of wheelchair users. The conclusions reached were as follows:

1. While not statistically significant, the oxygen cost index (OCI) of the 2% cross slope showed 1.3 times higher than that of the 0.4% cross slope. The significant unbalance between the downhill and the uphill handrim's push force was revealed through the wheelchair propelling in the 2% cross slope. The increased physical load by a cross slope may cause serious problems to propel wheelchair especially for hemiplegia patient and the development of secondary disorders or overuse injuries for wheelchair users. We should pay attentions to reduce such a risk.
2. The OCI of the wave-road (3% cross slope) was reduced to 2/3 by the barrier-free road (1.6%) with a statistically significant. The reduced OCI indicated that the barrier-free construction was effective for improving the accessibility of wheelchair.
3. The statistical difference of the OCI and the wheelchair propelling power in barrier-free road against a level surface was still remained. The fact showed a considerable physical load existed in an actual sidewalk environment. In order to realize the accessible sidewalk environments for everyone, it is important issue that the continuous and proper maintenance of a sidewalk to reduce a cross slope.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-190

Environmental Barriers and Use of Mobility Devices

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Abstract. Aim: To describe outdoor barriers in the nearby home environments of very old people, and to investigate whether the presence of these environmental barriers differed between users and non-users of mobility devices (MDs). **Method:** Baseline data on 397 Swedish people aged 80-89 years, collected with a study-specific question on MD use and a subset of the environmental component of the Housing Enabler instrument, assessing the outdoor environment nearby home, were used. Descriptive statistics were used for data analysis. **Results:** The most frequent outdoor environmental barriers nearby home concerned walking surfaces, level differences, manoeuvring spaces, seating and shelters. There were however no differences in the number of outdoor environmental barriers nearby home between users and non-users of MDs. The largest difference in presence for specific barriers in the nearby outdoor environment between users and non-users of MDs were for example complicated or illogical routes to/from the entrance, steep gradients, and letterboxes possible to reach only via steps or other differences in level. **Conclusion:** Even if the number of environmental barriers does not differ, there are differences between users and non-users of MDs regarding specific barriers. This implies that it is not the number of environmental barriers present that matters, but rather specific barriers that impact on MD use among very old people. For that reason, it is important to consider detailed information on environmental barriers as well as personal functioning to support performance of outdoor activities in everyday life for the ageing population.

Keywords. Outdoor Environment, Environmental Barriers, Mobility Device Use, Very Old People.

Introduction

Activity and participation in everyday life is important for health and well-being, and the ability to perform activities is crucial to an individual's feeling of independence [1]. Canes, wheeled walkers and wheelchairs are common mobility devices (MDs) used to compensate for functional limitations and to facilitate everyday life [2, 3]. There are, however, reasons for not using mobility devices, such as undesirable characteristics of the products and lack of fit between the physical environment and the device [4]. Mobility device users perceive that barriers in the physical environment affect the use [5] and in a previous study we found that outdoor environmental barriers nearby home predict the use of MDs [6]. Moreover, outdoor environmental barriers such as high curbs, uneven pavements [7] poor street conditions and hills in the nearby environment [8] affect activity and participation. To perform and participate in activities is a complex interaction involving the functional capacity of the individual as well as environmental factors. Therefore, it is important to explore the presence of specific barriers in the outdoor environment nearby home, in order to facilitate for older people

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that often experience decreased functional capacity and use MDs to perform activities in everyday life.

1 Aim

The aim of this paper was to describe outdoor barriers in the nearby home environments of very old people and to investigate whether the presence of these environmental barriers differed between users and non-users of MDs.

2 Method

The study design was cross-sectional, focusing on use of MDs and outdoor barriers in the nearby home environments in a sample of very old people. Data from the Swedish part of the ENABLE-AGE Survey Study [9], collected by experienced occupational therapists at home visits, were used.

2.1 Sample

At baseline, all participants (N=397) were single-living, aged 80–89 years, residing in ordinary housing; 75 % out of the total sample were women.

2.2 Data Collection and Data Analysis

Baseline data collected with a study-specific question on MD use and a subset of the environmental component of the Housing Enabler instrument (HE) (Iwarsson & Slaug, 2001) were used for the current study. The subset of HE consisted of 33 environmental barrier items assessed in the outdoor environment nearby home. Data on environmental barriers were missing for one person.

Descriptive statistics were used to study the frequencies of outdoor environmental barriers for users (n=184) and non-users (n=212) of MDs. Differences in total number of environmental barriers for users and non-users were tested with the t-test. Differences in presence of specific barriers were tested with chi-square tests, and the barriers were ranked according to the p-values obtained. The outdoor environmental barriers that differed the most between users and non-users (with p-values < 0.30) were thereby identified.

3 Results

The most frequent outdoor environmental barriers nearby home concerned walking surfaces, level differences, manoeuvring spaces, seating and shelters. The walking surfaces were uneven and irregular, and poor illumination of walking surfaces was common. Examples regarding level differences were refuse room/bin possible to reach only by steps or thresholds, high curbs, and the absence of tactile cues for level differences. Furthermore, limited space for manoeuvring, lack of seating places and inadequate shelter from weather were frequent.

The largest difference in presence for specific barriers in the nearby outdoor environmental between users and non-users of MDs were for example complicated or illogical routes to/from the entrance, steep gradients and letterboxes possible to reach only via steps or other differences in level. For details, see Table 1.

Table 1. Outdoor barriers in the nearby home environment that differed the most between users (n=184) and non-users (n=212) of mobility devices.

Barriers most common among users of MDs	Non-users (%)	Users (%)	P-value
Complicated/illogical routes to/from entrance	13.2	23.4	0.009
Steep gradients (more than 1:12)	15.6	23.9	0.036
Poor illumination of walking surface	82.5	89.1	0.063
No handrails on steep gradients	14.2	21.2	0.065
Insufficient manoeuvring space at refuse bin and/or letterbox	45.8	52.7	0.167
Unstable walking surface in parking space	32.1	38.0	0.214
Need to cross vehicular traffic when moving to entrance from the parking spaces for people with disabilities	9.4	13.0	0.254
Inadequate shelter from weather in passenger unloading zone	83.0	87.0	0.276
Extremely low, high or narrow seating surfaces	2.8	4.9	0.284
Barriers most common among non-users of MDs			
Letterbox can only be reached via steps or other differences in level	41.5	32.1	0.052
Landscape furniture placed in the path of travel	3.8	1.1	0.089
Kerb ramps with too much bevelled short sides	11.3	7.1	0.147
No marked parking spaces for people with disabilities within 10 m of the entrance	73.1	66.8	0.174
Rough ground at seating places	7.5	4.3	0.183

4 Discussion

Since in an earlier study we found that nearby home outdoor environmental barriers predicted the use of MDs [6], in the current study we investigated which those barriers were and whether there were differences in presence between users and non-users. The most common barriers identified, related to walking surfaces, level changes, poor illumination of walking surface and space for manoeuvring, can be assumed to affect older people when walking outdoors, especially if they have poor balance and/or limitations in stamina. Even pavements and lowered curbs are barriers that older people using MDs appraise in their environment [10] and dissatisfaction of MDs use has been shown connected to environmental issues; for example when environmental barriers put higher demands on the individual effort required to handle the device [11].

To have complicated or illogical routes to and from the entrance of the home can put higher demands on the individuals' physical as well as cognitive competences to perform activities in everyday life. Since a difference in presence of this barrier between users and non-users of MDs was seen, it could be understood as an example of how MDs are being used as facilitators for person-environment fit. That is, if the individual needs to concentrate on finding the way to the entrance, the MD give support and allows her or him to concentrate on finding the way rather than focusing on her or his physical mobility. This in turn allows the individual to focus more on the cognitive challenges when entering or leaving the home. Also the difference in presence regarding poor illumination of walking surfaces can affect the willingness to walk outdoors when it is not daylight. By increasing the lightning people might not only feel safe when it is dark; they might also have the opportunity to discover and master barriers such as uneven walking surfaces and level changes. Steep gradients either with or without handrails were more present in the environment among users of MDs, these barriers can also affect the feelings of walking safely and impact on whether the person takes a walk or not. Both hills and poor street conditions have been shown to have an impact on activity and participation for old people [8].

Barriers more common among non-users were connected to manoeuvring space and walking distance. Landscape furniture and other objects that reduce manoeuvring space might not be a problem as long as the person has the ability to walk safely, adjust to the situation or to choose an alternative way. On the other hand, it could also be that limited manoeuvring spaces not are that common among users since disturbing objects already has been removed in order to provide for MDs users' need of free pathways. Likewise, the walking distance to a parking space does not impact on the possibility to use the car as long as you have the ability to walk. However, when the ability to walk longer distances decreases, there might be problems to get to the car irrespectively if you use a MD or not. During the process of ageing, people often perceive decreased physical mobility which in turn can affect the willingness to go outdoors. Fear of going outdoors is common in old age [8] and can lead to avoidance of outdoor activities.

Applying a theoretical approach to understand the result of this study, the competence-press model [12] confirms that environmental press, such as the outdoor environmental barriers we studied, puts higher demands on the individual's competence. As the competencies often decrease during the process of ageing, very old people are more sensitive to environmental demands, impacting negatively on their activity performance. Even if the number if environmental barriers did not differ between users and non-users, there were differences between the two groups regarding specific barriers. This implies that it is not always the presence of number of barriers, but rather specific barriers that impact on MDs use among very old people.

In conclusion, it is important to consider detailed information on environmental barriers as well as personal functioning to support performance of outdoor activities in everyday life for the ageing population.

Acknowledgements

This study was supported by the Swedish Research Council and the Ribbing Foundation, Lund, Sweden. It was accomplished within the context of the Centre for Ageing and Supportive Environments (CASE), Lund University and funded by the Swedish Council for Working Life and Social Research.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-195

Automatic Kinodynamic Wheelchair Modelling for Architectural Design Accessibility Assessment

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Abstract. In this paper, we present a novel methodology to evaluate the wheelchair accessibility of architectural designs. The novelty is that the wheelchair operates under a fully dynamic environment using advanced and fast motion planning, which takes into account the virtual user's dynamic constraints. An elderly virtual user model has been tested under a hospital CAD design, depicting several and important accessibility issues.

Keywords. Wheelchair, accessibility, motion planning, virtual user models.

Introduction and Related Work

The present paper introduces a novel way of performing wheelchair accessibility evaluation to architectural designs. Related work includes mostly methods used in robotics motion planning converted for wheelchair simulation [1]. Yang Jing et al. proposes a methodology to estimate the reachable workspace of the wheelchair user [2]. The authors of [3] propose an inverse kinematics method to test the accessibility wheelchair users. All of the pre-mentioned methods do not take into consideration the dynamic capabilities of the wheelchair users.

The great importance of our system lies in the fact that it simulates the kinodynamics of a manually operated wheelchair model (Figure 1) in a fully dynamic virtual environment. An advanced motion planning algorithm has been implemented to drive the wheelchair to the target point. The proposed method uses the KPIECE algorithm [4], combined with customized path finding in order to produce realistic simulation results. Moreover, the motion planner takes into account the strength capabilities of a wide range of users, by taking into consideration the specifications of Virtual User Models. The proposed methodology has been intergrated into the VERITAS 3D Simulation Viewer, or VerSim-3D (Figure 2), which is part of the VERITAS simulation platform [5].

1. Wheelchair Modelling

The wheelchair is based on a manual operation design (Figure 1). It consists of seven parts: the seat, the four wheels and the two front wheel bases. Each part is modelled as a rigid body which has specific properties such as mass, position and orientation in space, as well as linear and angular velocities. The wheelchair can collide with the virtual scene environment and floor friction is applied to its wheels. The state of the wheelchair changes if forces are applied to the rear wheels. More specifically, the wheelchair's virtual user can push forward or pull backwards the handle of each rear wheel, resulting into four types of wheelchair motion variations: forward movement, backwards movement, left turn and right turn.

On each time instance the virtual user may apply a different pair of forces, one on each wheel handle in order to rotate them. The pair of forces F_{user} is defined in (1).

$$F_{user} = \left(F_{left}, F_{right}\right), \; F_L \in \left[-F_{Lpull}, F_{Lpush}\right], \; F_R \in \left[-F_{Rpull}, F_{Rpush}\right] \quad (1)$$

where the values of $F_{L/Rpull}$ and $F_{L/Rpush}$ are taken from the loaded Virtual User Model file specification.

The Virtual User Model (VUM) file contains values which are the result of the statistical analysis of biometric values collected from medical bibliography after fusion with data measured from real subjects via the VERITAS multisensorial platform [5]. More specifically, the VUM file is written in UsiXML language [6] and includes information relative to the motor, vision, hearing and cognitive capabilities of the Virtual User Model as well as information specifying its anthropometrics. In the wheelchair simulation only the motor and the anthropometrics sections are taken into consideration. A small portion of a VUM file is depicted in Figure 3.

The wheelchair model has 54 degrees of freedom (DoF). The DoF distribution is depicted in Table 1. A DoF is a free parameter of the wheelchair's system and may vary independently. A single wheelchair state is defined by giving values to each of its DoFs. Due to kinodynamic constraints, besides the position and rotation DoF, the wheelchair system has to also include velocity DoFs. Finally, the wheelchair's mass has been set to $20kg$.

2. Automatic Wheelchair Navigation using Virtual User Contraints

The wheelchair navigation in the 3d environment is based on a customized combination of the KPIECE algorithm [4] and the A* path finding [7]. The algorithm starts by dis-

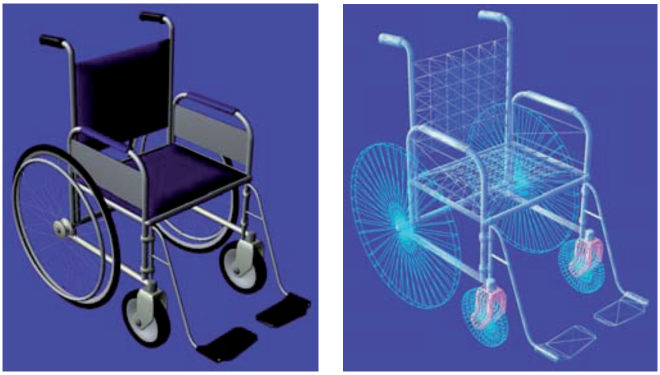

Figure 1. Wheelchair model: visual representation (left) and its collision primitive bodies (right).

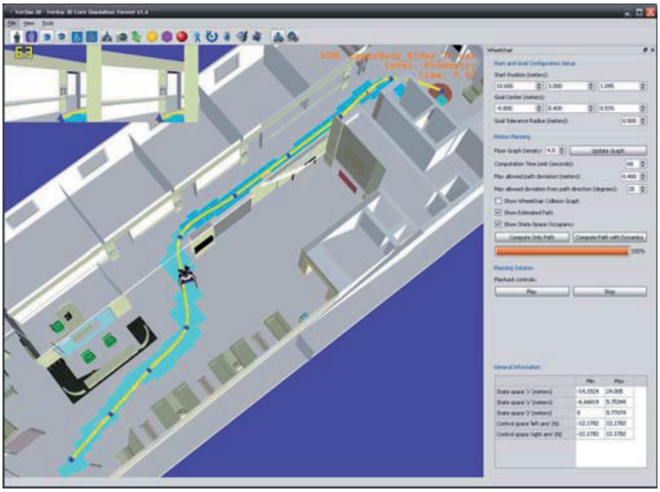

Figure 2. Graphical User Interface of the VerSim-3D tool depicting the wheelchair simulator.

```
<anthropometric>
    <weight measureUnits="kgr" value="81.023056"/>
    <stature measureUnits="cm" value="174.586060"/>
    <headLength measureUnits="cm" value="19.533623"/>
    <headBreadth measureUnits="cm" value="16.409887"/>
    <sittingHeight measureUnits="cm" value="92.134407"/>
    <bideltoidBreadth measureUnits="cm" value="48.190166"/>
    <waistCircumference measureUnits="cm" value="98.818848"/>
    <upperLimbAnthropometric leftRight="left">
        <shoulderElbowLength measureUnits="cm" value="33.710236"/>
        <forearmHandLength measureUnits="cm" value="47.450768"/>
        <bicepsCircumferenceRelaxed measureUnits="cm" value="25.926586"/>
        <forearmCircumferenceFlexed measureUnits="cm" value="28.615967"/>
    </upperLimbAnthropometric>
    <upperLimbAnthropometric leftRight="right">
        <shoulderElbowLength measureUnits="cm" value="33.710236"/>
        <forearmHandLength measureUnits="cm" value="47.450768"/>
        <bicepsCircumferenceRelaxed measureUnits="cm" value="25.926586"/>
        <forearmCircumferenceFlexed measureUnits="cm" value="28.615967"/>
    </upperLimbAnthropometric>
```

Figure 3. A small portion of a Virtual User Model file; the antropometrics section is depicted.

critizing the 3d mesh model of the scene into voxels (3d elements). The voxel size plays a crucial part in the path finding algorithm and in general smaller voxel produce a higher density model of the scene. However, increasing the voxel density has a great impact to the consumption of the computer resources (memory and CPU load). In our tests the voxels have been set to cubes with sides equal to 20*cm*, producing the best results while keeping the memory consumption in low levels. Additionally, the voxels that are not on the floor surface are completely ignored. Each voxel is assigned one of the following values: a) ”valid”, which is a passable floor region; b) ”invalid”, which denotes an obstacle region and c) ”controversial”, which is a region close to an obstacle, but can be passable under certain circumstances. Then, the A* search algorithm is used on the voxel grid and finds almost instantaneously a sub-optimal discretized path to the target, taking into account the bounding volume of the wheelchair and the virtual user. The final result is refined by fitting a Cubic Hermite spline to the orignal path points (Figure 4).

Table 1. Degrees of Freedom defining the wheelchair's state.

Wheelchair Property	DoF Number	Description
Global wheelchair position	3	Position is defined by a 3D vector.
Global wheelchair orientation	3	Orientation is defined by 3 Euler angles.
Wheels' rotation parameters	4×1	Each wheel can be rotated around its centre.
Front wheels steering rotation	2×1	The two front wheels may be also steered.
Linear velocities	7×3	Each wheelchair part has its own 3D linear velocity.
Angular velocities	7×3	Each wheelchair part has its own 3D angular velocity.
Total DoF	**54**	A full wheelchair state requires 54 values.

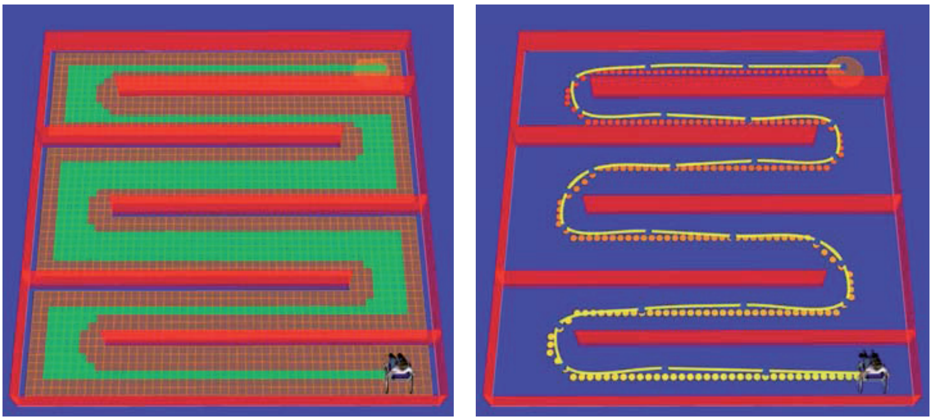

Figure 4. Path finding algorithm application; the target is denoted by the red circle. The voxel grid is depicted in the left image, where the passable and controversial regions are denoted by green and orange voxels repsectively. The path finding result is denoted in the right image, where both the A* path (dots) and the spline-fitting path are depicted.

The wheelchair motion planning problem is formally defined by the tuple of $S_w = (Q, U, I, F, f)$, where Q is the wheelchair's state space, U its control space, I denotes the starting state configuration, F is a set of valid target state configurations and f is the forward propagation function.

More specifically, for the statespace we have $q = (d_1, d_2, \dots, d_N)$, $q \in Q$, where d_i is a variable containing the values which a DoF may take and N is the number of DoF, where in our case $N = 54$. The control space contains all the F_{user} force pairs of (1). The starting state $I \in Q$ is given by the user by copying the current wheelchair's position and orientation to the wheelchair state and setting the rest DoF values to 0. The taget stateset $F \subset Q$ includes the infinite number of wheelchair states that are close to the provided 3d target point P_{target}, i.e. $F = \left\{q_f \in Q,\ where\ \left\|P(q_f) - P_{target}\right\| < r\right\}$ where $P(q_f)$ is the 3d position of the q_f state and r is the maximum valid distance from the predefined P_{target}.

The forward propagation function applies a control set to the current state and results into a new state, i.e.: $f : Q \times U \to Q'$. The function f takes into account the collisions with the scene obstacles, the user's dynamics. Moreover, it inserts two path related constrains: the position deviation from the path and the forward angle deviation, both being configurable by the user. These constraints result into reducing the search space of the KPIECE algorithm and provide natural and realistic solutions (Figure 5). The KPIECE

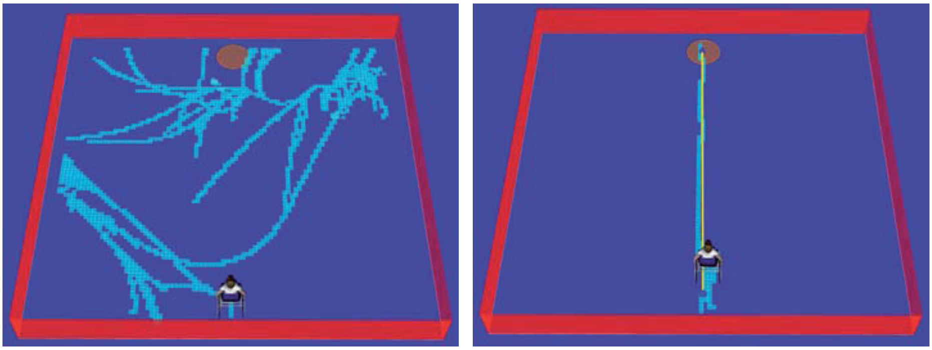

Figure 5. Using the KPIECE algorithm without any path constraints produces unnatural results (left image). Adding path constraints fixes the algorithm's irregular behaviour (right image).

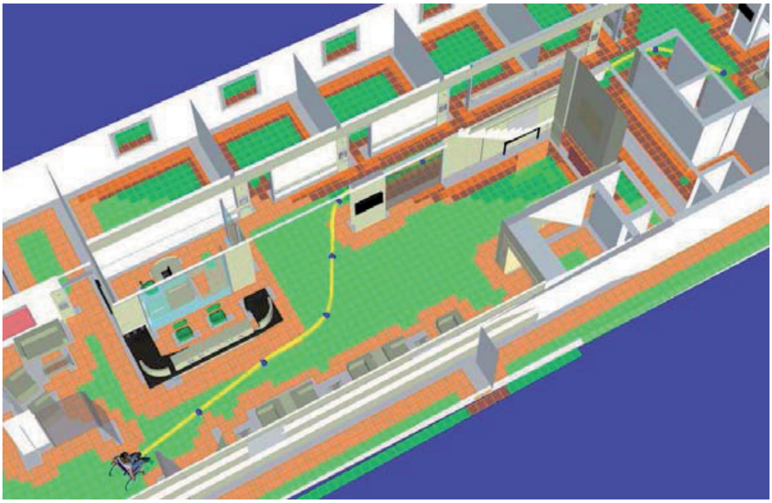

Figure 6. Wheelchair path finding in a complex hospital's CAD design. Some of the rooms in the top image region may be inaccessible as the controversial-voxel density is high near their doors.

algorithm was prefered over the RRT algorithm, because it converges a lot faster [4] - in our tests at least seven times faster.

3. Experimental Results

The proposed method was applied to a CAD design of a hospital ground floor to test its accessibility in terms of wheelchair navigation (Figure 6). The virtual user models of the average middle aged and elderly wheelchair female users were used. The elderly user had decreased strength capabilities compared to the middle-aged woman; around three times less in terms of the F_{user} values. Initially, the proposed methodology was applied to the interior of the hospital and found it to be generally accessible to both user models, despite some problems that would occur in some of its rooms, if a larger wheelchair model would be used.

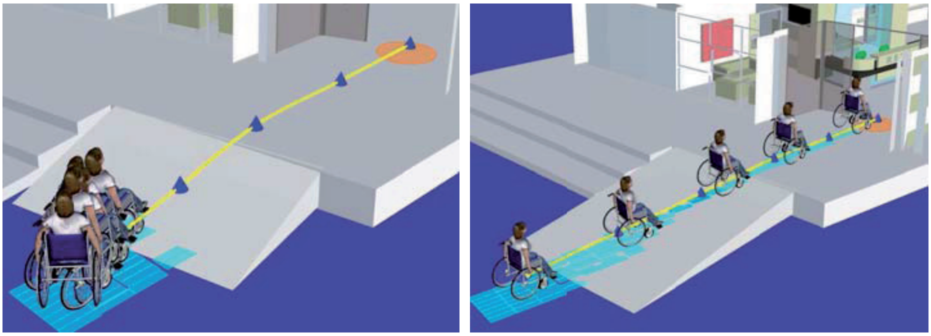

Figure 7. Testing the accessibility of a hospital CAD design: the ramp on the left image has been found inaccessible to the elderly Virtual User Model. Decreasing the ramp declination made the ramp accessible.

The hospital's exterior design was also tested. In its entrance the hospital had a ramp of 14° declination. The elderly was unable to pass the ramp, due to her limited strength capabilities (Figure's 7 left image). Decreasing the declination to 6°, made the ramp accessible and allowed the elderly woman to pass the declination without any problems (Figure's 7 right image).

4. Conclusions and Future Work

After several tests in simple and complex designs, it was observed that the proposed wheelchair accessibility testing methodology can be a very useful tool for the architecture designing community. The inclusion of dynamics to the wheelchair model produced a holistic assessment approach and have resulted into reporting accessibility problems that could not be found using current market tools. However, the current tool is still in research status and several improvements are possible, such as adding support for motorized wheelchairs and performing planning on multi-floor designs.

Acknowledgements

This work is supported by the EU FP7 IP VERITAS (FP7-247765).

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-202

Intelligent Wheelchairs: Filling the Gap between Labs and People

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Abstract. The works on Intelligent Wheelchairs (IW) have been an active research area in Assistive Technologies since its first prototypes in the 1980's. But more than 30 years after that promising start almost none (but a few) of those prototypes reached their final users. This work will try to analyze the problems that maintain those vehicles in the labs, far from the real people. Among the possible reasons for that, two main issues are the availability of suitable sensors (in terms of cost and reliability) and over all the lack of an appropriate standard platform in the market to build up an IW. In this paper we will focus our analysis on the platform problem. Under our point of view, it is mandatory to reduce the cost of any IW proposal by using a common framework from the more basic to the most advanced systems. To reach that goal, our proposal for an Intelligent Wheelchair framework take advantage of using standard Electronics systems and Communication devices (USB, CAN, WiFi) in order to guarantee its compatibility with other electronic subsystems and services around the environment (i.e. location based services) and to be able to follow the continuous upgrade of such subsystems.

Keywords. Intelligent wheelchair, Smart Wheelchair, Assisted Mobility, Distributed Control System, USB Wheelchair.

Introduction

Along the last decades there have been continuous and spectacular advances in several technological fields related with the mobile robotics systems. Better and cheaper sensors, actuators and embedded digital processors along with advanced control strategies have been the main results of such activities. Derived from those advancements, there has been also an active search for innovative applications for this kind of systems, some of them in the area of Assistive Technologies.

Already in the early 1980's some works at Stanford University [1] began to apply Ultrasonic Sensors (US) to an adapted wheelchair. Around the years 1990's, other research teams around the world began their works in developing innovative Mobility Assisting vehicles ([2] [3] and [4]). Those vehicles were similar in its initial conception to any standard mobile robot: a set of motors, wheels, sensors and controllers. Those activities were spreading out throughout the world in the pursuit of the so-called Intelligent Wheelchair (IW).

Nowadays, more than three decades after such initial works, just a few of such research reached their target population: those ones with strong mobility restrictions. During this period of time, new research teams have addressed the same task with more

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or less the same results. Then, how the people with severe handicaps could benefit from those advancements? Let's stop for a while to have a look backwards trying to identify the possible causes of the mismatch between labs research and the real world.

1 A Short Review: Intelligent Wheelchairs (and More) around the World

Keeping track of all the projects related with IWs is a heavy task. Currently there is high number of projects on the field and also there is a lack of a standard set of definitions about this kind of Mobility Assistance systems. In the scientific literature we can find different adjectives referred to such Wheelchairs like: Smart (SW), Intelligent (IW), Advanced (AW), Autonomous (AuW), Robotic (RW), and some other variations. Taking only those basic denominations into account and using Google Scholar as a searching engine, the evolution of scientific publications on those fields from the years 1980's can be recorded. Table 1 reflects such evolution in periods of five years; data from the last period (2010-2014) has been extrapolated assuming a short-term linear growth from the actual data (last column).

Table 1. Number of scientific publications about the listed concept in periods of five years. Source of information: searches on Google Scholar, till May 2013.

Five years period: **Concept**	**from 1980**	**from 1985**	**from 1990**	**from 1995**	**from 2000**	**from 2005**	**forecast 2010**	**actual 2010-13**
Advanced wheelchair	1	3	8	26	24	68	81	57
Autonomous wheelchair	0	2	11	95	189	322	356	249
Intelligent wheelchair	0	3	11	104	182	541	899	629
Robotic wheelchair	0	0	3	72	237	749	901	631
Smart wheelchair	3	4	13	59	80	391	544	381
Totals:	4	12	46	356	712	2.071	2.781	
Relative increment:		200%	283%	**674%**	100%	**191%**	34%	

The data from Table 1 cannot be thought of as a precise tool but it is useful to show the evolution of this field. It is clearly exponential with time, reaching currently about 500 references per year. From Table 1 some other conclusions can be derived:

- There is a huge increment of references in the 1995-1999 period. This effect can be related with the IJCAI'95 Robotics Wheelchair competition [5] that contributed to extend the interest in this field. In fact, the prototypes in that competition are among the most cited in the area [2] [3] [6] [7].
- The growth is lower in the 2000-2004 period but grows again between 2005 and 2009. This growth can be related with the application of new robotic strategies (for instance SLAM) to the IW problem.
- Finally, if the forecast for period 2010-2014 is correct, there are signs of a certain saturation on these topics because a relative growth of only a 34%.

As a conclusion, we may think that there is already a lot of accumulated expertise in this field, covering the entire world: U.S.A. [1] [6], Europe [4], Asia [8] [9], South America [10] [11], and more. We will not make here an extended review but there is an excellent compilation and analysis of the works up to 2004 in [12].

2 The Long and Winding Road to Market

The first work referenced here was the driving aid to quadriplegic users designed by David L. Jaffe in Stanford [1]. Despite the interest of this system as HMI to a robotic wheelchair [13] it is not commercially available. This has been also the case for other advanced HMIs, like Eagle-Eyes [14], which is available now as a communication tool but it was also tested for commanding wheelchairs on Wheelesley in the 1990's [2].

Going to 2005, in the review work from Simpson [12] he mentioned up to five commercially available Smart Wheelchairs (SW) or kits coming from four different companies. In 2011, only two of them [15] were still available:

- The "Smart Wheelchair" [16] [17], from Smile Rehab Ltd. (Scotland, UK) [18], available for children with cognitive disabilities,
- TAO-7, available from Applied AI Systems [19], but only for research.

How could we get IWs then? This is now the key issue [20]. Because the lack of commercially available IW, the transfer of all our accumulated expertise to people is blocked [21].

2.1 Looking for the IW Platform. First Problem: Industry.

To fill up the gap between labs and people we do need the active collaboration of the industry. Realistic productions plans are needed [15] in order to balance costs and demands in a very scarce market of potential users: those ones with strong mobility restrictions. The Fig. 1 summarizes the basic problem: too high costs for too little production, that is what we call "the inverted pyramids" question.

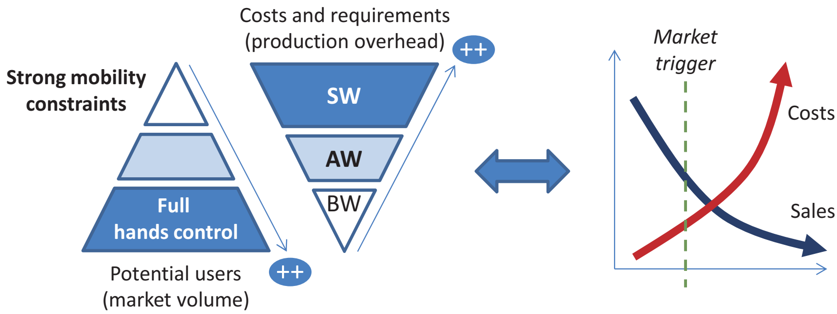

Fig. 1. The "inverted pyramids" question on Smart Wheelchairs (SW), related with a typical profile of market behavior. BW, AW and SW stand for Basic, Advanced and Smart Wheelchairs respectively.

To better understand Fig. 1 we have to assume that a Smart Wheelchair is not really a simple robotic platform: it must carry a person, the user, with comfort, safety and at a reasonable and affordable cost. Other important considerations are:

- If the user has a full control of his hands and other sensory abilities, this user will need only a Basic Wheelchair (BW), powered or not. That stands for the majority of potential users (base of the user's pyramid), so the cost of a BW is reduced also because the sales previsions can be high.

- There is also a big group of users that have got a reduced mobility on hands but can still maneuver a powered wheelchair with some electronics assistance (sensors and appropriate HMIs). The cost of such sensors has been lowering with time because big scale productions, for instance in the automotive industry. That stands for what we call Advanced Wheelchairs (AW).
- The smallest group of users, by far, is the one of those with strong mobility or sensory restrictions. They will need the best robotic sensors, the best processors and the best algorithms altogether with highly instructed personal for adaptation and maintenance of each SW to each user. So the SW costs are extremely high, which is represented by the upper base for the costs pyramid.

This model, as is, will not work: the cost is the highest when the potential market is the lowest. This is not affordable for any actual AT company unless:

- There were a massive injection of money from public instances, or
- The current cost of a customized Smart Wheelchair is lowered.

2.2 Second Problem: Suitable Sensors

This is another key issue about IWs. Sensors must be used in order to recognize the environment. But also they are essentials as safety devices by detecting obstacles and dangerous situations. From the beginning of IW research [22], safety issues were very important because the hard consequences derived from accidents like falling through stairs or curbs. The lack of sensors with enough reliability under a broad range of environments and situations kept the IW world mainly indoors.

This situation is about to change with the use of modern 3D sensors, able to deal with the outdoors challenge [23]. But this question will need more space than the one available here, so we will keep the focus on platforms: without them there will be no IW to put the sensors on.

3 Intelligent Wheelchair (IW) Architecture

Let's use the term Intelligent Wheelchair (IW) to identify a modular solution that could build Basic, Advanced and Smart Wheelchairs (BW, AW and SW) just using the same platform, modules and structure for all of them. This idea is shown in Fig. 2.

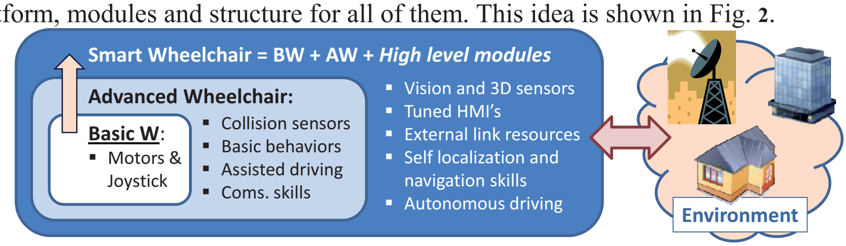

Fig. 2. The Intelligent Wheelchair model: from Basic to Smart Wheelchair by upgrading.

In this model, SW would benefit from a common framework and the reduced cost of a big scale production of fully compatible BWs. In between, some middle range behaviors, like Assisted Driving modes, could be implemented on a BW with a simple software upgrading. Further improvements can be installed also on top of that structure allowing a gradual evolution from a BW to the specific SW needed by any specific user.

Another key issue in that layered structure concept is using standard and high volume products as far as possible. That can be done almost in every point of this IW; for instance about the sensory system we could have:

- Basic Behavior Sensors: using low cost US modules and Vision sensors coming from the automotive and multimedia industry.
- Advanced Behavior Sensors: using up-to-date range sensors coming from the entertainment industry, for instance the new 3D Kinect sensors.
- Finally don' forgetting that the best sensor and controller ever is the user.

3.1 Intelligent Wheelchair: Our Proposal for a Common Framework

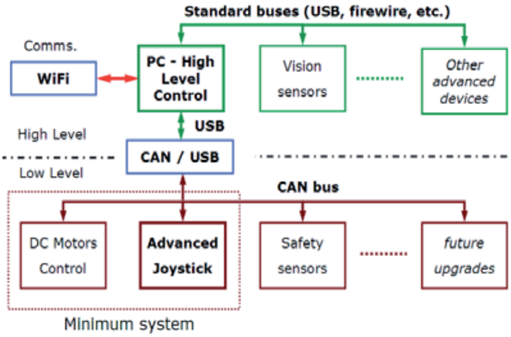

Fig. 3. General view and hardware architecture of the prototype of Intelligent Wheelchair.

Fig. 3 shows the basic prototype of Intelligent Wheelchair designed in our research group [10]. It summarizes the experiences derived from our former SIAMO project [4] [12], improving the standardization of it in a layered and distributed architecture.

The hardware architecture has a conventional robotic structure in two layers (high and low processing levels) formed by functional nodes interconnected by standard serial data links (USB, CAN, etc.). The use of standard modules and buses fulfil the standardization requirements. At the same time, this structure fulfils our IW proposal shown in Fig. 2. The BW can be constructed using just the motors and joystick (the minimum system). The AW and the SW levels can be done by adding the proper software and/or hardware modules.

Another advantage is that the BW could have a standard USB port available (the CAN/USB interface). So, any BW could behave like a standard peripheral to upper level controllers that links to the basic machine (the BW) through data and control messages. That helps to get lower development and exploitation costs by reducing both programming time and additional hardware requirements.

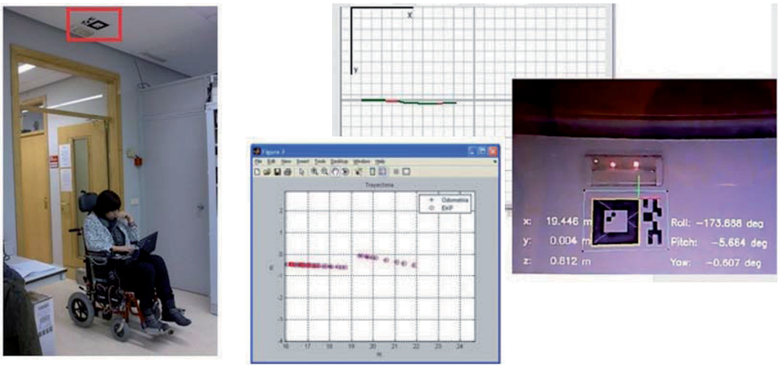

Fig. 4. The IW in an actual navigation test. An artificial landmark helps to correct odometry shifts.

Because the standardization in the interface with the IW, the connection of any external standard processor (like a laptop computer), running any kind of control algorithm is quite easy to do via the USB interface. The Fig. 4 shows one of these runs: a navigation algorithm, based on a Kalman Filter fusion strategy, has been installed in the laptop; the wheelchair uses motor encoders as odometry sensors, so there will be a position drift that must be corrected. The correction is done using a cost-effective absolute positioning system based on artificial landmarks placed on the ceiling; the vision sensor is a web-cam connected in a USB port of the control laptop.

The use of standard links simplifies the development of new control applications. As an example, Fig. 5 shows our IW being commanded with a Smartphone.

Fig. 5. Controlling the IW with a Smartphone, using the Bluetooth interface.

Present works on this IW prototype are devoted to take advantage of the inertial sensors available in modern personal processors like tablet-PCs. We are using the accelerometers, compasses, built-in cameras and, in general, any kind of built-in sensor to improve IW performances and usability altogether with the aforementioned reduction in cost and development time.

4 Conclusions

Throughout this paper we have seen that the works on Smart Wheelchairs have reached a high level of maturity after more than 30 years of research. Despite that, the industry has not shown enough interest in this field, so those advancements in research labs cannot reach to potential final users: those with strong mobility restrictions.

Apart from other considerations, like Safety issues and regulations, the first step is to reach the market. It is needed a standardization effort together (industry and labs) in order to have Smart-able wheelchairs available. The authors think that the proposal made in this paper, a layered and modular IW based on standard modules and interfaces, will help a lot in filling this gap between Labs and Users because the reduction of costs in every production phase (development, construction and maintenance). The advantages for research labs will be also related with the reduction of efforts while tuning a current powered wheelchair to the needs of any specific task.

Acknowledgements

This work has been supported by the Spanish Ministries of Economy and Competitiveness (project LORIS, ref. TIN2012-38080-C04-01), and Science and Innovation (project VISNU, ref. TIN2009-08984).

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-210

Understanding and Improving Power Mobility Use among Older Adults: An Overview of the Canwheel Program of Research

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Abstract. Power wheelchairs are an expensive yet essential form of assistive technology that can compensate for impaired mobility and improve quality of life for older adults. In this paper we provide an overview of the work of CanWheel, a Canadian research team dedicated to improving the mobility opportunities of older adults who use power wheelchairs. Through a program of research involving five individual studies, this team is addressing three basic questions: 1) How are power wheelchairs used now?, 2) How can power wheelchairs be used better?, and 3) How can power wheelchairs be better?. A brief summary of the status of this research is provided.
This study was funded by the Canadian Institutes of Health Research (AMG 100925). Salary/scholarship funds were provided by the Canadian Institutes of Health Research (PWR).

Keywords. Power Wheelchair, Wheeled Mobility, Intelligent Power Wheelchair.

Introduction

Mobility impairment is the number one form of disability for Canadians 60 years of age and older[1] and, with the aging baby boom population, the number of older Canadians living with mobility impairments will grow exponentially over the next 40 years. When mobility becomes sufficiently limited due to reduced physical and/or cognitive capacity, wheelchair assistance is necessary. With severe disability, individuals require the aid of power wheelchairs. Power wheelchairs can have a positive impact on the quality of life of older adults, including improved well-being and self-esteem, reduced pain and discomfort, and enhanced activity performance, participation and independence[2,3,4,5]. However, they are far from perfect in terms of their functionality, safety, and cost-effectiveness[3,6,7]. In addition to functional difficulties such as difficulty maneuvering in indoor spaces and difficulty transporting the power wheelchair,[3] cognitive impairment can also restrict the usefulness of power

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wheelchairs for some users. Safety for all users is also a concern[7]. For these reasons, it is critical to ensure that these devices meet users' needs and skill levels.

1 CanWheel

To improve the mobility opportunities of older adults who use power wheelchairs, the CanWheel Team was formed in 2009. Comprised of 14 scientists and clinical researchers, as well as 18 trainees from across Canada, this team has developed a program of research that uses a mixed-methods approach spanning five key research projects. This program of research, funded by a six year Canadian Institutes of Health Research (CIHR) grant, addresses three basic questions: (1) How are power wheelchairs used now?; (2) How can power wheelchairs be used better?; and (3) How can power wheelchairs be better?

2 The Five Canwheel Projects

2.1 Project I – Evaluating the Needs & Experiences of Older Adults using Power Wheelchairs

Despite over 30 years of development, there are almost no wheelchairs with intelligent technology on the market today[8], particularly for use by older adults. This may reflect insufficient technological capability, a mismatch between users' skills and the technology, or limited understanding of which technological advances are relevant and will promote function in end users[9]. This six-year project is crucial to the intelligent wheelchair technology that our team will develop as it will ensure that we create useful, usable technology.

The overall goal of this research project is to evaluate the effectiveness, impact, and relevance of power wheelchairs from the perspective of older adults, caregivers, health care providers, policy makers, and funding agencies. One of the objectives of this project, to investigate how older adults, caregivers, and health care providers perceive and experience smart wheelchairs and their concomitant influence on social engagement using qualitative interviews, has been completed. Selected findings supported the use of collision avoidance for power wheelchair users, particularly since concerns were raised regarding driving safety, specifically the risk for injury to others. Identified technology design issues included the need for context awareness in the intelligent system, improved reliability, and specifications for suitable user interfaces. The importance of the power wheelchair user maintaining as much autonomy as possible was highlighted and supported the need for a collaboratively-controlled intelligent power wheelchair[10]. Further work within this project will be ongoing collaboration with the Project III team to identify and prioritize the development requirements specified by the stakeholder groups.

2.2 Project II – the Natural History and Measurement of Power Mobility Outcomes

Initiating power wheelchair use in later life involves important challenges that are less relevant for younger users (e.g., familiarity with technology). To date, we have little comprehensive understanding of wheelchair use and limited empirical data to inform us how older adults adapt to their wheelchairs once the devices have been prescribed, including how these devices influence important indicators of quality of life particularly with respect to participation in social activities[11,12]. Moreover, few reliable and valid device-specific measures exist that enable us to evaluate relevant outcomes of older power wheelchairs users.

The overall purpose of this research project is to describe the variation in power mobility over time. Using a 1 year longitudinal study design, our objectives were to: (1) describe the natural history of power wheelchair use over a one-year period in cohorts of older adults who use power wheelchairs and their caregivers and (2) assess the reliability and validity of a power wheelchair outcomes toolkit. Power wheelchair user participants in this study complete an assortment of objective and subjective primary outcome measures, including the Assistive Technology Outcomes Profile for Mobility, Life Space Assessment, Wheelchair Use Confidence Scale, and Wheelchair Skills Test. Caregivers complete the Caregiver Assistive Technology Outcomes Measure and Wheelchair Skills Test. Both groups complete the Late Life Disability Index, Hospital Anxiety and Depression Scale, and Interpersonal Support Evaluation List as secondary outcomes. Currently 127 power wheelchair users and 35 caregivers have been enrolled and data collection is expected to continue up until December 2014. Preliminary results demonstrate that new power wheelchair users demonstrate a trend towards improved wheelchair skills, decreaseed anxiety and increased depression. In general, experienced power wheelchair users demonstrate stability[13]. Preliminary findings from the caregiver perspective suggest that the psychological burden of caring for a power wheelchair user is greater than the physical burden. Psychometric properties of the outcome measures in the toolkit are also showing promising results.

2.3 Project III – Strategies and Platforms for Collaboratively-Controlled, Environmentally-Aware Wheelchair Innovation

A significant proportion of older adults living in long-term care homes have some form of cognitive impairment that prevents them from driving safely and thus excludes them from power wheelchair use. Many intelligent power wheelchairs have been developed and tested previously, and can improve safety by compensating for cognitive deficits (e.g., through automatic collision avoidance); however, these systems have not been tested with cognitively-impaired older adults. Project III builds on existing work by members of the team who have already developed a wheelchair which detects obstacles using computer vision, stops the wheelchair, and suggests a clear path[14].

Our objectives in this project include: (1) determining how the previous obstacle avoidance system could be improved as well as studying adaptation of the current system to outdoor and non-institutional settings, adding more responsive vocal prompting, and choosing a common software platform for future design; (2) choosing additional features identified through the feedback from Project I and creating prototypes for subsequent feedback and testing; (3) using an iterative design process, refining existing features, adding new ones as appropriate, and collecting feedback on prototypes; and (4) delivering a final set of capstone prototypes which could be used in future studies and commercialization efforts. To date, Project III team members have developed and tested three different intelligent wheelchair prototypes with the target user population[15]. Results showed that our latest intelligent wheelchair prototype, NOAH[16], was able to improve safety by decreasing the number of frontal collisions using the collision avoidance module. In addition, the wayfinding module was able to shorten navigation route lengths by providing adaptive vocal prompts. User feedback from these studies and from interviews conducted by Project I is currently being used to develop a simulated intelligent wheelchair that will offer the user various levels of control through different driving modes. This system will be tested in realistic environments by the target population in a usability study. Results from the usability study will, in turn, inform the design of subsequent prototypes.

2.4 Project IV – Activity and Status Monitoring System (Data Logger)

The data collected using interviews, focus groups, subjective and objective outcome measures, and observational trials collected throughout the CanWheel projects provide important perceptions about how wheelchairs are used. Our understanding of power wheelchair use can be further broadened by capturing even more objective and ecologically representative data over longer periods of time (e.g., recording over days or weeks how far and how fast the wheelchair travels, how long the user is sitting in the wheelchair, the frequency of major jolts, etc.). A data logger, a collection of sensors and a storage system attached to a wheelchair, is an accurate and relatively unobtrusive way to collect this information[17-22]. There are currently three Canadian teams developing data logging systems for powered wheelchairs.

The objectives of this project are to: (1) unify existing Canadian data logger projects to ensure that comparable data is collected by all data logging platforms, to share best practices, and to identify avenues for further development; (2) integrate data logging features into the intelligent wheelchair prototypes; and (3) investigate what data analyses might be performed onboard the wheelchair. To date, we have determined that there is no centralized national data logger initiative. As a result, despite there being 3-4 data loggers in Canada, consistent variables are not being collected (e.g., physiological variables, movement parameters, and wheelchair positioning). A scoping review, designed to determine the breadth of published data logger variables collected for both manual and power wheelchairs in the grey and peer-reviewed literature, identified 186 papers. Our next step is to survey experts (wheelchair users, researchers, and clinicians) to identify the critical data logger variables to capture.

2.5 Project V – Evaluation of the Safety, Efficacy and Impact of the Wheelchair-Skills Program for Power Mobility Users and Their Caregivers

Although driving a power wheelchair is in some ways simpler that propelling a manual wheelchair, many obstacles in the environment (e.g., curbs) present even greater difficulties and risk, particularly when power wheelchair users tend to have more severe disability. Some unfavorable aspects of power mobility use include difficulty maneuvering in indoor spaces, difficulty in handling for caregivers, and potential for injury. Cognitive and perceptual impairments (e.g., unilateral visuo-spatial neglect) are examples of conditions that complicate wheelchair use and are potential barriers to the use of power mobility[23,24]. Given the desire of power wheelchairs users to participate in society, which includes community mobility, it is crucial to provide effective training to power wheelchair users. The Wheelchair Skills Program, a set of assessment and training protocols that draws on principles of motor skill learning, can be used to provide such training[25]. The value of the program has been well documented for manual, but not power, wheelchair use[26-30]. There is minimal evidence to support use of the program for powered wheelchairs[31,32].

The overall goal of Project V is to address the gaps in our understanding of wheelchair skills training, particularly the effectiveness of training in improving wheelchair skills capacity for power wheelchair users and the impact of skills training on other important outcomes (e.g., wheelchair confidence). Using a single blinded, randomized controlled trial as the design, the specific primary objective is to test the hypothesis that power wheelchair users who receive wheelchair skills training will improve their post-training total percentage capacity scores by at least 25% in comparison with a control group that receives standard care. Data is being collected at 6 sites across Canada and we are stratifying the sample to ensure that the groups are comparable with respect to age (18-50 years vs > 50 years) and power wheelchair experience (new [0-3 months] vs experienced [> 3 months]). To date, we have 58 power wheelchair users enrolled and expect data collection to be complete by December 2013 with a final sample size of 108.

3 The Future of Canwheel

CanWheel findings will make contributions to a variety of areas in the field of wheeled mobility research, including providing a clearer picture of how power wheelchairs are currently used, how these devices can be enhanced and how an aging population can use them more effectively. At present, the CanWheel team will to continue building on the existing research developments in the area of power mobility for the aging population. The current program of research will generate a wheeled mobility outcome measures toolkit for older adults and will benefit wheelchair skills training programs and development of intelligent wheelchair technology. At the end of our six-year grant, we will conduct a randomized controlled trial designed to evaluate the technological developments using an established training and outcome measurement protocol.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-216

iWalkActive: An Active Walker for Active People

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Abstract. iWalkActive aims to enhance the mobility of elderly people with mobility impairments, especially in the outdoor area by combining an all-terrain rollator with an e-drive system and a mobile device for indoor & outdoor navigation and further innovative services. This paper describes the idea of the iWalkActive project, organization and results of the requirements analysis and an outlook on the development process.

Keywords. Rollator, e-drive, indoor navigation, outdoor navigation

Background

Active living is a way of life that integrates physical activity into daily routines. This is particularly important for older people, as regular exercise can increase both mobility and the potential for independent living. However, a large proportion of the age group 60-85 suffer from some kind of physical disability that prevents them from living as actively as they would like to. Rollators have become very common mobility aids. One of the problem with existing rollators is that people in actual need of walking support often hesitate or refuse to use them, since they fill stigmatized for “old”, “sick” or “handicapped”. Problems also arise outdoors, when the user needs to overcome physical obstacles or uneven ground i.e. curbs, gravel, grass, sand and snow.

1. Aim of the Iwalkactive Project

The aim of iWalkActive is to offer people a highly innovative, attractive and open walker platform that greatly improves the user’s mobility in an enjoyable and motivating way, while at the same time enabling physical activities that are either impossible or very difficult to perform with a traditional rollator.

Technically and conceptually, the idea goes beyond that of a conventional walking aid. iWalkActive creates an active walker for active people. It takes an existing

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innovative rollator – the Veloped - extends it with an e-drive system and combines it with the possibilities of state of the art ICT technology acting as a mobile device dock connected to valuable assistive services.

The resulting activity platform offers outdoor as well as indoor navigation, orientation services and the assisting features of an outdoor capable rollator with a supportive e-drive. iWalkActive offers community services such as the recording, sharing and rating walking routes, and an open interface for new walker-tailored Apps. It will allow the end users to enjoy improved mobility, greater access to the outdoors and better possibilities to stay physically active.

Thus iWalkActive is a novel concept of an innovative, modular ICT-system existing in symbiosis with a new kind of outdoor walker. The project takes several state of the art technologies from different domains – coming from experts in their respective field - enhances each technology individually on its own and tailors them to fit the requirements to exact needs of the walker application, thus forming a seamless, user-centric and, extensible walker system.

2. State of the Art

Many attempts have been made to develop an intelligent walker with a navigation system [1]. Most of these attempts have either focused on indoor areas, [2, 3] on urban outdoor areas or on assisting elderly people with orientation in general.

No previous attempts have focused on the combination of an all-terrain rollator, an e-drive and a navigation system, especially intended for outdoor use.

The spring board for the project is the all-terrain walker Veloped developed by the Swedish company Trionic.

3. Beyond State of the Art

An ICT-supported walker with an e-drive is not commercially available on the market. Taking the state of the art into account, the iWalkActive consortium has identified the following technological novelties and potential for innovations.

Providing a rollator with an e-drive system that can be used in all terrains. The system will bring safety and assistance to the user.

Seamless indoor/outdoor navigation: Especially for this target group it would be difficult to have two systems to use for the same task. The development of an open platform for mobile devices that can combine data coming from the e-drive system with further services based on indoor / outdoor navigation will be the basis for innovative services enhancing mobility by giving the user the feeling of safety, comfort, assistance and new ways of communication.

4. Organization of the Project

The goal of iWalkActive is to develop and test prototypes of an ICT-supported active walker with an e-drive system, which offers the aforementioned features. The project work plan is divided into 8 work packages, and their related tasks are distributed over the project duration of 36 months.

The work plan involves two development cycles, each with its own integration and test phase. This will assure that valuable feedback from the test users is collected early in the project, preventing negative “surprises” which often occurs in “big bang” approaches with only one integration phase at the end of the project. The overall project plan comprises the following phases: user-requirements, analysis, system architecture, specification, design & development, integration & testing and user & field trials.

5. Description of the Requirements Analysis Process

The iWalkActive project started with user requirements, and the following methods were used to gather the requirements of potential end users; persona descriptions, scenarios, focus groups, online questionnaires and a Delphi-study. All direct contacts with end users were based on an informed consent developed by the project team, and approved by the funding agency of Austria. By basing all intended features on user scenarios, the end users involved found it easier to understand the aim and benefits of the features.

5.1. Description of Personas

The first input for creating the Personas for the project was the set of personas of the CURE-Elderly-Persona [5]. This set was developed for AAL projects. As the target group of our project was much broader, the project team decided to create personas that represent the actual user group of the Veleoped as the target group of the project. Additionally to the existing fields from the CURE-Elderly-Persona, for each persona a second page was created containing a use scenario, a more detailed description about their activity and mobility and how the person will use the iWalkActive system.

These personas were used for a better common understanding within the project team, and as basis for the user involvement steps. I.e. within the focus groups the personas were handed out to participants to be able to talk about a concrete situation of a (fictive) person. Thus it was possible to make discussions more precise and not to get lost in in topics that are not within the research focus.

5.2. Description of Delphi-Study and Outcome

The Delphi-study was organized in a written way with 5 experts, all interested due to their profession in the development of a future rollator, coming from the fields: market, science and end-user interest groups. Areas or research were: Perception of rollator use and the outlook concerning non-stigmatization, acceptance enablers, market trends, financial stimuli of insurances, social media use and general comments.

The experts were conducted without knowing the other experts. Results were collected and represented to the others in anonymized way for a second iteration. When the own opinion was diverse from the general opinion, the participant was asked for a detailed explanation.

Outcome of the Delphi-Study are:

- Normality: there are two different points of view, optimists see that rollator use is seen as normal within society, pessimist believe that ant stigmatization it will take several decades.
- Acceptance: Enablers are designs that allow an easy use (i.e. to put it into the car) and a modular structure, making adaptions for multiple use possible.
- Market: The common view of the experts is that within 10 years time most of the rollators will be paid private, without any funding of insurance.
- Financial stimuli: Within the both iteration there was an unexplainable change towards the opinion that within the next 10 years insurances won't fund modern off-road rollators.
- Social media: There was no real common sense about the social media use in combination with rollators after 7 years from now.

5.3. Description of Questionnaire and Outcome

Based on the persona descriptions an online questionnaire was done. The questionnaire had the aim to get a better impression of the target group and to see which functions of the future rollator will be used in which setting (everyday life, nature & leisure, exercise and rehabilitation, holiday and travel. In total 254 datasets were taken into the analysis. About half of the answers come from end users, average age was 61, 2/3 live in towns > 10.000 inhabitants. 2/3 of all participants were limited in their mobility due to medical conditions, 125 out of 200 cannot walk less than 100 meters without a support. Regarding the importance of the functions within the four different use areas, there are only very little differences.

5.4. Description of the Focus Groups

In Austria and Switzerland focus groups with mixed groups of elderly people and different experts and rollator users were organized. As it was seen that within the first meeting it was hard for some participants to identify themselves with the topic, follow up meetings were organized that were more productive, as the group members could think about different ideas in the meantime.

5.5. Focus Groups in Austria:

In Austria the focus groups was organized via existing contacts from a care organization on home care for elderly. In total 3 meetings were organized. Within the first meeting the overall idea from the project was explained and the informed consent was discussed and singed by the participants. Within the first discussion round the Veloped was presented and could also be tried out by the participants. This was extremely important for the further process, as an "all-terrain rollator" was new to the participants. The participants were asked, what should be added or changed to such a rollator to make it "the rollator of the future". Adding a motor was one or the main discussion points. The second half of the workshop was based on one of the personas and how she can use the rollator with a tablet PC in the areas of community building and fitness / rehabilitation training.

For the second meeting, the main topic to be discussed was how to plan a trip, outdoor- and on-trip navigation and how to share information within others.

For the third meeting, all ideas from prior meetings were collected as a list of user-stories. This list of 78 stories was prioritized within the group. Each user story was presented and asked to be rated as “less important, important and very important” Thus the outcome of the focus group meetings was a list of prioritized user stories.

5.5.1. Focus Groups Switzerland

In Switzerland four different groups were organized. Group I and II were built upon seniors, some of them with difficulties in their mobility. Some of them had a stimulating background, i.e. engineering for known car brands, volunteers in residential homes, etc. As in Austria, follow up meetings with the groups were organized to get information on the participant’s observations and reflection in the meantime.

Focus group III was organized with members in the field of mobile nursing and caring and focus group IV was done within a meeting of the representatives of "ageing responsibilities" of Switzerland.

6. Overall Outcomes

Combining all materials of the previous different steps, our major findings are:

There is consensus in: i) Easily transportable and storable; ii) Variety of models to choose from; iii) End-users are and will be mainly woman (impact on acceptance, functions, tests, training); iv) Potential for other end user groups, e.g. rehabilitation (financing, distribution, scenarios, marketing in general); v) Using well-known mobile devices that can be removed from the rollator; vi) Tracking for safety is requested

There was no consensus concerning: i) Hypothesis of this project: The active walker is primarily useable for people, who are already able to walk and fit enough. It focuses the target group of “active ager”; ii) Stigmatizing effect of rollators: 57% have a positive or neutral feeling towards the use of walkers (bias due to high number of rollator users); iii) There is a trend towards a second or third rollator for different application areas (indoor, hiking, etc.); iv) Additional features may be perceived as additional cost for something, that is not needed

Partly named within discussions were: i) Very different needs for the indoor- and the outdoor device make it senseless, to use the same device for both. The indoor-device doesn’t need motor, climbing-wheel, big bags, robustness, all-weather-capability, seat; ii) Financing of aiding products is different in every country; the trend goes towards private financing everywhere; iii) Thus Marketing becomes more and more important; iv) Positive communication of the usefulness instead drawing negative scenarios; v) An increasing number of end-users will be using social medias in the near future; vi) Coordination / cooperation with other communities like the wheelchair-community; vii) Need of control over the motorized devices

Additionally all ideas from the different user-involvement steps were collected and discussed within the project team concerning relevance from the project point of view and their realization feasibility within project time. An important concern for end users was safety concerning fall prevention and receiving help if needed.

7. Outlook

The analysis of the end user requirement showed five main areas of desired features of a rollator: ability to overcome obstacles, e-drive, outdoor navigation and adaptation possibilities for using the rollator in different use areas. Indoor-navigation and access to a community was not perceived as a perceived need among end-users. This implies that the benefit of developments in this area have to especially highlight the possible benefits for the end-users.

In the project iWalkActive, an architecture covering all the end user requirements is about to be created. The architecture has also to respect the openness so that future features can easily be added.

8. Architecture

There are two aspects of the architecture which have to be addressed. Firstly the architecture of the rollator itself, which is more hardware related; and secondly the architecture for the services.

The architecture of the rollator has to respect that a modular design shall be achieved. The basic rollator comes without any additional functions. Only if the user wishes, an e-drive and or a smartphone/tablet can be added. The architecture therefore must address mechanical and electrical connections. The configuration with an e-drive – which will consist of μC-controlled hub motors – and a smart device requires an architecture allowing the reliable communication between the devices.

Services like navigation or access to communities will run on the smart device. So the architecture has to be extended to the outside of the rollator and include also a server part where the services will be hosted. One of the challenges is to get an idea of services that are a user's need today and in the future. The architecture of the services must also consider the specific needs of the target group: elderly people. This has an impact to the UI and the guidance of the user.

Acknowledgements

The project iWalkActive – an active walker for active people is funded within the AAL Joint Programme by the European Commission and the funding agencies of Switzerland, Austria and Sweden.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-222

The Value of a Powered Wheelchair – Spouses' Perspective

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Abstract. Research concerning the significance of assistive technology to spouses of persons who uses technology is sparse and the impact of a powered wheelchair on spouses' activity and participation is not at all researched. Thus, the aim was to explore how spouses experience the significance of a powered wheelchair prescribed to and used by their next of kin.
A descriptive design with a qualitative approach focusing on the experiences of the spouses was used. The sample comprised of 10 spouses of elderly people that have been prescribed a powered wheelchair
Semi-structured interviews were conducted with the ten spouses (nine women and one man). The participants were 65 – 86 years of age. The questions posed during the interview concerned: i) the significance of the powered scooter for personal everyday activities, participation and quality of life; ii) the significance of the scooter for shared activity and participation; and iii) the significance of the next of kin using a scooter, from the perspective of the spouse. Interviews were transcribed verbatim and analyzed using qualitative content analysis.
The results showed that the spouses experienced that their everyday life and life situation had changed in a positive way as their next of kin received a powered wheelchair. They experienced a sense of freedom that had an impact on their own activities as well as on the activities they performed together with their next of kin. The spouses expressed that they now to a larger extent shared responsibility for different tasks in the home and also how the powered wheelchair had made it possible to spontaneously do things together again and to do things with more ease.
In conclusion, the narratives of the spouses of the elderly powered wheelchair users were to a great extent positive. The powered wheelchair was of great value and brought freedom to everyday life.

Keywords. Powered wheelchair, Spouse, Activity, Everyday life

Introduction

Some research [1] has been done to illuminate the significance of mobility devices for activity and participation in people in need of such devices. However the research concerning the significance of assistive technology to spouses of persons who uses the technology is sparse [2 - 6]. The research shows that assistive technology can relieve the burden of caring, be a support to the spouse [2, 3, 5] and affect the physical effort of the spouse [5]. The spouses have both positive and negative experiences of using the assistive technology [4] and that the restrictions of the assistive technology can also be felt by the spouse [6]. The impact, of a powered wheelchair, on spouses' activity and

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participation is on the other hand not at all researched. The aim of this study was therefore, to explore the value of prescribing a powered wheelchair to an elderly person from the spouses' perspective with the following question:

– How do spouses experience the value of having a powered wheelchair prescribed to their next of kin?

1. Method

A descriptive design with a qualitative approach focusing on the experiences of the spouses was used.

The criteria for inclusion in the study were; spouses who lived with a person who had been prescribed a powered wheelchair. The spouses should furthermore accept the invitation to participate and be willing to tell about his/her experiences. Fifteen spouses were invited to participate, five of them rejected participation for instance due to old age or own illness. Ten spouses participated (nine women and one man). The participants were 65 – 86 years of age. Six of the couples lived in cities, two in villages and two couples in rural areas.

Semi-structured interviews [7] were conducted with the ten spouses. The interviews were carried out when their next of kin had had the powered wheelchair for approximately 4 – 6 months and took place in the couples homes (nine of the interviews) and in another place according to the spouse´s wish.

The questions posed during the interview concerned: i) the significance of the powered wheelchair for personal everyday activities, participation and quality of life; ii) the significance of the wheelchair for shared (spouse and user together) activity and participation; and iii) the significance of the next of kin using a powered wheelchair, from the perspective of the spouse.

The interviews were transcribed verbatim and analysed using qualitative content analysis [8]. They were read several times to get an overall sense of the content. Then the interview text was divided into meanings units. The meaning units were coded and the codes were compared according to similarities and differences and sorted into three categories.

2. Results

The three categories identified from the interviews with spouses were: A sense of freedom related to own activities; A sense of freedom related to shared activities; and, A somewhat restricted freedom.

The results from the interviews showed first and foremost that the spouses experienced that their everyday life and life situation had changed as their next of kin had received a powered wheelchair. They experienced a sense of freedom that had an impact on their own activities as well as on the activities they performed together with their next of kin.

The value of a powered wheelchair was characterized by *a sense of freedom related to own activities.* The participants did not have to choose anymore whether they could do or not do an activity of their own. They did not have to interrupt an own activity to help his/her next of kin. They felt that they did not have to be available all the time just in case their next of kin wished to do something or needed help. Just to know that their next of kin also had the possibility of getting out of the house was a relief and facilitated own performance of activities. The spouses also said that they now to a larger extent shared responsibility for different tasks in the home.

The spouses expressed how the powered wheelchair had made it possible to spontaneously do things together again like shopping and visiting friends, but also to do things together with more ease. Furthermore they could resume activities that they previously had done together, but had not been possible to do for some time because of the next of kin's difficulties of moving outside of the home. This meant *a sense of freedom related to shared activities*, a life of more freedom.

The narratives of the spouses were to a great extent positive. The powered wheelchair was of great value and brought freedom to everyday life. However there were some disadvantages. The participants felt *a sense of somewhat restricted freedom* by the size and accessibility of the wheelchair in different arenas in the community.

3. Discussion

The interviews with the spouses showed that the value of a powered wheelchair was mainly connected to the experience of a sense of freedom in relation to own and shared activities. The sense of freedom was related to doing own activities without having to think about the next of kin and what he/she wanted or needed to do. This is in line with the result from a recently published systematic review [9] where the experienced need to assist the next of kin had been reduced. In our study the sense of freedom was linked to not having to be constantly available and, being able to do things without getting interrupted. The possibility of finishing tasks was liberating. A previous study [5] has shown that the time for participating in own activities has increased for spouses from their next of kin using assistive technology. The respondents in this study did not talk about more time per se but more of the feeling of being in an activity without interrupting it. This can be due to that all of the spouses were retired and that time in hours and minutes are counted differently. The sense of freedom, to be able to stay away a little longer, had to do with knowing that the next of kin also had the possibility of doing things of their own outside of the home. A study [6] concerning spouses of persons with a disability following stroke showed that some activities might get lost or not being performed to the same extent due to the fact that the next of kin could no longer do the activities. The results from this study show that a powered wheelchair might create possibilities for the spouses as well as for the next of kin to more freely engage in different activities and in society.

The interviews with the spouses also revealed that the powered wheelchair had facilitated shared social activities. It had made it possible to spontaneously go out together for a pick-nick or visiting friends. According to Demers et al [5] the time to do things together had increased when receiving the powered wheelchair. The powered wheelchair had also made it physically easier for the spouses, a result in accordance with Demers et al [5] and Rudman et al [6]. In these studies the reduced effort to push the wheelchair was connected to freedom. In this study the freedom was more related to the spontaneity and the decreased need for planning. The powered wheelchair had made it possible to regain activities and habits which were appreciated. To regain activities outside of the home increased the participation of the next of kin but were also important to the spouses as their everyday life became freer.

In the systematic review of Mortenson et al [9] spouses' anxiety concerning the wheelchair was mentioned. The spouses in this study did not have any worries when it came to the powered wheelchair. The worries were more in relation to life as a whole, how it is and how it will be. In this perspective the wheelchair was only a tool that made everyday life a bit easier.

In this study the data was collected through semi-structured interviews. One difficulty concerning the interviews was to get the spouses to talk from their own perspective, from their own point of view. When the spouses started to talk they started by saying that the wheelchair was of great value to their next of kin. To be able to elicit the spouses' point of view the questions had to be repeated at times or rephrased to keep the interview on track. The reason for this might be that spouses had seen that the wheelchair was of great importance to their next of kin and their possibility of going out. Another reason might be that the powered wheelchair was so strongly connected with the next of kin that the stories had to have this point of departure. In some cases there were also some difficulties to differentiate what can be related to life as a whole and what can be related to the wheelchair. The value of the wheelchair was interwoven in the everyday experiences. This complexity was also shown in Rudman et al study [6].

In conclusion, a powered wheelchair has a great value for the spouses. The users' independence meant a great relief for the spouse, both in doing personal things but also for resuming shared activities that had been impossible to do before the powered wheelchair was introduced. The freedom was sometimes restricted by the size and accessibility of the wheelchair in different arenas in the community.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-226

Mobility Device Use and Exploration of Housing Accessibility for Powered Mobility Device Users among People Ageing with Spinal Cord Injury

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Abstract. Aim: To describe the use of mobility devices among people ageing with spinal cord injury (SCI), with a specific focus on use of powered mobility devices (PMD) and housing accessibility.
Method: Data on the use of walking aids (cane, crutch/es or rollator), manual wheelchair and powered wheelchair/scooter were utilized. To describe functional limitations, environmental barriers and the magnitude of accessibility problems in the home and the closest exterior surroundings for each individual, the Housing Enabler instrument was used. Descriptive statistics were used for data analysis.
Results: *Mobility devices:* Among participants with paraplegia, the manual wheelchair was the most frequently used mobility device indoors, and among participants with tetraplegia, it was the PMD. The PMD was the most common mobility device used outdoors among those with tetraplegia, and among participants with paraplegia. *Housing accessibility:* In exterior surroundings, refuse bin difficult to reach was the environmental barrier that generated the most accessibility problems, while at entrances doors that cannot be fastened in open position was identified as the most severe environmental barrier. Indoors, the environmental barrier that generated the most accessibility problems was wall-mounted cupboard and shelves placed high. **Conclusion:** To enable optimal use of the PMD in the home and close neighborhoods, and support everyday activity and participation for people ageing with SCI, it is vital to take into account not only personal and environmental aspects but also the mobility device in question. Though, it could be discussed if all the environmental barriers identified in this study, actually are problems for users of a PMD, since some of them might be possible to overcome.

Keywords. Electrical Wheelchair, Manual Wheelchair, Walking Aids, Environmental Barriers, Home, Tetraplegia,Paraplegia.

Introduction

People with spinal cord injury often have severe mobility limitations, and therefore commonly use mobility devices [1]. Mobility is a prerequisite in managing every-day life, essential for everyone, so even for people with impaired mobility [2]. This in turn often leading to need of mobility devices, as for example powered wheelchair and scooter. For people with spinal cord injury, use of more advanced mobility devices such as powered mobility devices (PMD) is often necessary in order for them to be able

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to move around in housing and neighborhood environments [3-5] posing specific requirements on accessibility to the built environment. This in turn is necessary for activity performance, and to manage everyday life at large, but the knowledge on person-environment interaction as a prerequisite for activity performance among PMD users among those ageing with a spinal cord injury is scarce. Therefore, it is important to study environmental barriers that generate housing accessibility problems for this specific group.

The aim of this study was to describe the use of mobility devices among people ageing with spinal cord injury, with a specific focus on use of PMD and housing accessibility.

Methods and Material

This study is a part of a larger survey study; the Swedish Ageing with a Spinal Cord Injury Study (SASCIS) which aims to increase the knowledge of people ageing with spinal cord injury. People 50 years of age or older that acquired an spinal cord injury more than 10 years ago were recruited through existing databases at the Spinal Cord Injury Unit, Department of Rehabilitation Medicine, Skåne University Hospital, Sweden. Out of 796 individuals, 191 met the inclusion criteria and 123 individuals participated in the study, including 48 participants with tetraplegia (34 men, 14 women) and 75 participants with paraplegia (53 men, 22 women). For sample characteristics, see Table 1.

Table 1. Sample characteristics (n=123).

	Men	**Women**	**Total**
Sex	87	36	123
Age (years)	63 ± 8, 50-89	63 ± 9, 50-83	63 ± 9, 50-89
Age at time of injury (years)	38±16, 7-74	41±17, 17-72	39 ± 16, 7-74
Time post injury (years)	25±12, 10-56	22±8,10-55	24 ± 12, 10-56
Complete lesion	15	24	39
Incomplete lesion	33	51	84

Note: Data are expressed as mean ± SD, range and n unless otherwise indicated.

In the larger survey study, an extensive data collection format consisting of a study-specific structured questionnaire and established assessment instruments was used. For the current study, data on the use of walking aids (cane, crutch/es or rollator), manual wheelchair and powered wheelchair/scooter were utilised. Data were collected concerning the principal mobility device in use, indoors and outdoors. If the participant used more than one mobility device, the one used for mobility the furthest distance was reported.

To describe functional limitations, environmental barriers and the magnitude of accessibility problems in the home and the closest exterior surroundings for each individual, the Housing Enabler instrument [6], consisting of two different parts and a third step for analysis, was used. The first part is a personal component, where functional limitations and dependence on mobility devices are dichotomously assessed (present/not present), generating a profile of functional limitations (14 items). The second part is an environmental component, where 161 environmental barriers in the home and the closest outdoor surroundings are dichotomously assessed (present/not present). Finally, the magnitude of accessibility problems is analysed by means of a complex matrix, juxtaposing the profile of functional limitations and dependence on mobility devices with the environmental barriers found present. Using instrument-specific software, the environmental barriers that, in combination with the presence of functional limitations in the sample, contribute the most to the generation of accessibility problems is identified (so-called weighted environmental barriers) [6].

Results

1.1 Use of PMD and Other Mobility Devices

In all, 15% of the participants used a PMD indoors and 41% used such a device outdoors (Table 2). Among the participants with paraplegia, the manual wheelchair was the most frequently used mobility device and 25% used no mobility devices indoors. Further, only 2% used a PMD indoors. Among the participants with tetraplegia, 33% used a PMD indoors, and 27% used a manual wheelchair. When it comes to use of mobility devices outdoors, the PMD was the most common mobility device used among those with tetraplegia.

Table 2. Use of mobility devices indoors and outdoors 10-56 years after spinal cord injury, N=123.

Type of mobility device in use	People with tetraplegia (n=48)	People with paraplegia (n=75)	Total sample (n=123)
Indoors			
Manual wheelchair	27% (13)	62% (47)	49% (60)
PMD	33% (16)	2% (2)	15% (18)
Walking aids	16% (8)	9% (7)	12% (15)
No mobility device	22% (11)	25% (19)	24% (30)
Outdoors			
Manual wheelchair	18% (9)	38% (29)	31% (38)
PMD	50% (24)	36% (27)	41% (51)
Walking aids	18% (6)	13% (7)	15% (18)
No mobility device	9% (3)	9% (5)	12% (15)
Car	3% (1)	0% (0)	1% (1)

Note: Data presented in percentages, with numbers in brackets.

1.2 Functional Limitations among Users of PMD (N=51)

Among users of PMD indoors, the most common functional limitations were incoordination and reduced spine and/or lower extremity function, followed by poor balance and reduced fine motor skills. Among users of PMD outdoors, reduced spine and/or lower extremity function was the most common functional limitation, followed by incoordination and limitations of stamina. This is also in line with the functional limitations identified for the total sample (Table 3).

Table 3. Functional limitations 10-56 years after spinal cord injury among users of PMD indoors, users of PMD outdoors and total sample, N=122[1].

Functional limitation	Users of PMD indoors (n=18)	Users of PMD Outdoors (n=50)	Total sample (n=122[1])
Difficulty interpreting information	5% (1)	19% (10)	11% (14)
Visual impairment	11% (2)	15% (8)	14% (17)
Blindness	0% (0)	0% (0)	0% (0)
Loss of hearing	11% (2)	7% (4)	7% (9)
Poor balance	94% (17)	69% (36)	56 %(68)
Incoordination	100% (18)	90% (47)	85% (105)
Limitations of stamina	4% (8)	82% (23)	30% (40)
Difficulty in moving head	38% (7)	38% (20)	30% (36)
Reduced upper extremity function	88% (16)	% (41)	66% (81)
Reduced fine motor skills	94% (17)	78% (36)	60% (74)
Loss of upper extremity function	11% (2)	3% (2)	2%(3)
Reduced spine and/or lower extremity funct	100% (18)	96% (50)	98% (120)

Note: Functional limitations according to the Housing Enabler instrument [5]. Data presented in percentages, with numbers in brackets.
[1]Data is missing on one participant

1.3 Housing Accessibility

Among users of PMD (using their device either indoors, outdoors or both), the environmental barriers that caused the most accessibility problems in exterior surroundings, entrance, and indoors were ranked 1-5 (Table 4). In exterior surroundings, refuse bin difficult to reach was the environmental barrier that generated the most accessibility problems, while at entrances doors that cannot be fastened in open position was identified as the most severe environmental barrier. Indoors, the environmental barrier that generated the most accessibility problems was wall-mounted cupboard and shelves placed high.

Table 4. The five environmental barriers that generated the most accessibility problems, in three different housing sections, 10-56 years after spinal cord injury among users of PMD, N=51[1].

	Exterior surroundings n=50[2]	Entrance n=50[2]	Indoors[2] n=18[3]
1	Refuse bin difficult to reach	Doors that cannot be fastened in open position	Wall-mounted cupboard and shelves placed high
2	Irregular/uneven surface[4]	High thresholds and/or steps at the entrance[4]	No grab bar at shower/bath and/or toilet
3	Not/too few seating places[4]	Doors that do not stay in open position/close quickly[4]	Controls in high/inaccessible position in kitchen[4]
4	Low/high seating surfaces/no armrest	No handrails	Controls in high/inaccessible position in bathroom[4]
5	Poorly drained paths and roadways	Heavy doors without automatic opening	Controls in high/inaccessible position in housing[4]

Note: Weighted environmental barriers according to the Housing Enabler instrument [6].
[1]Data is missing on one participant with tetraplegia.
[2]One participant do not use the PMD outdoors
[3]18 participants use the PMD indoors
[4]Shared position in the rank order

Discussion

In accordance with previous research [1], people with SCI use different mobility devices to varying degrees. As expected, use of a PMD indoors is common among people with tetraplegia, and outdoors among people with tetraplegia as well as paraplegia. Based on detailed data collected with a state-of-the-art instrument, this study generates new knowledge on housing accessibility among people with SCI, focusing on those using a PMD. Data that make it possible to identify the environmental barriers that cause the most accessibility problems for users of PMD are valuable and can be used for actual improvements in housing environments, on individual and population levels.

In order to enable an optimal use of the PMD in home and its exterior surroundings, it is important that the environment is accessible for the person with functional limitations as well as for the mobility device in question. In this study we found that among people with SCI, some of the environmental barriers identified as the most accessibility problems in exterior surroundings, which indicate to be of importance for outdoor mobility. These environmental barriers were irregular/uneven surface and poorly drained paths and roadways which may lead to difficulties to use the PMD outdoors. When it comes to environmental barriers at entrances, we found that the environmental barriers that caused most problems were related to doors, as they cannot be fastened in open position or are heavy without automatic opening, and also high thresholds and/or steps. In turn, these environmental barriers may result in problems entering the housing with a PMD. The fact that the barriers that generated the most accessibility problems indoors were wall-mounted cupboards and shelves placed high, followed by no grab bars at shower/bath and also controls in high/inaccessible position at different places in the housing, illustrates that use of a PMD indoors and also managing every-day life may be difficult. However, it could be discussed if all the environmental barriers identified actually are problems for users of a PMD, since some of them might be possible to overcome thanks to specific functions of the PMD in use. One example is indoors, where controls and other objects defined as environmental barriers in reality are accessible provided that the PMD can elevate the user. That is, the Housing Enabler does not take the specific functions and characteristics of modern PMDs into account, demonstrating the need for further methodological development in this field of research.

This study gives information on environmental barriers and accessibility problems among people ageing with SCI using PMD, which is important to take into account when such devices are being provided. However, according to a recent study on older people using different types of mobility devices [7], existing standards for housing design do not accommodate wheelchair and rollator users. Therefore, there is need for further studies focusing on mobility devices as PMD. In addition, for future studies, comparisons can be made with other studies and groups, as for example people ageing with Parkinson's disease [8-9].

In conclusion, to enable optimal use of the PMD in the home and close neighborhoods, and support everyday activity and participation for people ageing with SCI, it is vital to take into account not only personal and environmental aspects but also the mobility device in question.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-232

Wizard-of-Oz and Mixed-Methods Studies to Inform Intelligent Wheelchair Design for Older Adults with Dementia

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Abstract. Testing complex assistive technologies with older adults with dementia is challenging due to difficulties in recruitment, lack of system robustness, and the need for real-world testing. We thus recommend using Wizard-of-Oz and mixed-methods studies in order to inform the design of intelligent wheelchairs. We summarize our previous studies with the target population, and describe ongoing research that employs the proposed methods.

Keywords. Intelligent wheelchair, wizard-of-oz, prototyping, mixed-methods.

Introduction

Older adults with physical impairments are often unable to walk or propel themselves in manual wheelchairs. In order to maximize their opportunities for independent mobility, clinicians usually prescribe powered wheelchairs. However, safe and effective operation of powered wheelchairs requires a high level of cognitive functioning. Impaired attention, agitation, poor impulse control, memory loss, disorientation, and visuo-perceptual difficulties are known symptoms related to Alzheimer's disease and other dementias [1, 2]. These symptoms make independent powered wheelchair operation challenging, and in some cases, impossible. Older adults with dementia can thus be excluded from powered wheelchair use for safety reasons [3].

In 2010, there were about 35.6 million people in the world living with dementia, and this number is expected to be approximately 65.7 million by 2030 [4]. As a result, there will be a growing number of older adults with dementia who are without an independent means of mobility and highly dependent on caregivers to porter them and assist them to complete activities of daily living that require mobility. In the context of long-term care facilities, this dependence increases caregiver burden in an already over-burdened health-care system.

Previous Work

Several intelligent wheelchairs have been developed in the last three decades [5]. The authors in [6] suggest that wheelchair users with cognitive and visual impairment

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would greatly benefit from intelligent wheelchairs that aid in collision avoidance and path planning. Despite these recommendations, however, only a small proportion of intelligent wheelchairs have been tested with users with cognitive impairment, possibly due to challenges with recruitment and/or lack of robustness of the systems trialed [7]. In addition, it is unclear whether study results with younger adults and children with cognitive impairment [8-12] are generalizable to older adults with dementia. Older adults can have multiple chronic conditions [13] that might affect intelligent wheelchair use, thus making them a highly heterogeneous population. While several challenges exist in developing assistive technologies with older adults with dementia, as outlined in [14], it is imperative that these systems are designed and tested with the target users in order to ensure technology adoption.

Of the intelligent/modified wheelchairs developed so far, to our knowledge only four systems have been tested with older adults with dementia (BSS [15], TOW [16], IWS-UT [17], NOAH [18]), and were developed by our research team and our collaborators. A summary of the systems' performance and study results can be found in [19]. We now present our findings with respect to the design methodologies used, and evaluate their strengths and weaknesses.

Findings

BSS was a commercially available powered wheelchair modified with a low contact force, collapsible bumper skirt to prevent collisions. TOW was a mock intelligent wheelchair, tele-operated by a researcher, who stopped the wheelchair if an imminent collision was detected, and provided audio, visual and haptic feedback to help the users drive around obstacles. The high accuracy of the bumper skirt and the tele-operation procedure for collision avoidance allowed both systems to be tested in natural settings (i.e., in the participants' long-term care homes). The total number of participants who tested each system was six and five, respectively, and they had mild-to-moderate cognitive impairments. The BSS had low user acceptance due to its bulky form factor and usability issues, and the TOW study revealed that audio prompts were the most preferred feedback modality. Results from these studies supported the need to develop vision-based systems in IWS-UT and NOAH, due to the recognized need for 1) more compact systems, 2) greater sensor coverage to prevent collisions, and 3) a non-contact approach to reduce the risk of bumping into elderly residents, who are particularly vulnerable to falls [20]. In addition to collision avoidance, NOAH used adaptive audio prompts to provide wayfinding assistance, since wandering is a common behavior in older adults with dementia [21].

The IWS-UT and NOAH study trials were completed with three and six cognitively-impaired older adults, respectively, using an A-B study design; however, these systems were tested in a controlled, static environment due to the engineering challenges faced in more realistic environments. Quantitative results showed that both systems lowered the total number of users' frontal collisions, regardless of phase ordering, and wayfinding prompts provided by NOAH helped users to navigate along the shortest path to the goal. However, qualitative data showed that users were frustrated with the collision avoidance mechanism (stopping at a pre-defined distance threshold) and that alternate strategies might lead to increased usability. The NOAH authors also reported that the use of foam obstacles in both NOAH and IWS-UT studies possibly impacted driving performance by making users more unconcerned about driving into the obstacles. In the NOAH study, it was noted that users' self-reported satisfaction and task load scores after trials were not always reliable, with some users providing inflated satisfaction ratings, possibly to please the researcher. Likewise, in the BSS study, user frustration or dissatisfaction with the device were not always self-reported in interviews after the trials, even when incidences of these responses were observed by the researcher during trials. One participant in the NOAH study was found to assign high frustration ratings based on uncontrolled factors such as her pants being "too big". Thus, the validity of standardized usability tools with our target population is in question. Observations and open-ended questions that specifically probed for perceived strengths and weaknesses of the NOAH system often resulted in more useful feedback with respect to improving the system design.

In conducting these studies, several challenges related to participant recruitment and retention were evident, such as older adults' health conditions, staff's or family members' perceptions about who might (not) benefit from the technology, or unwillingness of substitute decision makers to consent to powered wheelchair use by potential participants, even when the candidates were interested themselves. Furthermore, the total number of participants who completed the studies was often limited due to withdrawals and physical disabilities (pain), thus leading to challenges in statistical analysis of the data and generalizability of study results.

Recommendations

The prevalent challenges in the above studies are: a highly heterogeneous population that is difficult to recruit in large numbers and whose technology needs are currently unknown, complex assistive systems that lack robustness and usability, and the need for real-world testing. It is imperative that users are involved throughout the design process to avoid poor user acceptance of the designed technologies as with the BSS; however, recruitment challenges necessitate alternative development processes to ensure maximal user feedback with limited time and small participant numbers. Since achieving robustness can be resource-intensive, continuous prototype evaluation is required to determine design appropriateness early in development, while still providing the user with the experience of the intended system in realistic conditions.

These challenges can be circumvented by rapid prototyping methods, such as the Wizard-of-Oz technique [22]. In a Wizard-of-Oz study, the wheelchair is tele-operated by a hidden researcher, the "Wizard", who simulates the functionality of an intelligent wheelchair. The user can thus interact with the system and offer feedback regarding the wheelchair interface and functionality before the system is fully working. Technology development using these methods can enable an integrated knowledge translation approach by allowing end-user involvement throughout the design process and in an iterative fashion (i.e., a user-centred design approach). Increased and improved functionality of the system can then be tested in subsequent iterations, as in spiral development methods in software engineering [23], and prototyping methods in usability engineering, which start by testing low-fidelity paper prototypes, and move towards testing working systems [24]. When designing a Wizard-of-Oz study, care should be taken to ensure that the Wizard acts in a credible and consistent manner, possibly requiring significant training of the Wizard using clear tele-operation instructions.

Although the Wizard-of-Oz method has been used successfully in similar applications, such as wayfinding devices for older adults with dementia [25], they have not been employed in the development of most intelligent wheelchairs, especially with our target population. In addition, the majority of intelligent wheelchair studies have provided limited qualitative findings to inform design directions, focusing mainly on system performance measures and self-report scores for user satisfaction. However, our previous thematic analyses of qualitative data collected through interviews and observations in usability and other studies [15-18, 26] have resulted in important and non-intuitive findings, which have increased our understanding of the user population. Qualitative methods of data collection and analysis do, however, pose challenges such as the need for researcher training to prevent or reduce researcher bias during data collection and analysis, and the time required to transcribe, code and analyze potentially large volumes of data [27]. Existing software, such as NVivo [28], can aid in data coding and analysis procedures.

Usability literature suggests that initial usability studies can involve as few as five users to expose at least 80% of usability issues [29], and should focus more on qualitative findings. Subsequent testing iterations can then involve quantitative analysis to determine system efficacy and effectiveness with a higher number of test users. Since our target population is heterogeneous, a possible strategy to validate usability issues could be to stratify the target population based on characteristics that would most impact user needs, satisfaction and performance while driving, and to recruit three to five representative users from each subgroup. Finally, generalizability of results is a major challenge when testing usability with small participant numbers. Thus, recruitment issues eventually need to be addressed in order to allow larger studies. Suggestions such as building strong collaborations with clinicians are provided in [14].

Building on our previous studies, our ongoing and future work involves applying the above methods in a Wizard-of-Oz study, in which a tele-operated wheelchair will offer the user varying levels of assistance, ranging from simple stopping in front of obstacles to fully autonomous navigation. The study will thus be able to identify user preferences before a working system is developed. A mixed-methods approach [30] will be used to collect both quantitative data on user performance and satisfaction, and qualitative data through semi-structured interviews and field observations. The proposed study is informed by quantitative and qualitative results achieved previously. Study results will be shared with engineers and clinicians to aid in the future design of intelligent wheelchairs and to inform new policies regarding powered wheelchair accessibility. In addition, we hope that these knowledge translation efforts will increase recruitment opportunities, and allow us to conduct larger studies in the future.

Conclusions

In this paper, we described previous intelligent wheelchair studies with older adults with dementia. We provided key insights from our findings, strengths and weaknesses of the methods used, and rationale for use of the Wizard-of-Oz technique in the initial development stages of complex assistive systems. In addition, we recommended mixed-methods approaches that use both qualitative and quantitative findings to inform system design. Finally, we provided a summary of future work that uses the proposed methods. We hope that the insights provided will encourage other researchers to develop assistive systems that are successfully adopted by a highly heterogeneous and challenging population.

Acknowledgments

This research was funded by a graduate scholarship from the National Sciences and Engineering Research Council of Canada and by the Canadian Institutes of Health Research (AMG 100925).

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AT Policy/Service Delivery

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-241

OSCAR: Clinical Decision Support System for Prescription of Assistive Technology to People with Disabilities

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Abstract. This paper presents a novel, knowledge-driven approach for pointing device prescription that aims to enhance the prescription process via OSCAR, a Clinical Decision Support System. OSCAR was constructed in a three-stage process: developing a pointing-device ontology; formulating IF-THEN matching rules, and constructing a web-based user interface. Evaluating OSCAR's usability through the System Usability Scale reflected a high satisfaction rate with a mean score = 80.9 (SD = 10.6). OSCAR's effectiveness was evaluated through the prescription results which showed no significant difference between experts using the traditional approach and novices using OSCAR. These results indicate that OSCAR is able to support novice clinicians in the AT prescription process to a level that is comparable to experts. The main contribution of this research is in the development and evaluation of a CDSS which bridges the gap between existing general models for pointing device prescription and a process that can support expert and novice clinicians. Although the system is currently designed for adaptation of a specific device (physically controllable pointing device) it can be expanded to include other AT devices. The results will also serve as an example to demonstrate the utility of using a CDSS in other clinical areas.

Keywords. Assistive Technology, Clinical Decision Support System, Ontology, Rule-based Expert System.

Introduction

Clinicians working in assistive technology (AT) face many dilemmas when selecting a suitable device for people with special needs. When searching for relevant information about an AT device, they are faced with a fragmented knowledge base [1, 2]. Rapid changes in the field due to the continuing availability of new devices, technologies and approaches [3, 4] mean that clinicians are faced with a large array of models and frameworks [5] and often lack a systematic mechanism [6] for the complex adaptation process [7]. The phenomenon of technology disuse or underuse (with abandonment of more than one third of the previously adapted devices [8] has led to serious concerns about the effectiveness of the device selection process. Apple's iPad, for instance, was

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immediately greeted with enthusiasm when it became available two years ago, yet not all clinicians have sufficient experience to prescribe it properly.

Over the past decade, the International Classification of Functioning, Disability and Health [9], the Matching Person and Technology (MPT) [10], and the Human Activity Assistive Technology (HAAT) [11] models, among others, were established to support the standardization of the AT matching process [11, 12, 7]. These models provide an important general framework. However, in the case of AT device prescription, they do not always offer detailed guidance for clinicians.

This paper presents a novel, knowledge-driven approach for pointing device prescription that aims to enhance the prescription process via a Clinical Decision Support System (CDSS). A CDSS is an interactive system that helps health professionals make clinical decisions by using communication technologies, data, documents, knowledge and models to identify problems and solve them [13]. It consists of a systematic set of coded algorithms designed to use a computerized clinical knowledge base to propose matches between client characteristics, needs and abilities (obtained via specific clinical assessments) and appropriate solutions (available from database). One or more recommendations are then presented to the clinician and/or client to consider for implementation [14, 15, 16].

In order to construct a feasible CDSS, it is imperative to have a broader-based understanding of how experts reach a medical decision-making in the natural setting [17]. This involves obtaining accurate data, applicable knowledge and appropriate problem-solving skills [15]. One of the ways in which experts' knowledge can be represented is through a set of IF-THEN rules which simulate their reasoning in problem-solving [18, 19] or recommending advice [20, 21, 22].

The present paper describes the OSCAR (Ontology Supported Computerized Assistive Technology Recommender) CDSS, developed to help clinicians in the decision making process for selecting appropriate physically controllable AT pointing devices. OSCAR does not aim to become a substitute for the final decision making, but rather to help practitioners avoid errors, optimize quality, and improve efficiency and cost effectiveness in health care [23]. It thus supports the clinical decision process that is especially needed for less experienced clinicians.

1 Overview of the State of the Art

The field of CDSS is rapidly advancing due to its considerable potential to improve health care provider performance, quality of care and clinical outcomes [24]. MYCIN, an early CDSS, was used as a diagnostic tool for infectious diseases [25]. ISABEL, a web-based diagnosis decision support system, produced a list of likely diagnoses for a given set of clinical features such as internal medicine, surgery, gynecology and obstetrics [26]. ISABEL has been extensively validated and been shown to enhance clinician's cognitive skills and improve patient safety and quality of care [27]. LISA was primarily concerned with providing support during the chronic illness period when drug dose decisions have to be continually monitored and adjusted [28]. Evaluation studies of LISA concluded that the system is likely to be accepted by clinicians and that it may lead to a decrease in non-compliance with treatment protocols [29]. ATHENA was deployed in 2002 to implement guidelines for hypertension; it encourages blood pressure control and suggests recommendations about suitable therapies in accordance with the latest research developments [30]. Because evidence for best management of hypertension evolves continually, the ATHENA DSS is designed to allow clinical experts to customize the knowledge base to incorporate new evidence, and to reflect local interpretations of guideline ambiguities. It was expanded in 2006 to assist in the management of opioid therapy for chronic pain [30].

2 Methods

The construction of OSCAR entailed a three-stage process. It commenced with the identification and formalization of the experts' knowledge through the use of a domain ontology. An ontology is defined as a specification of a representational vocabulary or collection of concepts of a shared domain including definitions of concepts, classes of concepts, relationships between the concepts (and classes), functions, and other objects [31]. The second stage involved the formulation of a series of matching rules (IF-THEN) to emulate expert reasoning and achieve compatibility between client and pointing device characteristics. For example: *IF* (value of user feature = x) *AND* (value of device feature = y) *THEN* (rule score = Z). A user interface, a web-based CDSS, was then constructed.

The general architecture of the OSCAR system is presented in Figure 1. It consists of four parts: a data base, a reasoning engine and user and administrator interfaces. The data base contains information about the clients, clinicians and pointing devices, as well as a set of IF-THEN matching rules. The reasoning engine contains the formulae for combining the rules. The administrator interface enables adding or modifying information about clinicians, pointing devices and matching rules to the system. The user interface allows clinicians to activate the system by entering client data and obtaining recommended pointing devices.

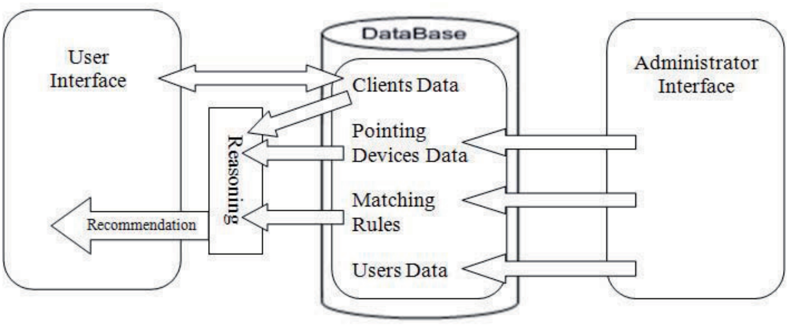

Figure 1. General architecture of OSCAR.

The clinician, who has already gathered the required data about the client's functional level related to the ability to use various pointing devices, is prompted to enter the relevant information through a set of Yes/No and Multiple Choice items. The system carries out a matching process between the existing pointing devices in the database and the client by applying the relevant rules. At the end of the matching process, three pointing devices, determined by the system to be most optimal, are provided with an option of a detailed report of the characteristics of each of the recommended devices. If the clinician is not satisfied with these recommendations, client details can be revised and the matching process repeated as illustrated by the OSCAR functionality flowchart in Figure 2.

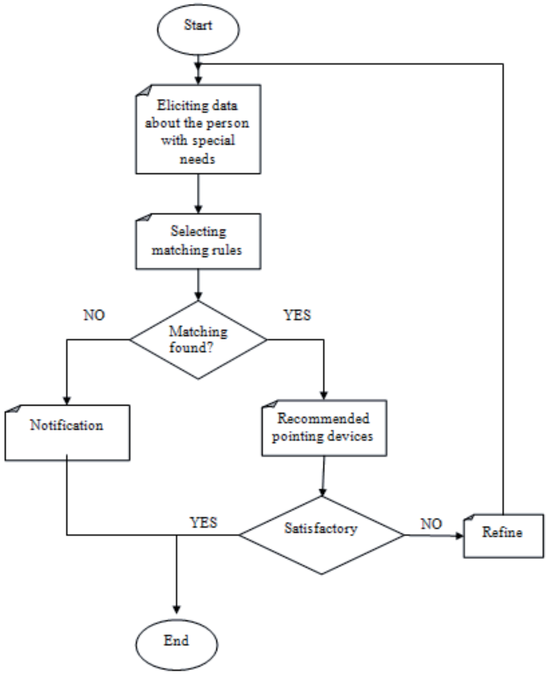

Figure 2. OSCAR functionality flowchart.

OSCAR's usability was evaluated by six AT experts and twenty occupational therapists who were novices to the field of AT. Following exposure to OSCAR via two case examples, the novice subjects completed the System Usability Scale (SUS) questionnaire. The effectiveness of the prescription process was examined for the two case studies by comparing responses of AT experts using a conventional approach with two groups of occupational therapists who were novices to the field of AT (group 1 using OSCAR and group 2 using a conventional approach)

3 Results

OSCAR Usability: The SUS mean score = 80.9 (SD = 10.6), which reflects a high satisfaction rate of the system's usability. OSCAR Effectiveness: There were no significant differences between the novice group using OSCAR and the expert group using the conventional approach to prescribe the effective pointing devices. There were significant differences between the pointing devices prescribed by the novice and expert groups using the conventional approach. There were significant differences between the pointing devices prescribed by the novice group using OSCAR and the novice group using the conventional approach. These results indicate that OSCAR is able to support novice clinicians in the AT prescription process to a level that is comparable to experts; novice clinicians using conventional methods do not show this ability.

4 Impact and Contributions

OSCAR is a CDSS that aims to support novice clinicians to benefit from expert-drive, well-reasoned options for AT prescription. This will help to improve their decision making abilities, reduce errors, and maximize usage and retention of AT pointing devices. Moreover, it will contribute to the young body of AT theory and knowledge by formulating a standardization of its terminology [32]. The main contribution of this research is in the development and evaluation of a CDSS which bridges the gap between existing general models for pointing device prescription and a process that can support expert and novice clinicians.

5 Conclusions and Planned Activities

The current version of OSCAR is a proof-of-concept case in which an ontology of physically controllable pointing devices was developed and used with a set of rules to emulate expert reasoning to match between client and pointing device characteristics. A user interface, a web-based CDSS, was constructed to enable evaluation of the system's effectiveness with novice clinicians. Although the system is currently designed for adaptation of a specific device (physically controllable pointing device) and needs the intervention of the clinician to make the final decision, it can be expanded to include other AT devices. The results will also serve as an example to demonstrate the utility of using a CDSS in other clinical areas. In addition, the information gathered may become a specified digital library for the domain of AT which enables machine learning.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-247

Service Delivery Systems for Assistive Technology in Europe: A Position Paper

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Abstract. As a follow-up of an International Workshop held in Copenhagen, Denmark, on May 21-22, 2012, a consensus process started under the leadership of AAATE (Association for Advancement of Assistive Technology in Europe) and EASTIN (European Assistive Technology Information Network) that led to the production of a European Position Paper. This Paper indicates a framework for exploiting the role of assistive technology (AT) in supporting care and participation of people with disabilities and elderly people through appropriate service delivery systems (SDS). The Position Paper is organised in four chapters. The first chapter (Background) discusses the reasons why a position paper on this issue was deemed useful; it also summarises the key themes of the Copenhagen workshop and recalls the previous HEART Study of the European Commission. The second chapter (The scope of an AT SDS), discusses the concept of assistive solutions – intended as individualised interventions providing users with appropriate environmental facilitators (AT products, personalised environmental modifications, personal assistance) to overcome disability and enable participation in all aspects of life – and states the mission of a SDS – ensuring that all people with disabilities can access appropriate assistive solutions that are able to support autonomy in their life environment. The third chapter (Basic features of an AT SDS) discusses why public SDSs are needed for AT, what the main SDS models are, and how the SDSs quality can be monitored. The last chapter provides a number of useful recommendations for those who are engaged in the design, development and implementation of AT SDS policies.

Keywords. Assistive Technologies, Service Delivery Systems, Quality Assurance.

Introduction

Public service delivery systems (SDS) for assistive technology (AT) have been in place in many European countries for many years, as part of their national or regional welfare systems. The various systems differ significantly from each other, in relation to each country's disability policy, socio-economic context and history. A system may be considered more or less advanced than others; however, no system recognizes itself as "perfect".

It is probably impossible to design a single SDS that is applicable in every country in the EU. Provision of AT is just one element of each country's healthcare and social support policy, which in turn is related to its geographical, historical, political and legislative context. Thus each country needs to design systems that are best tailored to its context. However, the experience of each SDS existing in Europe teaches lessons from which any other country could learn.

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For instance, it teaches that in each country there is room for improvement; that in the spirit of the UN Convention [1], which completes the shift from a *medical model* to a *citizenship model* of disability, people with disabilities should be included in any decision making process on issues that are relevant to them, including the design of service delivery policies; that within today's political climate of budget containment and accountability there is an increasing demand for evidence of the cost-effectiveness of any public support system for personal needs. Information should be available on the effectiveness of an AT SDS in meeting the citizens' needs, on how much its social cost is, on how it performs against appropriate quality indicators.

In relation to these new challenges brought on by today's rapidly changing society, there is a need to mobilise all expertise available in Europe and identify roadmaps for SDSs improvement. That's why, in early 2012, the AAATE (Association for the Advancement of Assistive Technology in Europe) and the EASTIN Association (the European Information Network on Assistive Technology) decided to jointly take the lead of an international consultation process leading to a Position Paper.

1 Method

First, an International Workshop was held in Copenhagen on May 21-22, 2012 in order to gather the most important experiences and discuss good practices concerning an "ideal" delivery system. It was supported by the Danish Ministry of Social Affairs and Integration, by Health and Rehab Scandinavia (a major exhibition of AT products) and was officially included in the calendar of events of the Danish Presidency of the Council of the European Union 2012. The workshop attendance included policy makers, scientists, professionals in health, social services and education.

The Workshop [2] included plenary sessions – that gave the opportunity to all participants to learn from each other's experience, to investigate how the various service delivery systems could evolve to best meet the user's needs and to be at the same time sustainable on the long run – and three parallel working groups – each addressing a distinct research question:

- WG1 (organization): "*How should the ideal system be designed so as to promote innovation, AT market and to meet the citizens' needs?*"
- WG2 (expertise): "*How to ensure the user influence in selecting AT? What are the appropriate professional roles within an ideal system? What should be the appropriate educational standards?*"
- WG3 (effectiveness): "*What are the appropriate outcome indicators for an ideal system? What are the appropriate cost indicators? How should cost-containment methods be appropriately implemented, such as public procurement procedures or recycling processes?*"

The thoughts generated in this workshop – followed by a literature analysis and a review of the material previously produced by the HEART Study of the European Commission (Horizontal European Activity on Rehabilitation Technology) [3] [4] – provided the starting point for a consensus process that involved several iterations and drafts until achieving and agreed Position Paper [5]. The following chapters summarise some key points of this Paper.

2 The Scope of an Assistive Technology Service Delivery System

2.1 Assistive Technology as Components of Individual Assistive Solutions

The definition of Assistive Technology – an umbrella term indicating any product or technology-based service that enables people of all ages with activity limitations in their daily life, education, work or leisure – is quite broad and includes not only devices that have been purposely designed for people with disabilities. There is an international classification of products falling within the concept of AT – the ISO 9999:2011 standard – that is currently used by most national information systems in Europe and by the European Assistive Technology Information Network (EASTIN) as well [6].

However, the border between *assistive* and *mainstream* technologies is sometimes blurred, in that it is possible sometimes to design *assistive solutions* by assembling mainstream technologies. The solution to an individual need often involves something more than just a device: it may require a mix of mainstream and AT products, whose assembly and configuration may be different from one individual to another; it may involve personalised environmental modifications (e.g. adaptation of a bathroom, a kitchen, a worksite); for certain people it may also require some personal assistance, to a lesser or greater extent in relation to the individual needs and the context. Altogether, all these products and interventions build up the personalised *assistive solution*.

Most SDSs in Europe put boundaries to the set of assistive solutions that are eligible for public provision. Some systems have a broader scope, with a large amount of products included as eligible for funding, while others have a narrower scope often limited to products focused on functions replacement or compensation, rather than on activity support or environmental improvement.

Some Countries consider AT, personal assistance and individual environmental adaptations within the same provision scheme, while others have separated procedures and responsible Bodies. In some Countries – or even in Regions within a Country – there may be different systems for different types of assistive solutions (prosthetic; orthotics; wheelchairs; home adaptations; ICT equipment etc.), or for different people (young, elderly etc.), disablements (blind, deaf, etc.), pathologies, certifications (e.g. "civilian" Vs "occupational" invalidity), or for different contexts (employment, school, domestic life etc.). The different systems are not always well-coordinated with each other or with other interventions (rehabilitation treatment, home care plans, educational programme etc.): which may lead to inefficiencies, unreasonable waiting lists, or multiple doors the user has to knock at.

This does not mean that there should be one single system for any kind of assistive solution. What's important – for the purpose of this document – is to have a common understanding of which interventions should be considered today *assistive solutions*, and as such deserving the attention required by the UN Convention.

2.2 Assistive Solutions as Environmental Facilitators

Luckily, the ICF model of the World Health Organisation [7] helps clarify the concept. Within the ICF Model, any *technology* supports – including both AT products in strict sense and mainstream products that can be used, assembled or configured to compensate for functional limitation or support participation in life activities – are classified as environmental contextual factors (ICF class e1). Individual adaptations of the *physical (or virtual) environment* where the person lives or carries out certain activities are also considered environmental contextual factors, although classified under a different class (ICF class e2). The same applies for *personal assistance* (falling within ICF class e3). Thus this concept can be summarised by the *"four A" equation*:

Assistive technologies + personal Assistance + Individual environmental Adaptations = Assistive solution

Each factor may work as facilitator or barrier, depending on how well it is implemented and how well it works in combination with the other two factors. Working as facilitator means supporting the person's *autonomy*, i.e. improving participation in life activities in relation to his/her personal hierarchy of needs. Thus an assistive solution can be judged as effective if there is evidence that it has improved *autonomy*, or made it possible to maintain it.

Autonomy – intended as ability to take control over one's own life, to establish relationships with others and actively participate in society – is a broad concept that doesn't depend only on technological enablers or personal assistance or suitable environments: it is the outcome of an empowerment process involving a personal growth, to which several other contextual factors also contribute (rehabilitation, education, counselling, housing, social measures etc.). However, it is evident that achieving autonomy is often impossible without appropriate *assistive solutions*.

The discussion so far clarifies the scope of an AT SDS: ensuring that all people with disabilities can access appropriate *assistive solutions* that are able to support *autonomy* in their *life environment*.

2.3 Accessibility: The other Side of the Coin

Assistive solutions are individualised interventions. Conversely, if we look from a societal viewpoint at the accessibility of mainstream environments, products and services – which means having in mind not a specific individual user but the whole population that may need to use them – we go to the other side of the coin.

The Position Paper makes it clear that accessibility is an *infrastructural* intervention, which is not responsibility of an AT SDS. Ensuring that the mainstream environment is usable by all people, including those with reduced function or who depend on AT, involves all sectorial responsibilities in society.

Of course there is a relationship between infrastructural accessibility and individual assistive solutions: the effects of both interventions add up. When infrastructural accessibility is poor, the assistive solution compensates for this, and vice versa (figure 1). However, the more inaccessible the mainstream environment is, the more difficult it will be to implement effective assistive solutions.

Figure 1. Add-up effect of infrastructural accessibility and assistive solutions.

This means that accessibility policies and AT service delivery policies should be well coordinated among each other. According to the UN Convention, both are related to the fulfilment of the same human right.

3 Key Features of an AT Service Delivery System

The Position Paper proceeds with discussing why are public SDSs needed for AT, what are the possible service delivery models, what are the quality indicators, and what are the quality drivers. The discussion is organised into eight research questions:

- Question 1: *"Are AT products going to disappear in the future, due to the embodiment of accessibility features in mainstream products ?"*
- Question 2: *"Why shouldn't AT products be dealt with as common consumer goods, purchased directly by users without the intermediation of a SDS ?"*
- Question 3: *"Are there different approaches for AT service delivery?"*
- Question 4: *"When can a medical model, or a social model, or a consumer model be considered appropriate ?"*
- Question 5: *"Independently of the model and the Country or Region, is it possible to identify common steps in the service delivery process ?"*
- Question 6: *"How does each step influence the costs and the outcomes of the whole process ?"*
- Question 7: *"How can the process be monitored by quality indicators ?"*
- Question 8: *"How can information support the service delivery process ?"*

There is no room in this article to look at each question in depth. We'll just pick-up questions 3 and 4 to highlight some fundamental issues.

First, the provision of an assistive solution to an individual user should be based on a *partnership* approach (team work, in which the user plays a key role) rather than on a *directive* approach (in which the professional selects and the user has little or no say). The partnership approach should drive the education, the attitude and the working methods of the involved professionals.

Second, from the organisational viewpoint we can identify three main SDS models (although well-defined boundaries among them are just theoretical): the *medical model*, the *social model* and the *consumer model*.

Within the so-called *medical model* each AT device eligible for public provision should be prescribed by a qualified professional under his/her responsibility. A medical model is usually regulated by a list of products (Registry) or product specifications (Nomenclature) eligible for public provision, with or without established prices or reimbursement thresholds.

Within the *social* model, the focus is on the whole assistive solution, rather than on specific devices. Once the individual assistive solution has been decided and the budget has been authorised, the choice of the devices is quite free, provided that they effectively meet the intended goals.

Within a *consumer* model, the user decides on the devices and purchases them directly. This does not mean that users have to pay everything out of their pockets (financial help may be provided through vouchers or cash) nor that they can purchase whatever they wish (financial help may be provided against authorised objectives on which the user should be accountable), nor that they are left alone in their choices.

There is not a fixed recipe to decide when a *medical* or a *social* or a *consumer* model is the most appropriate. The Position Paper suggests that, tentatively, *medical* models are suitable for health-oriented or function-oriented equipment (e.g. prosthetics) whose choice and personalisation require thorough clinical assessment, and whenever wrong choices may expose the user to significant clinical risk. Conversely, *social* models may are appropriate for participation-oriented equipment (e.g. daily living equipment) where the clinical risk related to wrong choices is negligible; where the range of equipment that can be considered for the choice is broad and varied; where installation/configuration require technical rather than clinical competencies.

Consumer models could be considered as derived from social models but with more responsibility and decision power shifted to the user. An advantage of consumer models is that they put the market supply in direct contact with the consumer demand, which is a powerful drive for quality improvement and price reduction; however this can only work if users are empowered to make informed and responsible choices. This can be done by setting up effective information services and assessment centres where users can learn about AT in an environment independent of commercial interest; by developing a partnership attitude among rehabilitation professionals; by including *empowerment* among the expected outcomes of a rehabilitation or educational plan; and by enforcing measures to prevent possible abandonment of the purchased devices.

4 Conclusions

The Position Paper also provides a list of recommendations for those who are engaged in the design, development and implementation of AT SDS policies. These are clustered round the six SDS quality indicators suggested by the HEART Study: Accessibility, Competence, Coordination, Efficiency, Flexibility, User Influence.

The Position Paper is currently being discussed all over Europe by professional organisations, user organisations and national or EU-wide Bodies. Although not providing detailed instruction on how to organise SDS at local level, it is a powerful catalyser of a debate among all stakeholders.

Acknowledgements

The author, who coordinated the development of this Position Paper, heartily thanks all those who contributed to the consensus process and provided valuable input, in their capacity of AAATE Board members, or EASTIN partners representatives, or speakers or participants in the Copenhagen workshop.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-254

A Taxonomy for Describing ICT-based Assistive Technologies

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Abstract. Within the ETNA project – a European Thematic Network aimed at implementing a EU-wide Portal devoted to ICT-based assistive technologies and e-accessibility solution – a *Taxonomy* has been implemented for describing the technical details of ICT based AT products. The taxonomy, based on a two level hierarchy of *Clusters* and *Features*, has been connected to the third-level categories of the ISO 9999 standard – "Assistive Products for Persons with Disability – Classification and terminology". A procedure has been defined to manage the continuous update of the taxonomy.

Keywords. Taxonomy, ICT Assistive Products, Product Description.

Introduction

The European Thematic Network on Assistive Information and Communication Technologies (ETNA) is a project partially founded by the ICT Policy Support Programme of the European Commission [1]. The ETNA thematic network, set up in January 2011, involves 23 Institutions, with acknowledged commitment in the ICT Assistive Technology (AT) area, and is coordinated by the Don Carlo Gnocchi Foundation. The objective of the ETNA project is to implement a European Web Portal providing unified access to all ICT AT resources available on the Web in relation to the needs of all stakeholders, involved as AT users, professionals, manufacturers/suppliers, researchers/developers, and policy-makers [2]. The aim of the Portal is to provide information on ICT assistive products, and on related organisations (manufactures, suppliers, service providers, ...) and material (fact sheets, case studies, ideas, ...). The ETNA Portal stems from the already-existing website of the European Assistive Technology Information Network EASTIN (www.eastin.eu) – the most comprehensive European information service on AT – which currently aggregates the contents of eight major national providers of AT information in the various European countries [3].

The ETNA thematic network is working in conjunction with the ATIS4All (Assistive Technologies and Inclusive Solutions for All) Thematic Network [4], that will create an online community of all the stakeholders involved in the AT field.

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1 Backgound

In the past years several attempts have been made to standardize the description of technical details AT products. Two interesting projects, among others, that worked on this subject are the *North-4 project*, funded by the Nordic Centre for Welfare and Social Issues (NSH), aimed at defining a common classification of AT products for the European Nordic countries [5], and the *ICT devices register project*, funded by the Italian Ministry of Health, aimed at defining a detailed dataset for the ICT based assistive products eligible for medical prescription [6]. Several online information systems that describe AT products using a detailed dataset and proprietary classification are also available. Interesting examples, among others, are the OATSoft [7], HMI-Basen [8], AbleData [9], SIVA portal [10], and EmpTech [11] websites.

2 The Basic Datasets for Assistive Technology Resources

The aim of the ETNA Portal is to provide information on the following three categories of resources: Assistive Products, Organizations (Manufacturer/suppliers, Service Providers, Projects), and Associated Information (Articles, Case Descriptions, Ideas, FAQs, Forums, News, Regulations). Within the ETNA project a *Taxonomy* has been developed for describing those three categories of resources that together constitute the *Domain Model* of the ETNA portal. The ETNA Taxonomy identifies, for each of the three categories of resources, a *basic dataset* that represent the minimum set of information needed to: 1) uniquely identify a resource, 2) to understand what kind of resource it is and what it is about, and 3) to make the resource retrievable by the ETNA search engine. The basic datasets for the three categories of resources are reported in Table 1

Table 1. Basic dataset for the resources of the ETNA portal.

Assistive Products	Organizations	Associated Information
Record identification • Product Name **Product Typology** • Classification code and name **Dates** • Insert Date • Latest update date **Manufacturer information** • Name • Address, Postal code, Town, Country • Phone, E-mail, Skype • Website, Social network **Free text description** • Original language • English **Image**	**Category** • Company/ Service Provider / Project **Record identification** • Full name in original language • Full name in English • Short name (Acronym) **Free text description** • Original language • English **Dates** • Insert Date • Last update date • Start date • End date **Contact Body**	**Category** • Article/ Case Description/ Idea/ FAQ/ Forums/ News/ Regulations **Record identification** • Title in original language • Title in English • Authors • Publishing details **Free text description** • Abstract in language • Abstract in English **Dates** • Insert Date • Latest update date • Publication year **Source of information**

• Product small image url • Product large image url **Links to further details** • User manual • Video demo • Brochure • Other documents **Source of information** • Information provider name • Information provider country • Link to Full product record **Download/Purchase website** • Download/purchase web page	• Name • Contact person name • Address, Postal code, Town, Country • Phone, E-mail, Skype • Website, Social network **Source of information** • Information provider name • Information provider country **Domain** • Organization domain according to ISO 9999 codes • Organization domain according to ICF codes	• Information provider name • Information provider country • Link to original record **Links to further info** • Link to Full record • Link to further information **Image** • Image url **Domain** • Related domain according to ISO 9999 codes • Related domain according to ICF codes

3 Detailed Dataset of ICT-based Assistive Products

As depicted in **Figure 1**, in the ETNA portal a product record is composed of two parts: the basic information (i.e. the *Basic Dataset*) and the technical details that represent the product *Detailed Dataset*. The Detailed Dataset of a product is composed of an array of *Features* selected among the collection of all possible features (i.e. the vocabulary) identified in the ETNA taxonomy.

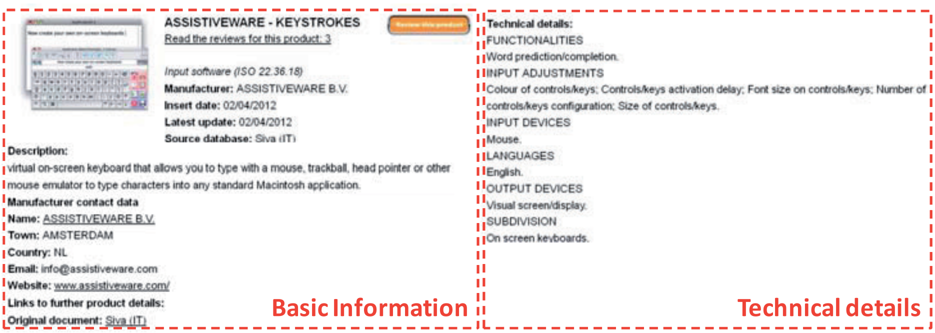

Figure 1. Example of a detailed product description in the prototype of the ETNA portal.

The taxonomy can therefore be basically seen as a *vocabulary* used to standardize the description of products' technical details. The taxonomy vocabulary is based on a two level hierarchy made up of *Clusters* and *Features*. Homogeneous Features are grouped together in the same Cluster. For example the Features "Windows", "Mac OS", "Linux", "Chrome OS" , etc... are all grouped in the Cluster "Operating System", while "Printer", "Visual display", "Tactile display", etc... are grouped in the Cluster "Output devices".

Features can be of two types: *Measures*, that can have a numeric value or an interval specified (e.g. weight, length, ...), and *Attributes*, that do not have a specified value (i.e. are Boolean features).

Overall 18 Clusters and 237 Features have been identified. In **Table 2** all the Clusters included in the current ETNA taxonomy are listed.

Table 2. List of Clusters included in the taxonomy.

Overall dimensions	Capacity/Range	Energy type
Activation modalities	Operating systems	Visualization
Browsers	Languages	Input devices
Linguistic representations	Functionalities	Output adjustments
Input adjustments	Output devices	Price
Connectivity	License	Subdivisions

The model that has been used for identifying the Clusters of features of an ICT based product is represented in Figure 2. The idea behind the model is that in an ICT based product the following conceptual "elements" can be considered: Input, Central Unit (for processing and storage), Output, Connectivity (with other products or services), Environment (in which the product operates), Physical characteristics, and Software characteristics.

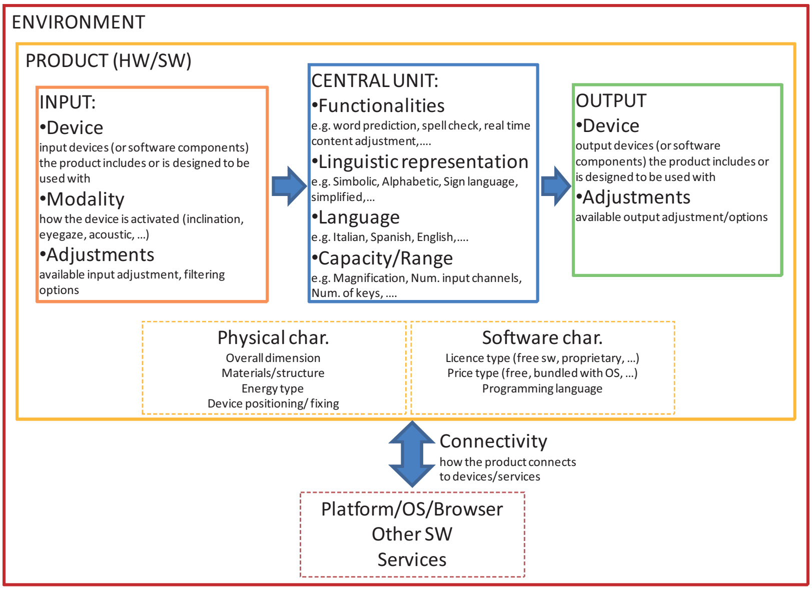

Figure 2. Model of an ICT based product

3.1 Connection of the Taxonomy Items with ISO 9999 Divisions

A mechanism has been created to put the items of the taxonomy vocabulary in relation with the divisions (i.e. the product categories) identified by the ISO 9999 standard [12] – that defines a three level hierarchical classification of assistive products for persons with disability. A matrix has been created to indicate, for each of the item of the taxonomy vocabulary, the "relevance" for the ISO 9999 divisions. Within the scope of ETNA project a subset of 38 ISO divisions have been considered (those more strictly related to ICT products). The relevance of a taxonomy item for each of the identified ISO divisions is evaluated by means of a 5-points scale (1 'absolutely irrelevant' to 5 'absolutely relevant'). For instance, for the ISO division "*22.36.18 Input Software*", the item "*Width (Overall dimensions)*" is ranked "1" while item "*Accelerometer (Input Devices)*" is ranked "3" and item "*Linux (Operating Systems)*" is ranked "5" (**Table 3**).

Table 3. Example of relations between taxonomy items and ISO divisions.

ISO divisions / **Taxonomy items**	22.36.03 Keyboards	22.36.18 Input Software	22.39.12 Special output software	…
Width (Overall dimensions)	5	1	1	…
Linux (Operating Systems)	4	5	5	…
Accelerometers (Input devices)	3	3	1	…
...	…	…	…	…

One of the advantages of this approach, is related to the possibility of presenting, in a data entry form, the taxonomy items ordered by relevance with respect to the specific product category (for example when data of an on screen keyboard are entered into a database the items related to the supported operating systems are presented before the items related to the input devices, while the items related to the dimensions are not presented).

3.2 ETNA Subdivisions

As part of the ETNA Taxonomy a list of product typologies have also been identified. Those typologies are intended to be a refinement of some of the divisions included in the ISO 9999 standard and are therefore called *Subdivisions* in the ETNA Taxonomy. Similarly to the ISO 9999 standard, each subdivision has a code, a title, and an explanatory note. For example the Subdivisions identified within the ISO division "22.39.12 – Special output software" are reported in **Table 4**.

Table 4. Subdivision included under the ISO division 22.39.12 Special output software.

Code	Title	Explanatory note
ISO 22.39.12	Special output software	Included are, e.g., software that enlarges the text and graphics displayed on a computer screen, software that reads the display and converts it to speech (screen reader).
223912.01	Magnifying software	Software that enlarges the text and graphics displayed on the screen of a computer or other electronic devices. May feature screen reading, colour choice and focus enhancement etc.
223912.02	Screen reader software	Software that interprets what is being displayed on the screen and presents it to the user with text-to-speech, sound icons, or a Braille output device.
223912.03	Software for adjusting color combination and text size	Software that allows adjusting the color of text, background, images and other elements displayed on the screen, and/or to adjust the font size, to improve visualization.
223912.04	Software to modify the pointer appearance	Software to modify the size, color, and/or shape of the pointer on the screen

3.3 Procedure for the Maintenance of the ETNA Taxonomy

The ETNA taxonomy is intended to be a dynamically changing vocabulary. New items can in fact be added to the taxonomy (both Clusters and Features) if they are needed. For instance, a new *operating system* appearing on the market will require that a new item is introduced in the Cluster “operating system” in order to describe products compliant with it; likewise, a new innovative product may not fit in any of the current ETNA *subdivisions*, thus a new subdivision should be created. A *consensus procedure* for deciding on the introduction of new items in the taxonomy has been defined. The procedure foresees the involvement of the Online Community that will be established within the ATIS4All project – a sister network of the ETNA thematic network - that will include all the stakeholders of the ICT AT field (end users, manufacturer, researchers, developers, AT professionals, ...). The proposal to create a new item will be discussed online and eventually submitted for voting by authorised members of the Community. If the vote is successful, the new item is entered in the taxonomy by an administrator of the ETNA information system.

A number of experts, selected within the online community, will also have the possibility to decide on the “relevance” of the taxonomy items for the different ISO divisions by means of a 5-points scale (as described above).

4 Conclusions and Future Work

The taxonomy developed within the ETNA project represents an important step forward in the effort to harmonize the description of assistive technology products in different information provider’s databases. This will facilitate the possibility for end users, AT professionals and anyone interested to compare the different AT products available on the European market.

Some among the challenges that the ETNA and the ATIS4All consortia will face in the next few months include setting up the tools and involving the online community to implement the taxonomy management procedure described in this paper.

Acknowledgements

The ETNA project has received funding from the European Union’s CIP - PSP (grant agreement # 270746).

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-261

Implementing the UN Convention in Euregio/ NRW – a (Re-)View on Accessibility of the Built Environment

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Abstract. Based on the requirement of article 9 of the UN Convention on the rights of people with disabilities, access to the built environment has taken renewed focus. In many countries plans and activities have been launched to improve the situation. Footing on national actions of various kind the cooperation in European regions deals with boarding countries. As a concrete example activities in the Euregion Rhine-Maas and Northrhine-Westfalia are presented. The EureWelcome presents the attempt to develop a common label. The data collection in Northrhine- Westfalia describes the effort of a survey on public buildings aiming at better information for the public. This is a cooperative action in the framework of the NRW action plan on the UN convention.

Keywords. Accessibility, Built Environment, Euregio, Data Collection and Publication.

Introduction

The UN CONVENTION ON THE RIGHTS OF PERSONS WITH DISABILITIES requires in Article 9 Accessibility, that all constructed environments are made accessible for people with disabilities [1]. Although the access to the built environment has been on the agenda for long Article 9 has given new emphasis to improve the situation. Over a long period in many countries activities in this direction have been undertaken. Various implementation strategies have been brought on their way, including different criteria, national standard [e.g.2], numerous instruments [e.g. 3], a diversity of documentation and information material, various symbol sets, etc. European or international guidelines and standards [e.g.3, 4] are developing, but are not yet fully replacing national regulations. While the conformance of new buildings with accessibility requirements seems to be an achievable task, the problem of changing the existing buildings is more difficult. In particular, in regions where several European countries have common borders the situation becomes even more complex due to the grown situation with a lack of common requirements, standards, approaches, finance strategies. This paper deals with aspects of this complex situation of the European Meuse-Rhine Region, where 4 European Member States are bordering. It describes the cooperation in the region and an initiative for data collection and provision in NRW as Bundesland overlapping with of the region.

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2 The Region and the High Level Group Inclusion

The Meuse–Rhine Euregion comprises the western part of the Region of Cologne in Germany, the German-speaking Community of Belgium, the Belgian Provinces of Liège and Limburg and the southern part of the Dutch Province of Limburg. With the bordering country Grand Duchy of Luxembourg and the western part of neighboring federal state (Bundesland) Rhineland-Palatinate the area has a population of about 4.5 million people of 4 nations, with 4 languages and cross boarding language minorities. Frequent exchange, business and commuting are day to day practice in the complete region. This is very typical for European bordering regions.

With regard to common activities with respect to inclusion in 1999, the High-Level-Group Inclusion was established. It consists of representatives of the regions of the Meuse–Rhine Euregion as well as the western part of Rhineland-Palatinate and the Grand Duchy of Luxembourg. The High-Level-Group Inclusion represents the administrations of the partner regions in charge of the affairs of people with disabilities and aims at the implementation of the United Nations Convention on the Rights of Persons with Disabilities.

3 EureWelcome Label – Transnational Information on Accessibility for All

The above described partners of the European Region have developed a common Label translating their willingness to facilitate free circulation over the borders - in terms of infrastructure and services - of every person, including people with particular needs namely disabilities.

The innovative approach of the EureWelcome Label consisted in the recognition that the accessibility of infrastructures and services is not a static, but a permanently ongoing process and that the transformation of existing rules needs time and consensus. The partner regions are contributing to the harmonization of the EureWelcome approach with the aim of developing a single transnational certification system in the partner regions based on Design for all principles. This initiative supports the certification process of existing and future activities aimed at assessing the accessibility level of buildings and institutions. The EureWelcome Label is planned to be anchored next to already existing labeling mechanisms at local level without any pretension to replace them.

3.1 Comparison of Sets of Criteria

The High Level Group Inclusion commissioned a group of experts named by the partner regions under the direction of the Agency for Accessibility NRW - Agentur Barrierefrei NRW (http://ab-nrw.de) in 2011. This working group was assigned the task to identify common assessment features to be checked in each region. During the work process in 2011 and 2012 the assessment features and the minimum assessment standards of each region were listed and compared. National standards, published by national standardization institutions like the German “Deutsches Institut für Normung”, also known as “DIN”, are in most cases the base for regional assessment features. For example the DIN 18040-1 defines the recognized standards of good practice for a public building in Germany [2]. The individual national traditions and following standardization processes have resulted in overlapping but diverging national accessibility standards [3], and also in varying assessment features. The table shows the variation and compliance of the applied principles. However, if one goes into more detail, the variation becomes more obvious. Activities using these national rules are ongoing in all of the partner regions. With this background a harmonization of the individual assessment features on the short term is not a realistic goal. However, apart from all differences approximately hundred common assessment features were identified as a result of the analysis done by the working group. These are used as common ground and as a starting point for the EureWelcome. The assessment of these common features will be a requirement for the certification of a regional label with the EureWelcome Label.

The partner regions plan to sign an agreement on the use of EureWelcome in the second half of 2013 and to publish Information about the implementation of the EureWelcome label and about the assessment certification process in the partner regions on the EureWelcome Web portal: http://www.eurecard.org

Table 1. Comparison of the applied principle in the parts of the Euregion.

Partner regions[2]	**Luxembourg[3]**	**Wallonia[4]**	**Flanders[5]**	**North Rhine-Westphalia[6]**	**Rhineland-Palatinate[7]**
Assessments by external, specifically trained assessors	yes	yes	yes	yes	yes
Commitment charter required	yes	(in the process of debate)	yes	(in the process of debate)	yes
Minimum assessment standards	yes	(in the process of debate)	no	(in the process of debate)	(yes)
Different quality levels	no	yes	yes	(in the process of debate)	yes
Differentiation between types of impairments	yes	yes	yes	yes	yes

3.2 Inventory and Information on Access to the Built Environment in NRW

In Germany North-Rhine-Westphalia (NRW) is the Bundesland with the most

[2]The Dutch Province of Limburg is not taking part in the High-Level-Group at the moment. The German-speaking Community of Belgium is not assessing buildings and institutions at the moment, but is planning to do so with the common features of the EureWelcome Label.

[3]Label Eurewelcome (http://welcome.lu)

[4]Le label Access i (http://access-i.be)

[5]Toegankelijkheid Vlaanderen (http://toevla.be)

[6]Bestandsaufnahme NRW (http://ab-nrw.de)

[7]Barrierefreies Rheinland-Pfalz (http://barrierefrei.gastlandschaften.de)

inhabitants, about 18 Million living on 34.000 sqm. It is divided in 31 administrative districts with 373 municipalities, 23 cities with more than 100.000 inhabitants with Cologne as the biggest and most famous with about 1 million people. NRW has a rich industrial heritage of coal mining and steel cooking and is currently undergoing a transformation towards modern industries and services. But it has also 14 natural preserves parks and one national park, many higher education institutions, rich cultural life and national and world heritage sites. The number of public and private buildings is uncounted and an overall picture of accessibility is not available. However, many regional activities of the organisations of people with disabilities and regional administrations have been undertaken to improve the situation locally. Unfortunately this remained unsystematic, is following different approaches and delivering very different information and results.

In the context of the NRW policy in regard to Inclusion but also to demographic change a NRW an initiative was created to analyse the situation and provide consistent information of accessibility to public buildings. This is complemented by plans to revise the building legislation for which each federal state (Bundesland) in Germany is responsible. All the activities are embedded in the action plan for the implementation of the UN convention in NRW [5]. In the survey project reliable information about the accessibility of entities and buildings for the public will be assessed with commonly agreed assessment standards and will be published on an accessible web portal. With this information people with disabilities have the possibility to decide in view of their individual situation if they get along when visiting an entity or a building. On the other hand the governments and administrations but also private owners of buildings with public access will be informed about good solutions and issues in their properties. The whole process is led by the MAIS in close co-operation with the organisations of people with disabilities in NRW and with the operational support of Agentur Barrierefrei NRW (Agency for Accessibility NRW). The concept of the survey project follows an inclusive approach. People with disabilities as user experts are participating in the process at all levels (Board of Agentur Barrierefrei NRW, working group accessibility, steering board of the survey, local entities coordinating data collection, data collection teams). It is very much based on community volunteerism in order to achieve a sustainable society based change rather than a singular one time inventory. It is obvious that this is more difficult to install, but it provides a much bigger potential for the intended results and change.

3.3 Important Process Steps

- In 2011 a working group of representatives of the organizations of people with disabilities in NRW was established under the leadership of the Ministry of Social Affairs of North Rhine-Westphalia (MAIS), with the mandate to discuss and agree on relevant criteria and assessment features. In summer 2011 the process of discussion led to the agreement on a catalogue of assessment features differentiating between movement issues, visual or hearing capabilities and cognitive or intellectual resources [6]. This agreed catalogue is used as a basis for the creation of easy to use assessment instruments.
- In 2012 volunteers of the organizations of people with disabilities and students of

the TU Dortmund University tested draft checklists for assessment in several steps. With the evaluation of all the test results modular checklists for data collection were designed.

- In parallel a data base was developed where all the assessment items and the collected data can be stored and handled.
- In 2013 the training of volunteers of the local organizations of people with disabilities started in nine exemplary regions of North Rhine-Westphalia, followed by the training of students of the TU Dortmund University. The assessment of at least hundred entities or buildings is scheduled until summer 2013.

4 Outlook and Future Work

After the data collection the information about the assessed entities and buildings will be published continuously via an accessible web portal, starting in 2013. The Agentur Barrierefrei NRW will continue to offer training and support of volunteers for the assessment of entities or in all regions of North Rhine-Westphalia. In cooperation with the organisations of people with disabilities the development of an instrument for labelling – quality marking – will be continued based on the data collection with the standardised instruments. Further the European cooperation will be continued in the Euregion Rhine-Maas, but also with other regions and initiatives in the same sector or neighbouring sectors like tourism, public transportation, information systems etc. The development of the European standards for access to the built environment will be of particular interest.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-266

Choice and Control: Assistive Technology within Australia's New National Disability Insurance Scheme

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Abstract. Government policy influences the individual and societal outcomes potentiated by assistive technology (AT) and related supports. Political theory suggests that concurrent problem recognition, potential policy solutions, and active political will, are necessary triggers for concerted government action. This has occurred in Australia, with the advent of a National Disability Insurance Scheme (NDIS), which will revolutionize disability services and, it is hoped, deliver equity for Australians living with impairment. Analysis of the stakeholders and processes involved in developing an NDIS provides a useful case study for others seeking policy change.

Keywords. Disability service delivery, political theory, AT policy, AT consumers

Introduction

This paper provides commentary and analysis on disability and AT reform in Australia. The Association for the Advancement of Assistive Technology in Europe (AAATE) encourages networking, discussion and collaboration between stakeholders with shared interests in assistive technology [1], for example recent reflection upon European AT projects and their impacts upon society [2]. This paper takes a sideways look to a sister organization, the Australian Rehabilitation and Assistive Technology Association (ARATA), and its contributions to the reshaping of a disability support system described as 'underfunded, unfair, fragmented, and inefficient' [3:2].

Australia and Europe share a context of reform inspired by civil rights and non-discrimination legislation in the USA [4], and the success of the disability rights movement in shifting public attitudes away from a medical model of disability toward a more social (or at least biopsychosocial) understanding. Having ratified the United Nations Convention on the Rights of Persons with Disability (UN CRPD) [5, 6], Australia and the European Union both developed strategies to realize the human rights of persons with disability in policy [7, 8]. Despite legislative reforms, operationalizing

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policy to ensure equity of access and equality of outcomes for all people with disability remains a challenge, as seen in the USA, particularly given contemporary fiscal constraints and economic uncertainty [9].

Australia's 23 million people (one in five of whom have a disability) [10] access universal health and aged care via publically funded programs across three levels of government (federal, state, and local). More than 100 separate schemes provide AT [11]; governed by a range of eligibility criteria, and focusing on a range of outcomes [12, 13]. The range and subsidy levels for AT provided by primary AT schemes vary, and cover less than 10% of AT device categories from the ISO 9999[14, 15], resulting in inequities across populations and state borders. In some jurisdictions, for example the State of Victoria, government-subsidized AT is only provided after a substantial individual contribution and a lengthy wait [16]. This is only one example of how current systems represent a 'cruel lottery where the services and support people with disability, their families and carers receive depends on where they live, what disability they have, and how they attained that disability' [17].

1 Methods

This paper distils first-hand accounts of Australia's experience from those within it[2]. The authors have synthesized information from many sources including policy documentation, grey literature and the media. Interpretation of the multiple factors at play is based upon policy pre-decision theory which suggests that, for concerted government action to occur, solvable problems, acceptable policy solutions, and political will or enthusiasm must occur concurrently [18]. The results are presented according to this structure, as it provides a useful way to understand changes within complex systems.

2 Results

2.1 From 'Condition' to 'Problem'

The concerted and sustained voice of people with disabilities or consumers was a critical factor in naming and problematizing the living conditions and limited outcomes of Australians with disabilities. Conditions of social marginalization which have been in place for many decades [19, 20] are now seen as unacceptable by the community in general [21]. Concurrently, consumer activism from organizations such as the Aids and Equipment Action Alliance [22], and initiatives encompassing AT use across health, disability and aging sectors such as National Aids and Equipment Reform Agenda (NAERA) [23], have been building an evidence base as to the current ineffectiveness of AT policy [24] and calling for change [11].

Bipartisan support for the NDIS legislation demonstrates political realization of a profound shift in perspective from disability as a 'condition' to disability as a 'problem'. Australians living with disability are understood as individuals with

[2] D de Jonge as ARATA President (2004-2012); N Layton as an ARATA member as well as representative on Occupational Therapy Australia's NDIS working party and partner in ARATA's NDIS tender consortium (2012-2103).

capabilities, whose lives are impeded by structural barriers as well as the effects of impairment, and who, as citizens, have rights and entitlements. This emerging narrative suggests that, no matter the extent to which the NDIS is able to address these problems, a profound shift has occurred in awareness of the universal nature of disability, and the need for an adequate social contract.

2.2 Policy Entrepreneurs

The term 'policy entrepreneur' is used to identify stakeholders 'willing to invest their resources in return for future policies they favor' [18:202]. Australia's Productivity Commission experienced the greatest ever stakeholder engagement as it tackled the NDIS design, with submissions made by groups including Australians living with disability and carers (including parents), allied health, pharmacy, engineers and AT suppliers, specialist services e.g. Independent Living Centers, Association for the Blind, the Mental Health Council of Australia, researchers and academics, and members of the 'disability industry' such as supported employment and disability service providers. The primary avenue for input was written submissions in response to the draft documentation publicly released on the accessible website (yoursay.ndis.au). Additionally, the government actively sought consultation and engagement in exploring and detailing key tenets of the NDIS, particularly with potential users and their supporters, and with supported employment and disability service provider organizations. Australia's disabled persons organizations were highly sought after to provide advice and representation: a situation that stretched their capacity and exposed the serious under-resourcing of the disability advocacy sector [25]. The allied health professions and AT associations were not initially consulted, leading a number of these groups to engage in active political engagement campaigns to gain a 'seat at the table'.

The small and collegiate nature of the AT sector in Australia, under the leadership of ARATA and NAERA and the sharing of information and skills led to cohesive and coordinated multi-stakeholder messages regarding AT. These strategic actions positioned ARATA as the active champion of AT and, when opportunity arose, advisor to the NDIS architects.

2.3 Political Will

The passing of the NDIS legislation in March 2013 with universal political support demonstrates Australia's political will to address disability. This builds on earlier bipartisan agreement on realizing the aspirations of the UN CRPD is described in Australia's National Disability Strategy 2010-2020 [8]. As well as enshrining general principles including respect for autonomy and "the freedom to make one's own choices" (Article 3a) consistent with the tradition of self-determination; multiple articles of the Convention explicitly mention AT and related environmental interventions (EI) [5]. The current whole-of-government commitment to a social inclusion agenda and underpinning notions of the Australian 'fair go', presents a rare opportunity to address the complexity of AT provision with objectives similar to those expressed in the AAATE's 2012 position paper [26] and the previous HEART studies [2].

2.4 Policy Solutions

The key tenets of the NDIS, sustainability, choice and control, and individualized service delivery [27], have been widely applauded. The plan to insure the whole Australian population, to minimize impacts of disability and maximize inclusion, recognizes universal perspectives of disability [28]. Social model foundations are evident in the targeting of information, referral, web services and community engagement to approximately four million people with impairment and 800,000 primary carers, deemed at risk of significant disability. Around 410,000 Australians will receive funding for 'reasonable and necessary' individualized services geared to meet social and economic goals. The NDIS is targeted at people aged under 65, and not intended to replace the health or aged care sector.

The feasibility of the NDIS as a policy solution for Australia is firmly grounded in economics [29]. The Productivity Commission reports on Disability Care and Support [3], and the subsequent NDIS legislation, are perceived to give the proposed Scheme a sound financial basis. There is ongoing tension between the productivity-flavored economic discourse of 'social and economic outcomes', and the whole-of-life outcomes valued and championed by other stakeholders, notably people with disabilities themselves, and many of the practitioners with whom they work [30, 31].

ARATA's approach to this tension was to articulate a vision of excellent, consumer-focused AT provision. Principles for AT funding programs specifically tailored to the NDIS individualized funding context were detailed in ARATA's position paper 'AT within the NDIS' [32]. AT and related supports such as environmental interventions and personal care were framed as interdependent elements of tailored AT solutions [3]. The complexity of real life, where multiple devices, strategies and supports are needed to address life goals and life stages [33] was emphasized, as was the view that the effectiveness of the individual solutions may depend on mainstream or specialized AT devices and soft technologies, thus provision should be broadly defined. 'Reasonable and necessary' AT provision was described in terms of ISO9999 (what is technically possible) and the UN CRPD (the rights that we are obliged to protect and promote). The economic potential of AT was specifically addressed [34], coupling 'social and economic' outcomes with broader, ICF-based definitions, and costing 'soft technology' [35] as an essential part of AT provision. Potential AT practitioner credentialing frameworks were explored in order to recognize choice, control, and expertise of AT users, suppliers, and practitioners, in the soft technology aspects of provision. A Practical Design Fund grant won from NDIS was used to develop an accreditation options paper [36]. Finally, ARATA formulated a major dissemination and engagement strategy for its membership in order to ensure uptake.

3 Discussion

Australia's progress toward an NDIS, and particularly the role of AT within it, demonstrates the leverage that concerned stakeholders can exert. In this case, multiple

[3] An assistive technology solution can be defined as an individually tailored combination of hard (actual devices) and soft (assessment, trial and other human factors) assistive technologies, environmental interventions and paid and/or unpaid care. www.at.org.au

stakeholders including suppliers, consumers, and all disciplines involved in AT provision, identified common aspirations and goals, articulated what 'good' can look like, and committed to sharing the message at many levels and at every opportunity. Outcomes include the ongoing dialogues occurring with the Scheme through Expert Advisory Groups, invited comments upon draft legislation and rules, and engagement in the Scheme launch sites.

Anecdotal feedback on the impact of various campaigns suggests that a unified message across the AT sector was influential. The impact of the AT policy entrepreneurs is evidenced by the shift in NDIS language and discourse, for example from 'aids and appliances' to AT, and the inclusion of soft technology as a concept and a term.

Stakeholder involvement has helped the government move from disability rights and principles to policy solutions, but several key concepts underpinning the NDIS are yet to be articulated. These include a shared understanding of what constitutes "reasonable and necessary supports", and how "choice and control" will be operationalized. Choice may manifest as the participant deciding whether to purchase 'soft technology' in the form of a professional assessment, or choosing which practitioner to consult prior to purchasing a scooter from their individualized package. Control may allow participants to authorize their AT solutions, unless significant risks are identified, displacing AT practitioners from the role of gatekeeper [37]. The interpretations of such concepts will shape the policy mechanisms, the roles of AT practitioners and, ultimately, the lives of consumers of the reformed disability services.

The stakeholders who influenced the policy development must remain engaged to ensure that the rights of persons with disability translate into equitable and effective practice. To be effective change agents, AT stakeholders therefore must look beyond their professional boundaries and engage with crucial aspects of economics and policy formation. Without sufficient resourcing, the most convincing of policy frameworks will fail. The Australian governments' recent commitment to increase the Medicare levy as a contribution to the NDIS funding base, and the positive public response to this tax increase, are seen as signs of commitment to real change. The next challenge for the sector is the 2013 launch of NDIS trial sites around Australia, which present further localized opportunities to build evidence and support for AT devices and services that will facilitate inclusion across the population.

4 Conclusions

As fellow signatories of the Tokushima Agreement, ARATA has sought to share recent political events with members of AAATE and pursue opportunities to strengthen international work being undertaken to improve AT service delivery. ARATA and colleagues engaged upon a coordinated set of political engagement strategies, underpinned by evidence in the form of targeted position statements [38, 39], and, thus far this approach has been effective. As can be seen from this update on recent Australian developments, while the context of AT service delivery differs across countries, many of the stakeholders, much underpinning philosophy and, most particularly, the elements of best practice in AT provision, are remarkably similar. It is hoped that the journey upon which Australia's AT sector has embarked will resonate with many international colleagues and, that the tale of our endeavors will both inform and inspire.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-273

Developing the Assistive Technology Device Services in North Savo Hospital District, Finland

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Abstract. Finnish Ministry of Social Affairs and Health has published Quality Recommendations of Assistive Device Services in 2003. According to these recommendations Assistive Technology Device Services should be centralized. North Savo Hospital district had a planning project which aimed at more centralized Assistive Technology Device Services. Main problems in today's delivery service are that the quality of services and specially maintenance varies, lots of devices are waiting at the storerooms and process protocols are unclear. To correct this situation, the project recommends that assistive device technology services are centralized at hospital district in order to get; equal services, better quality for devices to support safety of the users, and to increase knowledge of ATDS to support seamless services. In the long run it is expected that centralized model cuts down the increasing cost of ATD services. The model is financed by the fee/inhabitant in municipalities which is 6, 6 million euros altogether. This model is going for political decision- making during spring and autumn of 2013.

Keywords. Assistive technology, device, service, delivery.

Introduction

Local authorities provide basic health care services in Finland. Special health care is provided by hospital districts owned by municipalities. There are 20 hospital districts in Finland and their size varies from 1, 5 million inhabitants to 45 000 inhabitants. North Savo Hospital district (NSHD) has responsibility of 250 000 inhabitants' special health care services. [1]

The citizens in Finland have the right to get their Assistive Technology Devices (ATD) without any costs if they have difficulty in their ability of function or participation due to some medical conditions. ATD includes all devices such as orthotics, prosthesis, wheelchairs, canes, and hearing aids etc. which help the person to cope in everyday life. There are national and hospital districts guidelines for the grounds to lend the devices. The person returns the device when he/she doesn't need it any more. Very individually made devices, e.g. insoles, are not returned. In acute cases person gets the ATD immediately. If the need is not so acute or more assessment or fitting is needed, the process is longer. A uniform criterion for access to non-

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emergency treatment defines that after referral the urgency of the case has to be assessed within 3 weeks and the assessment process has to start within 3 months' time. This includes also ATD services.

Rehabilitation worker (mainly occupational or physical therapists) will make the assessment about the suitability of ATD to person's lifestyle and environment. The assessment is made in cooperation with the person, who needs assistive technology device. In the assessment process it is also evaluated if there is any need for individual adjustments of the device.[2, 3]

In Finland AT services have been divided into basic health care and special health care services. Special health care ATD services are run by the Assistive Technology Device Centers or Departments and basic health care ATD services are run by the municipalities. In national level it has been agreed that some device groups such as environment control units or communication devices are provided by the special health care [4]. Most of the hospital districts have been merging all or part of their basic and special ATD services delivery by establishing District Assistive Technology Device (DATD) centers in the hospital district [5].

1 The Assistive Technology Device Services of North Savo Hospital District

North Savo Hospital District has a small ATD Center. NSHD has centralized its' services only concerning children's devices and devices which belong to the responsibilities of special health care services. The NSHD area has 17 municipalities which own the hospital district. The size of municipalities varies from less than 2000 inhabitants up to 110 000 inhabitants. This means that they have very different resources to take care of Assistive Technology Services.

The NSHD executives make a consulting round in the municipalities every year to chart further needs to develop the health care services. After this round in spring 2011 Department of Rehabilitation got a task to start planning a centralized model for Assistive Technology Services. The planning project started in autumn 2011 and the aim was to start the centralized AT services at the beginning of 2013. The start was delayed until the beginning of 2014. In spring 2013 all the member municipalities of NSHD are making a decision on whether their municipality will join the centralized ATD Centre.

2 The Project of Developing Assistive Technology Device Services

The planning project started in autumn 2011 with gathering data from the municipalities and hospital. Municipalities were asked for their costs and resources of assistive technology services and project coordinator collected the data from Kuopio University Hospital. North Savo Hospital District area had ATD project in 2003 – 2004 which collected data on the main points of ATD Services that need to be developed. During that time the district wasn't ready for centralizing the services. [6] That information was a baseline to this planning process.

The main objectives of this project were to find a way to get equal and good quality ATD services for the inhabitants in North Savo Hospital District and also to produce ATD services economically and effectively.

2.1 Method

The data was gathered by email questionnaire from the health care centers of the municipalities. They were asked for their itemized costs for new devices, maintenance, staff and other expenses allocated to ATD services. Special health care costs were collected from accounts of the different departments. The NSHD municipalities use the same registration program, Effector, where all the AT devices are registered, e.g. loans, costs and repairing history. Part of the data was collected from Effector.

During the project seven health care centers were visited. Health care centers introduced their ATD service process and showed their maintenance rooms, storage rooms and practice areas.

The project had broad-based supervising group consisting of the representatives of the municipalities and hospital district. The supervising group met 6 times during this process supervising the final outcome.

The project organized 40 half-day discussion events for decision makers, therapists and the personnel of maintenance, cleaning and logistics. The purpose of the discussion events was to bring up different angles for AT device services.

The project ran four half-day courses of use of Effector, the computer program used in the district for ATD services. Tours were also organized to two different ATD Centers, Joensuu and Oulu. Over 100 people participated in all these events.

Therapists and maintenance workers followed their use of time on assistive technology device services during three weeks' time in autumn 2012. The aim of this follow-up was to get some baseline on how much time is used on ATD services and what tasks would belong to new centralized ATD services.

2.2 Results

Assistive Technology Device services have been developed since 2003 in NSHD when they were analyzed for the last time. In some municipalities they have got more resources to e.g. maintenance. There are big differences between municipalities and only the biggest cities can itemize their cost. The only comparable cost is the cost of new AT devices/ year and that varies from 3,78€/inhabitant up to 14,66€/inhabitant at the basic health care. Special health care costs in new AT devices are 8, 50 €/inhabitants. So it is approx. little over 4 million € spent on new ATs at North Savo Hospital District.

ATD volume has been growing, e.g. in 2011 129% more rollators and 144% more wheelchairs were lent than in 2003, but the number of the personnel dealing with ATD services has not grown. The NSHD made 54 238 new loans of different devices in 2012. Table 1 shows some examples of the numbers of new loans / year 2012 in some AT device groups. The number of loans includes new and recycled AT devices. The loan can be for short or long period of time e.g. after the operations forearm crutches are used for a few months or when walking balance has become worse, rollator is used all the time. The number of loans has been increasing in past years. This increasing number of AT devices adds pressure on rehabilitation workers, device maintenance and storages.

Table 1. Some examples of the number of new loans in 2012 in some AT device groups in North Savo Hospital District.

the International Classification of Assistive products ISO 9999 code	Product	Number of new loans
120306	forearm crutch	13 993
120606	rollator	3 957
122203	manual wheelchair	2 336
220615	hearing aid	2 160
222109	communication device	94

The conclusion is that the main problems are:

- **Equality:** Inhabitants in North Savo Hospital District don't have equal opportunities to get ATD services, because of different ATD service protocols and interpretations of law and other recommendations.
- **Storage:** Lot of rare AT devices are staying in municipalities storerooms for a long time. These rare AT devices don't go for recycling, because of small population. Storerooms are full and impractical.
- **Maintenance**: Lack of professional skills and time, because ATD maintenance is mostly a sideline besides the main job as a repairman. The space for maintenance and cleaning of AT devices is small.
- **Models of practice:** Models of practice vary a lot e.g. how to register ATD services to district IT program Effector or assessment process of suitable ATD for a client.
- **Health care personnel**: Basic and special health care personnel have overlapping tasks. They have lack of professional skills, because in small municipalities ATD assessments are rare and they don't have the time and possibility to keep up with developing AT field.

3 New mModel for Assistive Technology Device Services

The supervising group agreed to recommend that ATD services should be centralized in sections of maintenance, cleaning, procurement of AT devices, recycling of AT devices and special assessments of AT devices and adjustment work. Basic assessments e.g. rollators are still municipalities responsibility even if maintenance and ownership of the rollators belong to centralized ATD services. All municipalities have close-by service with small storage of weekly needed AT devices. The municipalities donate their AT devices to centralized ATD services. ATD services will be financed by a fee/ inhabitant in municipalities which will be 26, 50 €. ATD services will make the quality of service homogenous and spare time, when the routines of the process will be clear and well known. [7,8]

Maintenance is a crucial point in improving ATD services. Well-organized maintenance enhances the life cycle and recycling of AT devices which also has an economic effect by cutting down the costs in the long run. Good repairing and cleaning service improves client's safety.

The ownership of AT devices in one organization enables recycling effectively. That reduces the need of ATD storage which lowers the costs of ATD services.

Centralizing the ATD service processes gives more opportunities for ATD service staff to develop their skills and knowledge in the field of Assistive Technology. That supports the progress of cost-effective service model.

The challenge for this centralized ATD services will be to create a common understanding of the complexity of ATD services and their impact on costs in the long run. Based on the experience of the centralized service of powered mobility devices it can be said that centralized model will cut down the fast increasing costs in the long run and even out the variations of costs between different years.

There will be the need for clinical research for Assistive Technology Devices and processes; how this will affect clients' possibilities to obtain the devices they need at the right time, how AT device will help the client to lead a more independent life and what effects it has on clients need of other services e.g. helper and homecare, how well devices will be recycled, what will be the role of experts and what will be the cost-effectiveness of ATD services.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-278

Resource Use in the Service Delivery Process of Powered Wheelchairs and Scooters in Finnish Assistive Technology Centres

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Abstract. Assistive technology (AT) services support independence in the population, quality of life, as well as repair from injury, illness, or disability. This study examines the current stage of the Finnish service delivery process (SDP) as well as documenting the resource use in its different steps by professionals, device retailers and users. The results can be utilized when considering user-centred, consistent and effective services for disabled as well as for the ageing population in general.

Keywords. Rehabilitation, assistive technology, provision, service delivery, powered wheelchairs, scooters, resource use.

Introduction

Powered wheelchairs (PWC) and powered scooters (PS) are assistive devices which are granted in order to improve independence, mobility and participation. Population ageing and a subsequent expansion in home care will increase the need for their use [1, 2]. Variation exists in the service delivery for assistive technology (AT) throughout the Nordic countries [2,3,4], while in Finland, there is a need for a standardisation of regional provision practices [5]. Which service provision steps are best recommended, however, remains unclear, as evidence on their effectiveness is inadequate [6].

In Finland assistive technology is granted free of charge to individuals whose functional capacity is permanently impaired due to illness, injury or physical defects [7, 8]. Additional criteria for PWC and PS are that the user should be able to use it safely in various environments and the device should increase the independence, mobility as well as participation of the user [9].

The AT services are part of the patient's medical rehabilitation, which rests with local authorities. Evaluation, selection, maintenance and follow-up of the assistive devices that require special expertise, as is the case with PWC and PS, are provided by specialized AT centres in hospital districts. Access to the services requires a physician’s referral. The expertise of the device retailers is used as part of the process, if necessary. Social services are in charge of the acquisition-related housing adaptation. The service delivery process (SDP) starts according to the needs of the user and

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requires collaboration of several experts during the process. Part of the SDP may be carried out in the client's environment, or in an environment which is as close as possible to the user's natural environment. In addition, the SDP involves essential procedures that are processed without the user directly involved, such as the acquisition of knowledge, documentation and commercial operations [10].

In order for AT services to be user-centred, consistent and cost-effective as part of the public health care, more knowledge about the SDP is needed. This study is part of a larger Nordic study on power mobility outcomes, where Sund et al. [3, 4] have previously documented the SDP in Denmark and Norway. Thus, this study examines the current SDP in the Finnish assistive technology centres where PWC and PS have been provided, and evaluates 1) how much time was spent in the SDP and 2) which actors were involved in the different steps of the SDP. In addition, we evaluate the differences in time use between 3) the AT centres and 4) the PWC and PS users.

1 Materials and Methods

1.1 Study Participants

All twenty assistive technology centres serving municipalities in twenty hospital districts were sent written information about the study and invited to participate. Eleven centres were interested, of which ten participated, representing a geographical variation within Finland. Informants were recruited between February and December 2011. Persons aged at least 18 who had been provided with a PWC or PS for the first time, having sufficient cognitive function to understand and answer to interview questions and lived in ordinary housing were recruited. Users with rapidly progressive degenerative diseases such as amyotrophic lateral sclerosis (ALS) were excluded. Of the 72 eligible users, 70 were invited, and 68 consented to participate. The final consecutive sample consisted of 57 users, as eleven dropped out during the study. The mean age was 55 years, SD 12.4 (range 32–76) and 68% were female. Forty-two applicants (74%) were granted a PS, while fifteen (26 %) received a PWC. Forty-eight applicants (84,2%) had poor or average physical ability and nine (15,8%) had good or very good physical ability. All fifteen (100%) PWC users had poor or average physical ability, whereas the percentage for PS users was 78,6% (thirty-three).

1.2 Instruments and Procedures

A study-specific questionnaire recorded time taken and actors involved in the documentation of the SDP, similar to that used in the previous study on Norway and Denmark [3]. The questionnaire divided the SDP into eight stages: 1) assessment of user needs, 2) selection of model, 3) driving test, 4) individual adaptation of the device, 5) follow-up, 6) housing adaptation, 7) administration, and 8) other activities. The questionnaire was translated into Finnish using terminology from the Finnish Nomenclature for the Assistive Technology Devices [11], and as a consequence, stages two to four were named and defined somewhat differently: 2) selection, fitting and trial, 3) individual adaptation and 4) training and delivery, as driving tests are nonexistent in Finland. The number of minutes spent on each step including documentation and travelling by each stakeholder was registered. The time registration started at the beginning of the process when the professionals first were involved in the case and ended when the PWC or PS were provided to the users. This included appropriate training and immediate follow-ups. The data collection was carried out by the therapists who were responsible for the SDP. The procedures for the data collection was personally agreed with each therapist at every AT centre by the second researcher.

1.3 Data Analysis

Participation of the actors was presented in percentages of cases. The workers were categorized into four groups: 1) physical or occupational therapists and technicians; 2) physicians, secretaries and technician managers; 3) service and transportation workers, and 4) dealers, while users and their personal assistants or accompanying family members were treated as one. As the social workers time in housing adaptations was registered in one of the cases, only the time use of professionals was analysed. The time spent on the main activities was presented in number of minutes of median time and 25 and 75 percentiles. Because the time data was not normally distributed, Mann-Whitney-U and Kruskal-Wallis tests were used. The level of statistical difference was set to $p<.05$.

2 Results

The median total SDP time use was 5 hours (300 minutes, IQR 205-300). Including the dealers, the median total time increased with only two minutes (302 minutes, IQR 205-445) as the dealers were involved in only nine cases (median time use 90 minutes, range 10-630). Highest median times for the separate stages in SDP were in selection, fitting and trial (75 minutes) and in training and delivery (60 minutes). See table 1. There was a huge variation in the total SDP time use (range 100-898 minutes) and a significant difference in the total time use between the ten AT centres (shortest median time 162 minutes vs. highest median time 587 minutes, p=.001). Additionally, the total median SDP time was longer for the PWC than for the PS users (380 vs. 270 minutes, difference 110 minutes, p=.004).

Total median time spent by the users (n=53, four cases were treated as missing values) was 4 hours and 45 minutes (285 minutes, IQR 204-403, range 90-995).

The personnel resource use in the SDP was most prominently put in the assessment of the user's needs, selection, fitting and trial (100% of the cases), training and delivery (96 % of the cases) and in administrative tasks (82% of the cases). Follow-up was done in less than half of the cases (46%), and individual adaptations of the device, housing adaptations, or other activities were needed in even lesser cases (25%, 11% and 11%, respectively, Figure1). The therapist and technicians were involved in all cases, mostly in the selection, fitting and trial (100% of cases), training and delivery (96%), follow-up services (46%) and in administration (42%). Physicians, secretaries and technician managers participated in administration and in assessments of user needs in 39 cases (68%). Service and transportation personnel were involved only in fifth of the cases (21%). The dealers participated mostly in the selection, fitting and trial (11% of the cases) and in the training and delivery (7% of the cases).Users were mostly involved in selection, fitting and trial (100% of the cases), training and delivery (96% of the cases) and in the assessment of the user's needs (77% of the cases).

Table 1. Number of cases and median time (interquartile range) spent on different tasks.

Stages of the SDP*	N	Median minutes	IQR
Assessment of user needs	57	45	26-128
Selection, fitting and trial	57	75	110-160
Individual adaptation of the device	14	23	15-68
Training and delivery	55	60	45-90
Follow-up	26	38	18,75-94
Housing adaptation	6	20	14-218
Administration	47	25	20-40
Other activities	6	45	19-71
Total time excl. dealers	57	300	205-300
Total time incl. dealers	57	302	205-445
Total time users and relatives	53	285	204-403
Total time PWC users	15	380	302-570
Total time PS users	42	270	194-356

*All stages included possible phone calls, enquires, documentation and travelling. Assessment of user needs=assessments of the device before trying it (etc. acquisition or process of delivery); Selection, fitting and trial=testing, fitting and selecting the device under the guidance of an expert; Individual adaptation of the device = fitting and adaptation of e.g. the seat or the back of the device; Training and delivery=training in AT centre or in user's home environments; Follow-up=follow-ups of the usage of the device e.g. as part of home visits, all contacts from the users if the devise has not worked as it should, including possible change of the device and new fitting; Housing adaptation=necessary housing adaptation caused by the new device; Administration=decision making, letters to the user, enquires from the physicians or other professionals; Other activities=other than the above activities, which were service, repair, acceptance inspection, transportation and searching for a slope.

3 Discussion

This study focused on the resource use of the SDP of PWC and PS in Finland. Taken all the ten AT centre's SDP time use together, the total median time used was 5 hours. This is close to the time use found in Norway and Denmark [3, 4]. The difference between the Finnish and Danish samples was only 25 minutes more, while it was 50 minutes less in comparison to the Norwegian sample.

In Finland the AT centres took care of all the stages in SDP, whereas the dealers were involved only in few cases. This finding was similar with Sund et al. [3, 4], although the dealers were used far less in Finland than in Norway and Denmark. This indicates that in Finland the expertise in SDP of the PWCs and PSs is strongly concentrated in AT centres, the dealers are used only in very few specific areas, if necessary.

The fact that the total time spent by the professionals was only fifteen minutes more than the total time spent by the users indicates that users together with their assistants and relatives spend equally time on the SDP. However, the users were not included in all stages in SDP. A question arises as how user-centred the processes really are and are users taking part in all the necessary stages to ensure that the services eventually meet their needs. Qualitative research would add value on these matters.

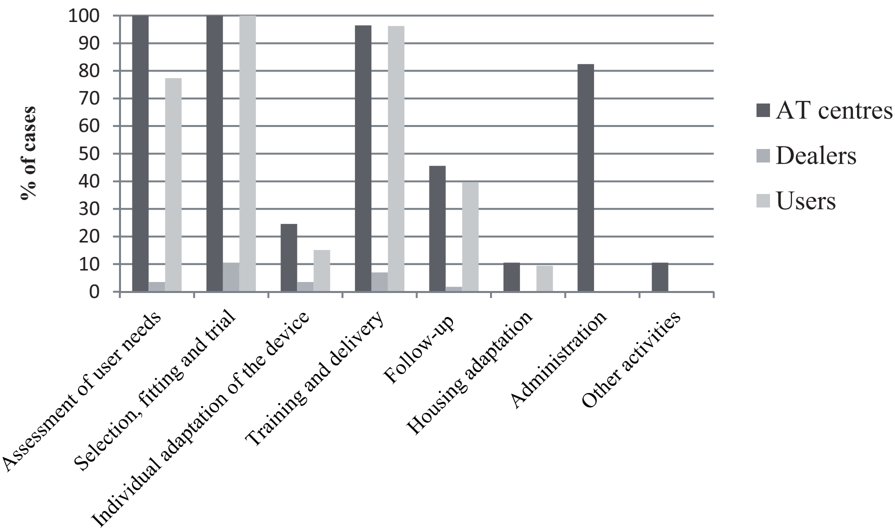

Figure 1. Involvement of the assistive technology centres, dealers and users in the different tasks in the SDP.

The AT centres were mostly involved in the assessments of user needs, selection, fitting and trial and in training and delivery, but participated less in administrative work, individual adaptation of the device and follow-up services. High participation in the assessments stage was equivalent with the finding with Sund et al. [3, 4], where Norwegian and Danish municipalities were involved in assessments in most cases, although lesser in Norway. The fact that there are no driving tests in Finland is a clear difference. Even so, the median time spent in training and delivery was similar to the times spent in driving tests in Denmark and in Norway [3]. Also the involvement in this stage was somewhat higher in Finland, which indicates that Finnish AT centres invest in training at least as much as in Denmark and in Norway.

Low time use in administrative tasks in the Finnish sample may be explained by the fact that administrative work has been registered into different stages depending on the professions (i.e. secretary's and physician's time use was recorded only in administration or needs assessment, whereas therapist wrote down their recordings in different stages). As housing adaptations are planned and financed by social services in Finland, low involvement in this task indicates that the AT centres are really not cooperating with them.

This study showed that the SDP is perceived and produced differently across the Finnish AT centres. For example in some centres individual adaptation is part of the selection, fitting and trial, while in some cases it´s made part of assessments, and made only if necessary. This explains most differences within the sample. As the AT centres differed a lot in their total time use in the SDP, some of the differences might as well be explained by different practical approaches, as the amount of visits to the AT centres and to users` homes varies between the centres in Finland. Additionally the distances to the centres may be different. This sample consisted more of PS users than PWC users which is why lesser adaptations may have been needed. Respectively none of the PWC users had good or very good functional ability, which indicates that processes are different according to the functional ability of users and their needs. In addition, as Jedeloo et al. [12] also found, the "delivery time" is related to the type of AD provided.

Since follow-ups were present only in few cases, it´s likely as in Sund etc. [3, 4] that in this sample the time span between the delivery and the registration of times was too short for all the follow-ups to take place. Otherwise, low use of follow-up services is problematic, since follow-up is important in order to make sure that the device is appropriate and in active and safe use. More examination is needed to find profound reasons for the differences.

4 Conclusions

In Finland the SDP for PWC and PS provision is mainly managed by assistive technology centres. The SDP lasts approximately 5 hours both for professionals and users, being longer for PWC than PS. Moreover, much variation was found across the AT centres. Further analyses of user-centeredness of the processes, and costs and benefits for the users are needed to complete the current picture.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-284

Multidisciplinar Team on Assistive Technology for University Students

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Abstract. University is in general a challenging phase for a student. During University students usually must face with new study methods, subjects, tools and technologies, and supporting them requires specific and advanced skills. But for students with disabilities there is also a number of additional problems that can make University even more difficult. In Italy, thanks to the Law 17/1999, each University is organized with a center supporting student with disabilities, providing logistic support, tutoring and technical aids. Unfortunately, this center is typically not organized to help the student identifying the most appropriate technical aids in order to face University Studies. To this aim a multidisciplinary team would be required involving not only experts from the University but also experts on assistive technology from the technical, social and sanitary point of view. The proposed project was exactly conceived in order to create such a multidisciplinary collaborative framework for the students of Pisa University. The three main actors are the Unit of Services for the Integration of students with Disabilities (USID) of the University of Pisa, the Laboratory for Aids, Communication, Learning and Autonomy (LAPCA) of Azienda USL 5 Pisa and the Department of Information Engineering (DII) of the University of Pisa, structures with complementary competencies respectively in the logistical support to disabled students, in the healthcare and in electronic engineering and computer science.Thanks to this project a multidisciplinary team has been established, with the aim of taking care of the needs of technical aids for student of Pisa University. Several students have been enrolled in this project not only identifying the most appropriate technical aid for the given student needs but also customizing and developing new technologies when required. A couple of case examples will be presented.

Keywords. University, Disability, Assistive Technology, Support, Multidisciplinary Team.

Introduction

University is an important step in the development of our personal and professional profile. Although declining, the annual number of University students in Italy is quite high, amounting in 2012 to over 280,000 units [1]. In general, the University period can be hard because of many reasons such as the different approach to studying

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compared to high school and the need of travelling to and from University or to relocate in a new town.

For disabled students University can be even more difficult for several reasons: they can have a relevant number of logistical problems, they can have difficult access to learning contents and tools like books and the personal computer (PC). This situation may cause a strong discouragement in relation to their own capacity and may lead to give up their studies.

In many cases the service units located within Universities, by Law 17/1999, such as the Unit of Services for the Integration of students with Disabilities of University of Pisa (USID), do a great job providing the disabled student with an excellent and updated service and with all kind of supporting materials. Unfortunately, the USID mostly guarantees logistical support while a multidisciplinary assistance would be the best for the purpose, as described also in [2-4]. Furthermore the USID does not include a team of experts to support students in the selection and configuration of assistive technology so the student has to rely on external services. Even though this can be quite easy for local students it becomes very hard for students coming from outside Pisa.

In Italy an essential service for disabled students is provided by the "Technical Aids Competence Centers" (a part of Italian national healthcare service) located throughout the country. [5] Among other activities, they provide support to students with disabilities to identify the most suitable technical aid for each type of disability. Unfortunately, very rarely there is a strong link between University and these centers and so it is not common to have the opportunity to work together for supporting students' special needs.

Furthermore, high school students are facilitated by the presence of parents, relatives, friends or care givers, while at university, especially for off-site students, this support may not be present. Aids centers and service units can play an important role, but in the last years information technology tools (such as development tools, CAD software, word processors and simulators) have become increasingly popular during university and their configuration and use often require advanced and specific skills. This results in a growing difficulty for healthcare staff in helping university students; it may happen that, even if students are provided with the appropriate material, the training and access to the tools is not guaranteed or supported enough.

This scenario given, it is clear that a significant improvement can be made. This inspired our project, which aims to give the disabled students the best instruments, in order to carry out their own university studies at the best of their potential.

The staff is composed by three separate structures: the USID, which is the first interface for the student, the Local Sanitary Unit (USL), which participates with a number of relevant experts skilled in providing social and healthcare services including assistive technology provision, and the Department of Information Engineering of the University of Pisa (DII), which provides a team of experienced researchers in the field of assistive technology both from the hardware and the software point of view.

Therefore this project aims to provide any tool and support to facilitate students with disabilities during their university studies, both in terms of technological devices, training, configuration and customization of the instruments.

Methodology

As a sort of state-of-the-art, we first compared our idea with other methodological approaches described in relevant works [2-4], trying to adapt and transfer those kind of results in our context. Then, we established a link with the aid centers placed in the territory and in particular with the Laboratory for Aids, Communication, Learning and Autonomy of Fornacette (named LAPCA), in order to compare a multidisciplinary team (IT engineering plus healthcare) to a standard working group of the national health service. Since the early stages it has emerged that a figure with technical skills in electronics and computer science can add a significant value to the health care staff.

A multidisciplinary group of experts in assistive technology with different skills has been created. Among these there are indeed speech therapists, physiotherapists, psychologists, sociologists, doctors and researchers in IT engineering, all characterized by a significant experience in the field of disability. There is currently about a dozen people involved in this project.

The methodology adopted is theoretically divided into a first phase of information to students with disabilities by the USID, a second stage of intervention and a final period of follow-up. Whenever a disabled student has a particular request to the USID a meeting with the team is organized. After evaluating the requirements of the student an internal procedure is activated, which is different every time, depending on the nature of the requests. In Fig. 1 a brief representation about connections between the three structures is shown.

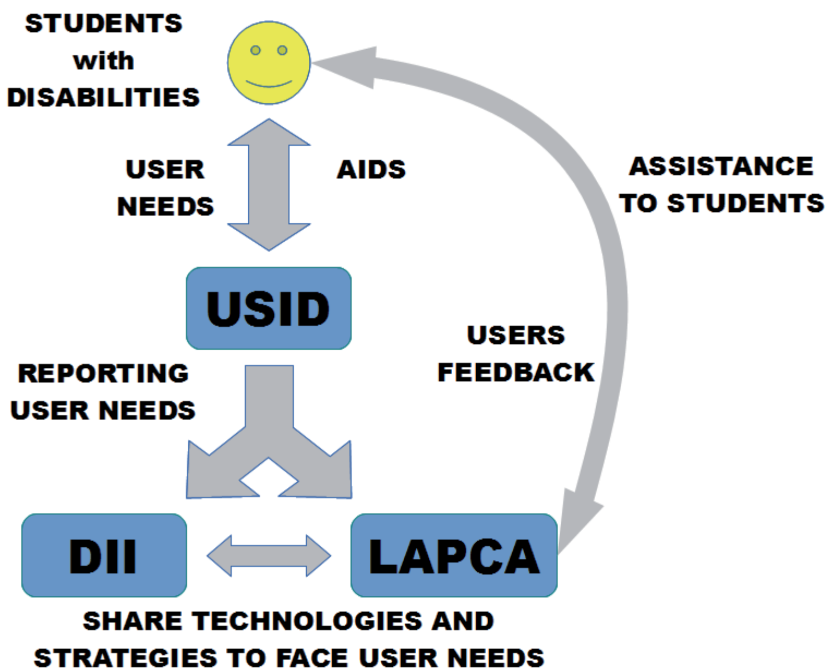

Fig. 1. A brief representation about links between three main actors.

The presence of staff skilled in different areas is fundamental because, as it often happens, one aspect may depend on many factors, so a multi-disciplinary approach is required taking into consideration the person as a whole. For example, the student who wants to access the PC may need a special mouse emulator, and the use of this might need the student take a particular position on his chair. Therefore it is clear, from this trivial example, that the single request can easily involve both technical skills, for the selection and configuration of the emulator, and health professionals, for the part related to the correct posture of the person.

The services offered to students with disabilities are many and different. An exact way to describe them is not easy because each person, through a unique combination of skills, cognitive abilities and needs, is a special case. The required actions must be structured each time in a different way and in the presence of different experts.

In the following paragraphs, some examples of the actions carried out within the project are described.

Consulting and Evaluation

Sometimes it happens that the solutions available on the market are not known or are not accepted by a person, either for personal reasons or external ones. In other occasion it happens that a specific device or a software is used only partially, usually for lack of specific knowledge. In these cases our duty is to evaluate the aids currently used by the student, and possibly, after a careful evaluation, suggest the most appropriate solution. The procedure used is the same applied by LAPCA, which has been developed through years of experience and successfully applied in hundreds of cases [3].

Technical Support and Training

The technical aspect is often overlooked because it is not a tool itself but rather a means to make the instrument operate correctly. Very often it is instead a critical aspect. In fact it may happens that a software stops being used because the owner does not have the skills to solve common problems, like manage the license, the lack of updates or any malfunctions caused by installing other softwares on the same operating system. Regarding electronic devices it often happens that, even in the presence of trivial problems, the object remains for long time at the respective repair center, causing the user lose the advantages obtained by the device.

In addition, many devices require a correct configuration, and this usually needs good IT skills. These facts are fundamental in order to take full advantage of the device and to make the person use it easily and correctly.

The presence of a team of experienced IT engineers makes it possible to assist students in the installation and configuration of any electronic aid and the solution of many common problems. Note that in our country this type of skills is not normally present within the permanent staff of an aids center, except in rare cases such as the “Ausilioteca” in Bologna [7].

Customization

Sometimes, in addition to a configuration of a commercial device and/or software, a person may need a custom adaptation to better suit his own needs. For example the ergonomic modifications of the handle of an object, the addition of inputs to an electronic device or the creation of a special software to enrich those already used with new functions.

Many of these interventions can be carried out independently by engineers of the team, obviously with particular respect to the patents and to the compliance of any electronic device.

Designing from Scratch

A new aspect of our project is the involvement of a research and development unit of the DII, which is able to develop new devices specifically designed on the user's requests, thanks to its extensive experience designing hardware and software in various projects dedicated to the disabled users.

Results

One of the best results is undoubtedly the cooperation established between the various structures and the intense exchange of knowledge derived from it. This fact certainly enriches the personal and professional profile of each operator with positive feedbacks in the quality of the own daily work.

During the first year of the project the team carried out many consulting, training and technical support to students with disabilities. As examples we briefly report two cases that required respectively a customization and a design from scratch.

(i) XX is a boy enrolled in the second year of the course of natural sciences. His most important request was to have access to the computer. As having a physical disability in the upper and lower limbs he cannot use both traditional interfaces (mouse and keyboard) and commercially available emulators. After a long analysis and many tests, the solution that we suggested was the use of Dragon Naturally Speaking in conjunction with a free mouse emulator, eViacam. Additionally, we dealt with a phase of training and we added an external control for switching on/off the equipment. We also equipped the system with a wireless microphone so ensuring freedom of movement inside his home. Note that the student had had the opportunity to try the software in the past and had to give up because through the audio chain used at that time could not get satisfactory performance. At the end he shared many positive impressions about the program, contrary to what it was reported during the first meeting.

(ii) YY is a visually impaired student enrolled in the first year of mechanical engineering. He had experienced difficulty in reading the text written by the teacher on the blackboard or projected in the classroom. So we had to find a technology solution that would be compatible with his visual ability and the various teaching methods of teachers. After an analysis of available software solutions (TightVNC, FreeRDP, FreeNX, Neatx and more) it was decided to develop an ad-hoc solution. The idea is a client-server software that transmits the video of the PC used by the teacher (and projected in the classroom) by a wireless network to the notebook on the desk of the visually impaired student. The developed application has been written in Java and exploits an innovative image encoding technique to reduce the latency of the system within 2/3 seconds. The only requirement is to install a Java Virtual Machine both on the student’s and teacher’s PC.

Conclusions

Thanks to our project a multidisciplinary working group was established including professionals from University of Pisa and Public Sanitary Systems providing complementary skills for students with disabilities. This allowed the development of a methodology to support the students with disabilities enrolled at the University of Pisa starting from the analysis of the special needs, selection and provisioning of most appropriate technical aids and relevant training. Moreover, in some cases followed during the first year, we also designed and realized new assistive technology solutions to meet specific educational needs which do not find any answer among the commercially available products.

The successful collaboration within the project was also the opportunity to think and propose new activities for supporting the student with disabilities in the selection of their university career and to provide a complete set of information about their daily life in Pisa area, i.e. healthcare services, rehabilitation services, sports, leisure, etc.

Acknowledgements

Authors acknowledge the financial support of the Italian Ministry of Education and Research for the project *"Ausili Tecnologici per la fruizione e la produzione di contenuti Didattici da parte di studenti universitari disabili"* in the framework of the innovative projects for the support of university students with disability (Law 17/99).

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-290

Sustainable Solutions for Wheelchair and Seating Assistive Technology Provision: Presenting a Cosmopolitan Narrative with Rich Pictures

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Abstract. In the wheelchair and seating assistive technology (WSAT) literature, sustainability concepts are beginning to emerge in relation to appropriate provision from design to follow up and management involving key stakeholder perspectives. A qualitative research design utilising a soft systems methodological framework which included organisational ethnography and critical participatory action research was chosen to study this complex system. The research process overall involved participant observation, individual interviews and a series of collaborative workshops.The process was made up of four main pillars. Pillar 2 as an example sought to understand stakeholder perspectives individually and collectively. This paper presents the first of a series of workshops which created rich pictures of wheelchair and seating provision representing collective experiences. Findings identified the complexity of the system and key areas for development to improve the flow of the overall provision. Specific concerns that were reported to exist related to individual and nationwide organisational roles, responsibilities and regulation which appeared to influence the disproportionate rhythm of the wheelchair and seating provision system. A better understanding is required to set the provision of WSAT for prioritisation at a public and policy level both nationally and internationally.

Keywords. Wheelchair and Seating Assistive Technology, Primary Need, Stakeholder Perspectives, Sustainability, Policy

Introduction

Sustainability has no single meaning; its meaning varies depending on the context. The demographics, goals and inter-connectedness of a given community of practice will impact on its ability to sustain itself. In modern times there is an economic scramble for resources and the sustainability concept needs to be actioned in real terms to benefit the whole community. The sustainability agenda increasingly encourages diverse and innovative approaches to empower people to work together in a non-hierarchal way [1]. Throughout the literature there are concerns that sustainable development is piecemeal and fails to encompass all dimensions of sustainability to truly achieve sustainability action [2]. Edwards [3] stated that sustainability or the 'sustainability revolution' is dealing with the global triage of social, economic and environmental issues with millions of diverse sustainability groups impacting on local and international issues

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from climate change to human rights. However there appears to be general confusion and understanding about how to apply sustainability concepts without becoming clichéd, expressing tired philosophical banter which becomes meaningless without activation [3, 4].

In the wheelchair and seating assistive technology (WSAT) literature, sustainability concepts are beginning to emerge in relation to appropriate provision from design to follow up and management involving key stakeholders [1, 2, 5]. Much of the research to date focuses on user perspectives. In recent years however, there have been a number of initiatives which shift the focus from uni-variant perspectives to more multivariate views [1, 2, 6, 7, 8, 9, 10,11,12, 13]. Gowran [1,2] appears to be the main contributor to this subject in terms of specifically defining and refining sustainability concepts, research, strategy and model development which takes a holistic view, incorporating numerous dimensions within the provision context. In addition, findings from Hammel *et al* [13] reiterate the importance of driving these concepts forward given the individual, environmental and societal factors which are equated to WSAT use and provision from stakeholder perspectives. It is therefore important to define WSAT to determine the importance of providing a sustainable system which meets peoples' primary needs now and in the future.

Using the terms wheelchair and seating together strengthen their use as a primary and essential assistive technology grouping which cannot be replaced by the assistance of another human being. These terms are further classified and defined as both an intrinsic and extrinsic enabler. This combination is supported by classifications and research findings within the literature [13, 14, 15,16]. For instance Hammel *et al* [13] reaffirm this concept based on the findings of their comprehensive multi-stakeholder analysis evaluating use and outcomes of mobility technology which incorporates the ICF as the universal language and describes and presents the findings for mobility technology in terms of categories which include individual factors encompassing body functions and structure, activity and participation. Therefore by adopting the universal model perspective based on equality and human rights and utilising the language used in ICF (WHO 2001), wheelchair and seating assistive technology (WSAT) is classified and noted to be a primary technology in the hierarchy of assistive technology devices (ATDs). In doing this WSAT is defined as:

> *'An enabler both extrinsically and intrinsically for people with short-term and permanent posture and mobility impairments of body functions and structures to actively participate across their life span in everyday living. The type and complexity of the wheelchair and seating technology provided will depend on the limitations and restrictions caused to individuals' posture and mobility to personally participate within their desired environment and context.' [17]*

Given this definition, the challenging, complex and unsustainable nature of environmental, economic, social and political structures of wheelchair and seating provision appear to dys-enable individuals to reach their occupational potential [13, 18, 19, 20, 21]. Evaluation of provision involving a shared understanding among all stakeholders to take sustainable action is seen as essential, in order to promote a seamless system that does not jeopardise a person's survival and participation as an equal citizen.

1. Methodology Creating Rich Pictures

Drawing on the pADL (political Activities of Daily Living) framework based on complexity theory delineated by Kronenberg *et al* [22] and adopting soft systems methodology [23,24], this research sought to achieve a number of aims and objectives. As an example, one key aim and objective is represented in this paper (adapted from Kronenberg *et al* [22]). The purpose was to identify the complex influences within wheelchair and seating provision. The overall aim was to identify the aims, interests and motives of stakeholders from a social, economic and environmental perspective and examine the characteristics of the conflict and cooperation between stakeholders in the provision of WSATs. Given this, the objective was to raise awareness and understanding of and actively consider the complex nature of stakeholders' participation in the wheelchair and seating provision.

A qualitative research design utilising a soft systems methodological framework which included organisational ethnography and critical participatory action research was chosen to study this complex system. The soft systems approach is a long-standing generic participatory method, designed to act as a vehicle for negotiation among stakeholder groups, who share a common goal. A research partnership with the one specialist seating service in the Republic of Ireland was established as a host institution. This service acted as a tangible location to connect with key stakeholders as there are no easily accessible lists of specifically identified wheelchair services nationally. The research process overall involved participant observation, individual interviews and a series of collaborative workshops.The process was made up of four main pillars, these included: Pillar 1: Stakeholder Identification; Pillar 2: Understanding Perspectives; Pillar 3: Meaningful Collaboration and Pillar 4: Strategy Development.

Pillar 2, as an example here, sought to understand stakeholder perspectives individually and collectively. Firstly, in-depth individual interviews of 35 key stakeholders from a possible 44 invited to participate following stakeholder identification in Pillar 1. Key stakeholders included service users, service providers, suppliers and manufacturers, regulators and policy makers. Interviews determined the nature of stakeholders' aims, interests, motives and experiences while identifying issues of conflict & collaboration among the group. Secondly, stakeholders involved in individual interviews were invited to participate in the first of a series of workshops to create rich pictures of wheelchair and seating provision which represented their collective experiences (n=23). This paper represents the finding of the rich picture workshop

1.1. Rich Picture Workshop

The workshop provided participants with the opportunity to meet each other and share experiences and ideas in a non-hierarchical way. Preliminary findings from individual interviews were provided during the workshop for discussion. The format of the workshop and presentation of the preliminary findings was carefully organised to provide participants with the 'opportunity to express and test their ideas in informal and [as] risk-free [an] environment' as possible, which required 'a strong degree of safety and intimacy between members' [25, p.344]. During the workshop participants (n=23), created a pictorial representation of the wheelchair and seating provision process, known as a 'Rich Picture'. The purpose of the 'Rich Picture' was to provide an opportunity for open discussion and come to a broad, shared understanding of the wheelchair and seating provision process, identifying issues, interactions and connections between them, locally and nationally. It gave participants the opportunity to prioritise issues found during the individual interviews that inhibited the smooth flow of overall system and to identify and include any other issues.

2. Rich Picture Results

The rich picture represents a cosmopolitan narrative which was created to reflect the individual and common aims, interests and motives communicated during the workshop. This pictorial narrative reflected the innovativeness of the participants as a community of practice, integrating their knowledge, 'learning, creativity and innovation', implicitly depicting both personal (autonomy, flexibility, diversity, communication and proactiveness) and organisational (democracy, heterogeneity, difference and capacity) traits to produce a proposed strategy document during Pillars 3 and 4 [26, p.60].

Of the twenty three participants who took part in the workshop they were divided up into 4 mixed groups each producing rich pictures, figures 1 and 2 provide two examples. One of the rich pictures produced during workshop one made a representation all of the 'People' as individuals, groups and organisations involved in providing wheelchair and seating (see Figure 1).

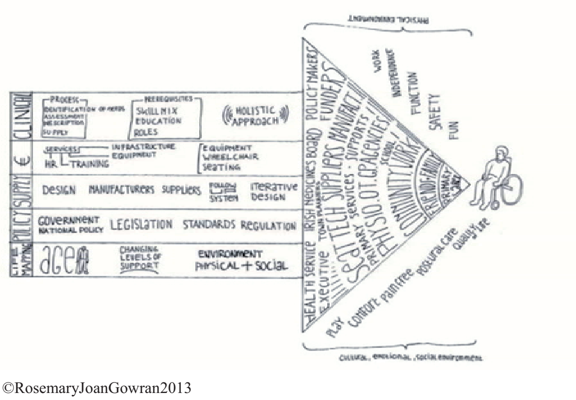

Figure 1. Rich Picture representing the complexity wheelchair and seating provision.

This quote describes the meaning of the 'rich picture' shown in figure 1, detailing all the people involved and the connections between them to meet a common goal *'a satisfied happy person'*

> *"Have to say everything is leading to a satisfied happy person. And the top part of the arrow in no particular order – independence at work, at school, function, safety fun play, comfort, pain free, postural care, quality of life. That's the whole, what we are looking for, for the person. Then straight, that's what is coming and supporting the person is the primary carer and then the family and friends. And then, all the people in their environment, in school, working in the community, it is kind of layers. And then the primary, coming in then, starting to come in with the medical world in the primary community care support or the therapists. Or when they need support or help they will need a centre like SeatTech or if the suppliers and manufacturers and you are looking at the whole equipment piece. And the other layer on top of that is the HSE or the governance, the regulatory body, the IMB and yeah the policy makers and funding…."* [Verbal description G2, W1, RP, speaker 1]

Waiting times throughout the process appeared to be a major cause of concern. Waiting times in terms of planning appointments, funding and the wheelchair breakdown service appeared to be the primary source of concern among participants directly related to the service. One group during workshop one referred to the process as *'The Wheelchair Game – a waiting game to test your patience'* [G4, W1, RP]. This featured strongly in 3 out of 4 Rich pictures [Rich Picture, G1, G3, G4] (see Figure 2)

Figure 2. Rich Picture depicting the waiting game .

This quote describes the rich picture presented in figure 2,

> *"The quick start there you roll your dice, not implying that it is a game of chance! The Wheelchair Game a waiting game to test your patience or your patients. Ok you start and roll the dice and get your seating appointment,… but you pass though all your points, you're waiting for a seating appointment, the bus breaks down on the way there so then you have to wait for another seating appointment, [Yeah] so you have another snake and then start all over again. The point that we really wanted to bring up is how long the whole process can take. And even though there is a set procedure there it can fall down at any point in between. [Yeah] And occasionally things are needed in a hurry you don't do get to climb a ladder, you do get to jump a few steps if it's needed but, that's really about it. But then you have, a happy person and then sometimes it doesn't go quite as planned so you have to start all over again."* [Verbal description G4, W1, RP]

Following analysis of rich pictures key items for review were identified (see Table 1)

Table 1. Wheelchair and Seating Provision key items for review following discussion and analysis of rich pictures.

Waiting Times **Throughout The Flow Of The Provision Process**
Funding **Being Sanctioned By The Health Service Executive (HSE)**
Follow Up **& Management Services**
Breakdown **/ Repair And Availability of Emergency Services**
Refurbishment**, Reissue, Recycling Services**
Common Language **/ Communication Systems**
Education **For All At A National And Local Level**
Research **& Development**
Identifying Who Takes Responsibility **For Wheelchair Provision**

3. The Impact of the Rich Pictures

While services continue to develop and grow, there are no specific government policies or guidelines relating to wheelchair and seating provision in the Republic of Ireland. During the research process questions arose among participants as to who was ultimately responsible for overall provision. Specific concerns that were reported to exist related to individual and nationwide organisational roles, responsibilities and regulation which appeared to influence the disproportionate rhythm of the system. The question as to who was ultimately responsible for the overall provision of wheelchair and seating was expressed in talk of *"bureaucracy"*, *"politics", "no emergency service"* and being sent from *"Billy to Jack"* to get a repair job done on a wheelchair. The impact of poor infrastructures, incomplete service delivery processes and lack of government policy in this area appeared to exist. The lack of regulation regarding supply and repair services may leave people vulnerable. Poor back up services and the absence of a dedicated emergency breakdown service excludes equal opportunity in accessing education and employment which would be likely to impede on health, social and financial gain and hence limit individuals' quality of life. A number of key issues were made visible regarding responsibilities that needed to be addressed and included standards of provision, wheelchair and seating procurement, education and training, tracking, tracing and taking care of equipment and the impact of the recession.

3.1. The Way Forward

The findings provided the materials to paint the richest picture which placed the WSAT user as the central focus and gave consideration to key stakeholders views on the complexity involved when building a sustainable wheelchair and seating provision community locally and nationally (see Figure 3). This picture illustrates the essentiality of building a sustainable system to meet peoples' primary needs now and in the future. It demonstrates the impact every aspect of the service has on a person being in the world.

Figure 3. Richest pictures.

A sustainable wheelchair and seating provision system is required which blends into the background as a prerequisite to peoples' lives, becoming part of the natural way of things [16, 27]. Without a comprehensive review and government commitment to reforming and resolving some of the serious issues raised by the participants in this study, people may be deprived of equal opportunities and basic human rights, leaving them feeling vulnerable and at risk within the current system.

As this research was underway a number of guidelines for wheelchair and seating provision emerged. The most notable was the Guidelines for Manual Wheelchairs in Less Resourced Settings [5], which appears to be the most comprehensive document available and accessible on the world stage. However any guidelines, no matter how comprehensive, need to be implemented within the country of context. This requires an understanding of the importance of service development and willingness to activate a sustainable system which utilises resources effectively to providing appropriate WSAT.

Uniting nations to build sustainable communities of practice is deemed essential to address this human rights issue and achieve the best outcomes. Member states can utilise efforts to contextualise WSAT provision and in turn seek to develop and implement of national policies globally. Policy needs to be developed which creates a model to enable active agency, by shifting the locus of equality control to a common ground, placing the wheelchair user as the centre forward on a level playing field. It is paramount to stress the importance of WSAT and to identify where it lies on the hierarchy of needs for survival as an extrinsic and intrinsic enabler from basic physiological functioning to active actualised participation. A better understanding is required to set the provision of WSAT for prioritisation at a public and policy level both nationally and internationally. Building a sustainable future for all, where every citizen reaps the benefits of sustainable wheelchair and seating provision that seeks to meet peoples' primary needs now and in the future, should be our goal.

Acknowledgements

The author would like to thank all those who participated in this study and SeatTech Enable Ireland who acted as the host institution. Thanks also go to Dr Elizabeth A Mc Kay and Dr Bernadette O'Regan for their support and research supervision; the Health Research Board (HRB) for awarding the author a research fellowship to complete this work and Jeroen Timmer for drawing up the final images presented in this paper.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-298

The Use and Usability of Accessibility Standardization

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Abstract. This paper discusses recent research carried out with British Standardizers working in the area of systems and products with user interfaces to identify when and where they considered the needs of older people and people with disabilities. The research was carried out in support of the ISO JTAG TAG activity on the revision of ISO/IEC Guide 71 and was designed to assist the writers of the re-written guide to enable them to target the Guide effectively. The document ISO/IEC Guide 71:2001, Guidelines for standards developers is designed to address the needs of older persons and persons with disabilities and to ensure that standards which affect the design of user interfaces do not discriminate in their design. It is currently being updated. The work was carried out by a series of online and face to face interviews during Winter 2012/2013. The results indicated that a majority of the standardizers did not routinely consider the needs of older and disabled people. In conclusion it is important for those in the accessibility field to identify effective promotion methods as well as work to create useful, useable, quality standards.

Keywords. Accessibility, Standard, ISO/IEC Guide 71.

Introduction

Over the last few years there has been a large amount of research and standardization activity in Europe aimed at removing barriers to participation in the Information Society by disabled or older people. In theory the results from high quality research can be used in the standardization process to ensure that technology is as accessible as currently possible. The successful implementation of this process would depend on information being transferred from relevant research to standardizers and onto designers and creators. The transfer of information is a time consuming and complex business and is most successful in the area of standards which are directly related to accessibility. The amount of work in this area can be seen by the large range of activities of the JTC 1 Special Working Group on Accessibility. The International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) created the Joint Committee JTC 1 for cooperation in the area of information technology.JTC 1 believes that the work in the area of information communication and technology standardization for accessibility is a major undertaking, encompassing many international, regional and local interests [1].

Standards can be used by designers and manufactures to demonstrate their commitment to relevant accessibility regulation and legislation. Unfortunately this is not a straightforward process especially as older and disabled people wish and need to use mainstream products and services in addition or instead of specialist products and

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services. It is impractical to assume that standardizers or designers of mainstream products are aware of the needs of older and disabled people or of ways of meeting their needs. In addition standards for mainstream products do not always make use of the latest research in the area of accessibility and of course standards are not always followed. The aim of this paper is discuss the current situation and how the use of ISO/IEC Guide 71 can be maximized to increase the accessibility of mainstream products and services.

1. Background

Digital inclusion is not a binary state, nor is it static state as people's access will vary throughout their lives, this is particularly true of the older population whose access may be affected by changes in financial or disability status as well as by the contact or lack of contact they have with people who are digitally connected. There are many standards that apply to 'accessible ICT' and many others which ensure the quality or usability of technical products, services and delivery methods. The ability to mix and match from relevant standards and to stay abreast of current standards development is not a trivial matter. It becomes more difficult (and probably impossible) if the developer can not see the usefulness of a particular standard or understand a particular need. Standards may also be in conflict with one another. Even where a standard is widely respected or viewed as a significant improvement on what went before, it may be extremely long, with implementation guidance that adds to its length. Standards are not the only source of information on accessibility solutions, to design an accessible product or service requires three levels of knowledge and practice (see Figure 1). The use of appropriate standards can ease the acquisition of knowledge but can not provide the commitment to accessibility.

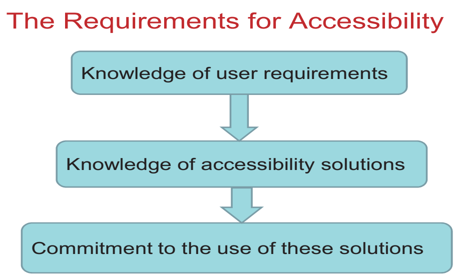

Figure 1. The Requirements for Accessibility.

Thus, many standards fail to have the influence they were intended to have when developed. Some of those who should use them don't know they should be taking account of standards at all or fail to see where they are applicable, some see no driver to apply them, some find them too difficult or complicated to implement. The role of the accessibility standardizer can be seen as involving both promotion and creation.

2. ISO/IEC Guide 71

ISO/IEC Guide 71:2001: Guidelines for standardization to address the needs of older persons and people with disabilities [2] was originally written in 2001 to provide information to standardizers. It was designed to provide information to writers of standards including those working on standards for mainstream products as well as for special accessibility products. An ISO/IEC Guide is designed to provide “a rich resource of helpful advice for standards dealing with specialist issues, such as consumer needs, when writing standards. They are also expected to be useful for people not involved in standards work as the advice they contain can be generally applied to their subject areas” [3]. This Guide was adopted by the CEN (European Committee for Standardization) Technical Board and the CENELEC (European Committee for Electrotechnical Standardization) Technical Board in January 2002 and published as CEN/CENELEC Guide 6. Further activities have taken place to try and ensure that the Guide is used. These have included the adoption by CEN of the "Mechanism on the use of the CEN/CENELEC Guide 6" and the creation in 2011 of CEN/CENELEC Guide 11: "Product information relevant to consumers - Guidelines for standard developers" which refers to CEN/CENELEC Guide 6 for guidance on informational needs of people with disabilities and older people. In addition in 2008 a working group was set up by CEN to create a method for implementing Guide 6 (this work was promoted by amongst others NEN - the Dutch standardization organization and ANEC (the European Association for the Co-ordination of Consumer Representation in Standardization). Other activities have been used to support the use of Guide 6 and to include people with disabilities and elderly people, not only in the content of standards, but also in the standardization process. These included the USEM and STAND4ALL European projects which both worked with end users to train them in the use of Guide 6.

In 2008 ISO/IEC Guide 71 created a supporting document: ISO/TR 22411:2008: Ergonomics data and guidelines for the application of ISO/IEC Guide 71 to products and services to address the needs of older persons and persons with disabilities. This document provides additional guidance on the accessible design of products, services and environments. Unlike ISO/IEC Guide 71 and CEN/CENELEC Guide 6 it is not available free.

In 2011 work started on the revision of ISO/IEC Guide 71 to update the content and increase it’s relevance with respect to developments that have taken place since 2001 in the field of knowledge of the needs of older and disabled people. As part of the revision there has been discussion on how to increase the uptake of the Guide, this requires standardizers and others to know about the Guide and to choose to use it.

3. Research

Recent research was carried out using an online survey and face to face interviews with 649 committee members of the British Standards Institute. This work was carried out as part of the work of the ISO JTAG TAG for the revision of ISO/IEC Guide 71. The research was carried out to identify whether standardizers have an unmet need for information on accessibility for older and disabled people. Prior to the research it was assumed that a proportion of the standardizers would be making use of Guide 71 to meet their needs for accessibility information. The information was collected from standardizers who are designing accessibility standards and those who are working in other areas to enable a realistic picture of the likely users of any future advice to be collected. The response included responses from standardizers who were working on standards which did not have a direct or indirect impact on human end users and who would therefore have no requirement for accessibility information. The most interesting result of this work was the fact that the majority of standardizers who were working on standards which did impact people did not appear to consider older and disabled people an obvious subset of the group people. The results of the relevant question were as follows;

- 33.3% of the people said yes to the question “Do any of your standardization activities involve the standardization of products or services where the accessibility for older and disabled people needs to be considered?”
- 76.7% had said yes to “Do any of your standardization activities involve the standardization of products or services which are designed to be used by people?”

This result suggests that standardizers do not consider that products and services designed for the general population do not need to be accessible by older and disabled people and is potentially worrying.

A total of 17 of those who replied had made use of ISO/IEC Guide 71 or CEN/CENELEC Guide 6 and 1 planned to do so in the near future. This is 4% of the total number whose standards impact on people. A further small number made reference to a wide range of other sources of relevant information. More promisingly 86 of the respondents said that they planned to increase their knowledge of end users including older and disabled people and 196 said they would possibly attempt to increase their knowledge. The sources that they planned to use to gain this additional knowledge included both standardization documents and direct contact with end users.

4. Conclusion

This research indicates a potential lack of knowledge of the needs of older and disabled people by standardizers and could result in problems where those standards are used both in the design and procurement process. It could lead to the development of ICT systems that continue to exclude groups of users, and to be less usable than is desirable. It can be seen that people whose needs are perceived as non-standard may not have the same access to ICT products and systems unless a range of professionals acquire the accessibility information they require and adopt best practice methodologies at all stages of the commissioning, design and production process. The use of standards is a useful tool to ensure accessibility. Standards are required as a way of maximizing the few resources available. The identification of effective promotion methods is also required as well as further work to create useful, useable, quality standards.

The lack of knowledge of the needs of older and disabled users and of information resources about their needs can be seen at different levels in organizations. Further informal research amongst standardizers and standard users identified that sometimes there is top-level buy-in to accessibility standards compliance or to the ideal of best practice, but no knowledge of what this entails in practice: this can lead to demands to comply with unrealistically high standards (perhaps a blanket expectation of WCAG AAA) or conversely to no corporate standards-setting – either can lead to a lack of buy-in at lower level. Sometimes there is no understanding at the top level, so those at practitioner levels who may want to follow good practice or standards find they are stymied unless they have the tools to be able to convince their boss. Sometimes a lack of understanding among those who would have to implement them, about the basis for the standards and the business rationale for following them, blights any hope of seeing them adopted and followed more widely.

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Augmentative and Alternative Communication

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Energy Security in the Wider Black Sea Area – National and Allied Approaches
E. Lyutskanov et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-260-8-305

Text Messaging with Pictures and Speech Synthesis for Persons with Cognitive and Communicative Disabilities – Professionals' Advice for Successful Use

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Abstract. Communication problems can restrict people from communication over the phone. Text messaging is a way of using the phone without speech, but requires good cognitive skills. People who use augmentative and alternative communication (AAC) and have limited skills in reading and writing can write text messages by using symbols representing words or phrases. This interview study examines the views of professionals regarding criteria for successful use of text messaging with symbols. The professionals worked with project participants with cognitive and communicative disabilities who tried text messaging with picture symbols and speech synthesis in smartphones. The users' experiences of text-messaging are reported elsewhere. Results point to the necessity of individual assessments and that this is a time consuming task. It also shows a need of a supportive environment and of good cooperation with everybody involved to make remote communication and introduction of new technology work.

Keywords. Cognitive and Communicative Disabilities, Augmentative And Alternative Communication, Text Messaging, Occupational Therapy, Speech Language Pathology.

Introduction

1.1 Augmentative and Alternative Communication (AAC) and Technology

A person may have problems with communication due to disability. People with communication problems can use augmentative and alternative communication (AAC) to communicate with others, that is, low- and high technological aids and strategies to enhance communication [1-4]. The rapid development in information technology opens new opportunities for people who use AAC [5-8].

According to professionals, the type and amount of training and support the person with disabilities receives and attitudes towards the system by the person as well as by other people determine the success of an AAC-system [9]. Other important factors are system characteristics and the overall fit to the user's needs [10, 11]. Vocabulary and phrases need to be individually adapted by skilled professionals [12]. A functional AAC system is important for the person's possibility to have social contacts and to

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participate in society [10, 13-15]. Poor maintenance, lack of training and support and poor fit are factors that may lead to the abandonment of technology. Speech language pathologists (SLPs) and occupational therapists (OTs) can have key roles in the provision of individualised AAC systems and technology as well as in forming supportive environments [16].

Mobile phones can be used for remote communication like calling, text messaging and sending e-mails to other people. For a person with communication problems, remote communication may facilitate social contacts, independence and security in relation to the fulfilment of goals in daily life. It may have an impact on the feeling of participation and quality of life [17-21]. Even though technology can be helpful many people with complex communication needs, who use AAC and have limited assess to mobile technology and remote communication. People with complex communication needs, who use AAC and have limited reading and writing skills, may communicate by using picture symbols representing words or phrases [1-3, 22]. Picture symbols can also be used for texting.

1.2 AAC and Text Messaging

People who use AAC and have limited reading and writing skills may communicate by using picture symbols representing words or phrases [2, 3, 22, 23]. Picture symbols can also be used for sending text messages (from now on referenced to as texting). The user needs a phone with software that makes it possible to write messages with symbols. The software converts the symbols to a regular text message that can be sent to any phone. When the user receives a text message, the speech synthesis helps the user to read it [24].

The aim of the project “Texting with picture symbols - Possibilities for persons with cognitive and communicative disabilities” was to increase the possibilities for people with cognitive and communicative disabilities to use text messaging with picture symbols and speech synthesis (TMSS) [25, 26]. Three men and four women between the age of 15 and 59 with cognitive and communicative disabilities participated in a one year intervention. When the intervention started there were two devices available in Sweden that offered TMSS: Micro Rolltalk and Handifon [27]. These devices were small, dynamic aids for communication and cognitive support that was accessed by pressing pre-defined symbol cells on a touch screen, using a finger or a pen. When using TMSS, the symbol was translated to text and sent as a regular text message. After an initial assessment each user was given one of these devices with individually tailored software, vocabulary and speech synthesis. The users had an active role in designing vocabulary and setting up goals of the intervention. Each of the seven users had a professional (i.e. an OT or an SLP) and a support person (i.e. a family member, assistant or teacher) who worked with them regularly during a year.

A study investigating the views of the participating users show that six of seven participants increased possibilities for remote communication and increased participation in daily life activities [24]. A second study investigating the views of the professionals confirms and gives explanations on how texting with picture symbols and speech can increase independence and participation and it points to the necessity of individual assessments [28].

1.3 Objectives

The present study is part of a process evaluation of the texting project. The main purpose of the study was to examine the views of the professionals regarding what they thought were the criteria for successful use of TMSS and to collect their advice to other professionals working with TMSS.

2 Method

The study used a qualitative method with semi-structured interviews with the seven professionals who worked with the seven users that participated in the texting project; four OTs and three SLPs. The analysis was based on retrospective qualitative content analysis where the authors first familiarized themselves with the material and thereafter started the process of analysis with a written condensation of the answers. Talk about other topics and social warming up was removed. Six categories were identified. Quotes were picked out from the material and condensed further.

3 Results

Below the main result categories are presented.

3.1 Make a Thorough Assessment

It's crucial to make a thorough assessment concerning the wishes and needs of the user, the skills of the user (including language and cognition) and characteristics of devices and software.

3.2 The Importance of a Thoroughly Planned Structure of the Software Adaptations

The user needs an individually tailored adaptation of the communication software with suitable vocabulary and phrases that correspond to needs in daily life activities. The initial assessment is a basis for this work which is done in cooperation with the user and his or her network.

3.3 The Importance of a Thoroughly Planned Introduction

Introduction and training needs to be thoroughly planned in a step by step approach with a gradual increase of complexity.

3.4 Good Cooperation in the Network

It is important that persons in the network are interested of taking responsibility in the process of introduction, training and daily support to the user. To ensure good cooperation, as many as possible should be involved from the start. There is a need of a detailed work plan, including who is doing what. One person should have an overall responsibility for needs in daily life. This person should take responsibility for contact with professionals and be a bridge between people in the network.

3.5 Find Meaningful Activities

To create and maintain motivation of the user, it is important to find meaningful activities for training and introduction. Find out which people the user wants to communicate with and make sure that vocabulary and phrases match the needs of the user in these situations.

3.6 The Need of Continuous Support and Re-Assessment

Both technology and the needs of the users are in constant change. This means that follow-ups need to be done on a regular basis.

4 Conclusions

According to the professionals in the study it is necessary to have an individual approach to phones and their applications, even though it is a time-consuming task. Cooperation between SLP and OT is a good insurance for a thorough assessment and intervention. This agrees well with results of a previous study describing a need for a supporting environment and the importance of actively involving the user from the beginning [24]. Involving the user in the process requires time and methodology for interviewing the user in an adequate way [2, 29].

Once the device is individually adapted, introduction with the user starts. This process requires frequent training appointments which should fit in with the user's daily activities. There is a need of cooperation between professionals and other people in the user's network to be able to evaluate and update the device and its vocabulary so it fits the user's needs in daily life activities.

Together with previous studies, this study shows that according to OTs and SLPs, texting with picture symbols and speech is useful for remote communication for persons with cognitive and communicative disabilities. It also shows that professionals play an important part to fulfil the users' goals concerning remote communication with TMSS. This is accomplished by close cooperation with the user and their network throughout the process of assessment and training

Acknowledgements

The authors want to thank the professionals for their dedicated work, time and sharing of experiences. The project "Texting with picture symbols – Possibilities for persons with cognitive and communicative disabilities" was a collaboration between The Swedish National Association for Persons with Intellectual Disability, DART – Centre for AAC and AT at Sahlgrenska University Hospital in Gothenburg, The Swedish Institute of Assistive Technology and SPRIDA Communication Centre in Örebro County Council.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-311

Apps for Augmentative and Alternative Communication – A Forum on the Web

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Abstract. Smartphones and tablets have taken place in the field of assistive technology and there are now many apps to use for people with communication difficulties. There are websites, blogs and Facebook groups discussing different apps, but it can be hard to navigate between different forums and get the information you are looking for. The long-term goal with this project is to increase knowledge and compile data on how smartphones and tablets may be equipped with apps to support the every-day life of people with communication difficulties. In the first part of the three-year long project, a web forum has been designed within the realms of the website of Swedish Institute of Assistive Technology (SIAT), where information about communication apps for smartphones and tablets are compiled. The forum makes it easy to search and compare apps and read about others' experiences. It is open to everyone, and relies on tips and reviews from those who use it. The project members maintain the forum by testing and evaluating apps and submit them in the forum. Address to SIAT's forum: www.hi.se/appar.

Keywords. Augmentative and alternative communication, apps, smartphone, tablet, IOS, Android

Introduction

1.1 Augmentative and Alternative Communication (AAC) and Technology

Sharing opinions, thoughts and ideas with others are fundamental needs for human beings. Those who are not able to express themselves in speech, due to for example aphasia, cerebral palsy or autism, are said to have a communicative disorder. People who have communicative disorders often have limited possibilities to make themselves understood, and sometimes also to understand others. It is common to experience isolation and limitations in the every-day life, and to be heavily dependent on assistance.

Today, there are methods and aids for supporting individuals with communicative disorders. They may use signs from their native sign language (manual signs or keyword signs), or combine signs with pictures, gestures and what speech they may have. Many of those who have limited speech use pictures and photos to communicate, for example via picture communication boards, where they point to a picture to express

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their meaning. Some people also need pictures to support understanding of spoken language. By using communicative aids, many people are able to live a more independent life. Many of those with a communicative disorder have additional motor impairments, which causes a need for alternative ways of controlling a computer. They may need to control it with their eyes, switches or joystick.

The rapid development in technology has given people with communicative disorders increased independence. Computers and smartphones now offer speech synthesis, picture symbols and photos to carry out tasks like talking, texting and e-mailing. The project ”Text Messaging with Picture Symbols”, funded by the Swedish Inheritance Fund, was carried out at DART - Western Sweden's Centre for AAC and AT and has gained interest within the field [1]. Follow-up studies have shown the importance of texting for increased participation for adults with cognitive and communicative disorders [2, 3].

The development of smartphones and tablets opened a new market for assistive technology. Swedish Institute of Assistive Technology (SIAT) has initiated several projects aiming at increasing the knowledge about how smartphones and tablets may give support to people with cognitive impairments [4]. These and similar projects on neuropsychiatric diagnoses and mental illness show that the smartphone is not considered a stigma, which traditional assistive technology may be. It is also shown that a smartphone or a tablet equipped with applications (apps) suited for the individual's needs can give good support and even replace considerably more expensive assistive technology [5]. There is also evidence that smartphones and apps may support people with cognitive impairments in their work [6].

There are supportive apps also for people with communicative disorders; however, the current commercial market is lacking several of the functions available in the traditional selection of communication aids. The need for support from professionals and from the surrounding in using smartphones and apps is considerable for both of these user groups. DART is also actively developing new technologies in different projects, such as the European AEGIS project (Open Accessibility Everywhere: Groundwork, Infrastructure, Standards) [7], TIVOLI (sign learning via computers and playful interaction) and Chatterbox (reading subtitles with speech synthesis) [8]. Along with these attempts to facilitate accessibility to technology there are several other resources [9-11].

To give people with communicative disorders the support they need in using smartphones, tablets and apps, there is a need for more knowledge in this field. It is a time consuming task for speech language pathologists and occupational therapists to find the apps that may give good support for an individual. The app market is growing rapidly and there are new apps from one day to another, something that makes it even harder for professionals to stay updated on the knowledge required for recommending apps as assistive technology. Apart from the time required, it is also an economic issue. Many apps within the field of assistive technology and communication cost somewhere between 20 and 200 Euro (although sometimes there are limited free versions available).

Today, several websites and Facebook groups focus on apps for communication. There are also local projects and caregivers who have attempted to compile information on apps for communication. However, this information is spread over many different sites, and not structured or easy to find. In addition, Facebook and other social media are often blocked from computers placed in hospitals or other public workplaces within the county council. This excludes many people who would need this information, and a common site with compiled information is often asked for.

1.2 Goal

The overall goal with this project has been to increase knowledge and compile data on how smartphones and tablets may be equipped with apps to support the every-day life of people with communicative difficulties.

1.3 Project Plan

The project runs for three years and consists of three parts of which the first has been carried out:

- development of a web forum for communication apps and access methods
- adjustment, testing and evaluation of apps and access methods
- dissemination and maintenance of the web forum and of the adjustments made.

Those three parts will partly overlap.

2 Method

2.1 Target Group

The project's target groups are children and adults with communicative disorders and persons around them, such as family, assistants, teachers and speech language pathologists and occupational therapists within rehabilitation services and primary care. The web forum is a meeting place for everyone interested in learning more about apps as communication support and how smartphones and tablets may be equipped to suit individuals' needs.

2.2 Procedure

The current web forum is a result of a several step development. Initially, a questionnaire was sent out to professionals nationwide working with AAC and assistive technology. They were asked to describe how they would like the forum designed regarding the graphical user interface, the functionality and the content. The questionnaire was also sent to disability associations like The Autism and Asperger Association, The Swedish National Association for Disabled Children and Young People (RBU), The Swedish National Association for Persons with Intellectual Disability (FUB), and spread via Facebook and websites to reach as many interested as possible. Together with additional discussions with disability organizations, the response was used as a basis for the design of the forum. As soon as there was a beta version, all of those previously informed were asked to evaluate it.

Responses from the evaluation were used to make changes in the design. The design was then implemented in a CMS, EpiServer and the module Relate+ which is based on .Net technology. The forum also consider the Web Content Accessibility Guidelines 2.0 (WCAG) from the W3C Web Accessibility Initiative (WAI) [12]. The forum was then launched nationally and marketed by SIAT and DART in channels such as mailing lists, Facebook pages, websites and printed information material.

3 Results

Today, the web forum lies under the national website of SIAT, and is thus available to a large number of people interested in assistive technology and AAC. The forum is accessible to suit various needs and is easy to grasp and use. It contains descriptions and reviews of many different types of apps that may give support to persons with communicative difficulties, and the number of apps is constantly increasing. The forum is interactive and it is easy for visitors to search for information, add and edit content and discuss apps and their use. The forum makes it possible for individuals with communicative difficulties and persons around them to find and share updated, relevant and accessible information on apps for communication support.

The forum is built to collect apps in various categories and with a number of attributes. The user can use these aspects to filter the search result and find the most relevant apps. It is for example possible to grade the apps, save favourites and compare apps. Users can also contribute to the forum by registering as a member and by adding more apps or by editing existing information about apps. The management of the forum is at SIAT but most functions are automated or executed by the users themselves.

4 Conclusions

4.1 Further Work

The second intermediate goal is to gather experiences and knowledge. This will be done by letting users test different smartphones and tablets equipped with apps. The aim is to see to what extent the apps are useful for communication, and if they are accessible for various needs. The knowledge gained from this will be shared on the website. Letting professionals, users and people around them share facts and personal experiences like this will make it an active web forum and community.

The third intermediate goal is to put together a basic Swedish vocabulary for communication. The idea is to facilitate for others to get started with communication via a tablet without having to translate an English vocabulary or invent one of their own. This will be a material ready to download to a couple of specific apps, and able to modify and adjust for the individual user.

4.2 Dissemination and Continuation

It is essential that a neutral party is responsible for disseminating information about assistive technology. In addition, a goal for the project is that the web forum in the future will be maintained by those using the site. In Sweden, SIAT is a public and well-known authority working with several forms of dissemination activities on the web. Establishing the forum on SIAT’s website, where it is combined with other forums for e.g. cognitive impairments makes it likely that it will live on after the project’s end.

Acknowledgements

The project is financed by the Swedish Inheritance Fund and is a cooperation between

DART – Centre for AAC and AT at Sahlgrenska University Hospital in Gothenburg, SIAT - Swedish Institute of Assistive Technology, The Autism and Asperger Association, The Swedish National Association for Disabled Children and Young People (RBU), The Swedish National Association for Persons with Intellectual Disability (FUB).

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-316

Alternative Telephony – Making Phone Calls using AAC or Sign Language

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Introduction

The Swedish Institute of Assistive Technology (SIAT) ran two projects during 2011-2012 and one project during 2009-2010 concerning alternative means for communicating at a distance, for persons who cannot use an ordinary phone due to limited hearing or speech. All three projects were commissioned by the Swedish Government, and one of them was commissioned to both SIAT and the Swedish Post and Telecom Authority (PTS).

Specifically, deaf persons, persons with deaf-blindness, severe hearing impairment and speech impairments have been targeted in the projects (the target group). Focus is mainly on facilitating for persons who have difficulties making voice calls due to hearing or speech impairment, not including persons who have a hard time using an ordinary voice phone due to motor or cognitive impairment.

PTS have been developing the relay services and both SIAT and PTS have promoted the use of mainstream technology as means for distant communication. Since county councils are responsible for providing end users with assistive technology (AT), they have been the main target of SIAT's communication activities.

Successful ways of using AAC to communicate over the Internet have been found in trials. These will be explained in more detail in the presentation.

1 Background - the General System for Provision of Assistive Technology in Sweden

In Sweden, the county councils and municipalities are responsible for health care, including habilitation, rehabilitation and provision of assistive technology (AT) for daily life to persons with disabilities. Some AT, for specific purposes, are provided and/or funded by other authorities, e.g. AT needed at work which are funded by the Swedish Social Insurance Agency and the Swedish Public Employment Service. Users usually pay a fee for visiting health care professionals, but most of the costs for health care, including rehabilitation, rehabilitation and AT, are covered by county councils or municipalities, which are funded through local tax.

Most funding of health care is through local taxes, but the government provides funding for specific purposes to county councils and municipalities. One of these purposes is providing equipment for communicating at a distance to deaf persons, persons with deaf-blindness, severe hearing impairment, speech impairment or language impairment. The funds are provided four times a year and can be used by county councils to buy equipment for real-time communication to be used by the users from the specified groups and their relatives. Traditionally, the funds have been used to buy textphones, from the early 1980's, videophones, from the late 1990's and total conversation terminals, from the early 2000's. No regular statistics on purchases on a national level exists, but according to prescribers in the county councils, deaf persons are provided with total conversation terminals and hard-of-hearing persons with textphones. It is uncommon for persons with speech disorders to get any such equipment at all. SIAT's analysis of the cause is that it is mostly due to different organisations for rehabilitation of different user groups, in combination with little knowledge of how distant communication can be improved and a lack of time for each user.

As Hilde Haualand reports in her doctoral dissertation [1], there are deaf users who are not satisfied with this medical approach, witnessing that they have to apply and undergo a medical examination before receiving a video phone.

Complementing the provision of terminals to end users are the relay services: The text relay service for textphone users and the video relay service for deaf sign language videophone users. There is also a speech-to-speech relay service that helps interpret speech, keep structure or take notes. The speech-to-speech relay service is accessed through an ordinary voice phone. All the relay services are provided through funding by the PTS, which procure the services.

Vogler et al summarises and puts the Swedish Video Relay Service in an international context in the conference proceedings from the AEGIS 2011 conference [2]. Vogler's abstract provide more information on different kinds of videophone calls, with or without the video relay service involved. One clear difference between e.g. the American VRS and the Swedish, Bildtelefoni.net, is that Bildtelefoni.net can be used both for relayed phone calls and for remote interpreting.

2 Project Goals and Actions

2.1 Alternative Telephony - the First Siat Project concerning Alternative Telephony

The project that ran during 2009 and 2010 was named "Alternative telephony" and its main focus was supporting county councils and user organisations by providing information and expertise.

Some of the specific actions in the project were:

- Informing about AT for alternative telephony provided by the county councils on SIAT's web site as well as on conferences for user organisations.
- Producing a guide to resolve simpler technical issues with commonly prescribed videophones and total conversation terminals. The guide was produced in simple-to-read Swedish as well as Swedish sign language and provided on SIAT's website as well as directly to users by technicians and prescribers in the county council and to members of the Swedish National Association of the Deaf.
- Lab testing of a number of free or low-cost videophone software and providing information about them to end users and county council professionals. The purpose was to provide information about software which could serve as a complement to prescribed AT. This was motivated by the fact that communication means were limited to users of prescribed videophones/total conversation terminals (AT) or

videophones using interoperable communication protocols, which at the time were video conferencing tools intended for business use and at a corresponding price. By informing about software that could serve as communication tools, SIAT hoped to promote empowerment and self-efficacy, making people less dependent on the county councils.

- Researching on system for providing video relay services and video phones in other countries. This work was done by Hilde Haualand from the Norwegian research institute FAFO in Oslo, who at the time was also doing academic research on this topic.
- Producing a set of recommended technical requirements for procuring textphones, videophones and total conversation terminals. SIAT procured these products on behalf of the county councils until 2010, when changes in regulation forced county councils to procure themselves or in collaboration with other county councils. From 2010, county councils procure these products in regional co-operation.

2.2 The SIAT and PTS Project "Alternative Telephony – from Special Solution to Solution"

The project, that SIAT and PTS ran together, focused on stimulating the use of mainstream products and services as alternative telephony. County councils ran trials together with end users to investigate how smartphones, tablets, PC's and other consumer ICT could be used to communicate with others in order to replace voice telephony.

The project was not a technology development project, but rather a project on developing policies and methods in county councils' rehabilitation and habilitation practices. A central notion has been that the assortment of AT should be widened to include mainstream technology in order for the prescriber and end user to find the technical solution that best meets communication needs. There is however, a de facto principle in county councils that mainstream products cannot be prescribed as assistive technology. With the gap between mainstream and assistive technology for distant communication getting narrower, a more subtle approach needs to be found.

Another important goal with the project was promoting and improving provision of ICT to persons with speech disorders to help them communicate with friends and relatives. From earlier contacts with professionals from county councils, user organisations as well as surveys among county council professionals, SIAT knew that persons in this group rarely get equipment for distant communication as AT.

PTS, apart from providing and extending the technical services of the relay services, promotes development of AT and accessible ICT through innovation competitions. The competitions are usually announced twice a year and each competition has its own theme [3]. During the two years that PTS has been part of the alternative telephony project, there have been a number of projects focused on alternative telephony that have been financed through the competitions. In one of the competitions on the theme "make daily life easier for persons with deaf-blindness", two of the projects are developing technology to communicate as well as use remote text interpreting. One of the two projects is using and further developing an app for Android, the other is developing an accessible web interface for real-time text communication.

Among the findings and results of the project were:

- Among deaf persons who participated in a web survey researching preferences among users, many use prescribed videophones or total conversation terminals as well as mainstream videophone software such as Skype, Tango and Oovoo. Text relay service was used by 74%, video relay service by 70% and Skype by 70% of deaf sign language users [4].
- PTS procured the video relay service Bildtelefoni.net and added new requirements to the existing service. One of these requirements were that the service shall be accessible using Skype video calls, another that the service shall provide applications for smartphones in order for users to access the service. The possibility to access the service using Skype has been open since March 31 2013.
- Most participants in the county councils' trials had speech impairments, 56 of 82 participants. Mainstream solutions to communicate were found for many of them, but key to success were whether significant others took part in communicating. I.e. for many social networking applications, both the person with a disability and the person he/she wants to get in contact with must be using the same app and be logged in, in order to be able to communicate. For some participants social network had diminished since the onset of their speech impairment, meaning they had noone to communicate with [4].
- A shift in attitude has started in county councils. Several of the county councils participating in the trials are currently revising their AT policies, which determine what products can be prescribed as AT, in order to be able to prescribe or help patients (persons with disabilities) use consumer products as AT. The most perceivable shift in attitude is that professionals in most county councils that have taken part in the project now talks about the county council's responsibility to help people find mainstream or assistive technology as tools to overcome disabling barriers.

2.3 The SIAT Project "Alternative Telephony – Facilitate for Persons Who Have Difficulties Speaking"

The project ran from late 2011 to march 2013. It has been closely linked to the parallel running project "from special solution to solution".

The main goal of this third project was raising awareness of possibilities for communication at a distance for persons with speech impairments and responsibilities of county councils to help these persons find ways to communicate over the phone or Internet.

SIAT co-operated with the county councils of Västerbotten and Örebro in producing a film showing good examples and practices. The film is published on SIAT's web site and DVD copies have been sent to professionals in county councils and municipalities around Sweden. In the film, six persons with different disabilities and needs participated and showed their ways to communicate. These users and some of their relatives gave their view of how the use of ICT to communicate had changed their ways of communicating and participating in society. Health care professionals (speech-language therapists and technicians) shared their experience on how to reason in order to find good solutions that meet user needs. The examples of communication ways shown in the film were:

- Using an eye controlled computer to chat, e-mail and use the Internet in other ways.

- Using a smartphone based AT with symbol input and text messaging to keep in touch with relatives, as well as using video chat in a smartphone.
- Using spell correction tools to chat on equal terms with friends on a social forum.
- Combining video chat with a laser pointer operated communication board to communicate with parents. The person with a speech disability can see his parents on his screen and the parents see the communication board on their screen. The parents re-phrase the letters and words pointed at when communicating.
- A woman who uses eye-blinks for communicating has started using video chat to call her mother. Conversation is mainly through the mother asking questions and the daughter replying yes/no.

SIAT interviewed professionals in county councils and municipalities, associations of persons with speech impairments and others to analyse what barriers there are to providing ICT solutions to persons with speech impairments in order for them to communicate at a distance. A number of ways to remove barriers were proposed, among which were

- Increasing general "ICT proficiency" among professionals meeting persons with speech impairments in Swedish health care, e.g. speech-language therapists, occupational therapists and physiotherapists.
- Improve co-operation between county councils and municipalities as well as between different professional groups.
- Include remote communication in documentation in county councils and municipalities, e.g. medical records, professional guidelines etc., in order to help professionals take that into account when examining needs of their patients.

3 Conclusions

SIAT have been working in three projects during the last four years with developing the system in Sweden for providing assistive technology or mainstream ICT for distant communication to persons who cannot hear or speak in an ordinary phone call. The projects have been focused on helping reshape attitudes among professionals in the county councils as well as forming technical specifications for public procurements and guiding users to different technologies.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-321

Simplifying User-tuned Content Management in Assistive Software

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Abstract. Information and Communication Technologies (ICT) are of upmost importance in the field of assistive technologies. Previous research from our group has proposed Troc@s, a multimedia tool to help children with Autism Spectrum Disorders (ASD) in the development of communication skills. A cornerstone of Troc@s is the ability that the caregiver has to customize the tool according to the profile of each child, creating the need to have streamlined procedures for the caregivers to follow. In this paper we propose an approach for easy customization of the tool, and present results of a usability study conducted with several caregivers, which show that, although training is required, our approach is considered to be a simple and adequate solution for routine use.

Keywords. User-tuned content, Rapid customization, Assistive technologies.

Introduction

Content management in multimedia assistive technology software solutions, usually involves a back office, manual file upload and related procedures that require a considerable amount of time when there are large sets of files to handle, and generally have high learning curves since caregivers are often technologically insecure or non-proficient. Troc@s [1] is a software tool recently proposed by our group for children with ASD; currently in use over 10 schools and with an overreach of nearly 50 children, customization has been a problem, because caregivers have several children to look after and must prepare user-tuned content to better address the individual needs of each child. In addition to not being computer experts, the time that caregivers can spend to setup the tool is very scarce, and in between customization sessions they tend to forget the procedures.

Still, user-tuned content is of paramount for children with ASD; as shown by Boyd *et al.* [2], children that are stimulated with suitable content for their circumscribed interests are more motivated and show better outcomes in their social and communication skills. Several recent studies on content customization for children with ASD explore the

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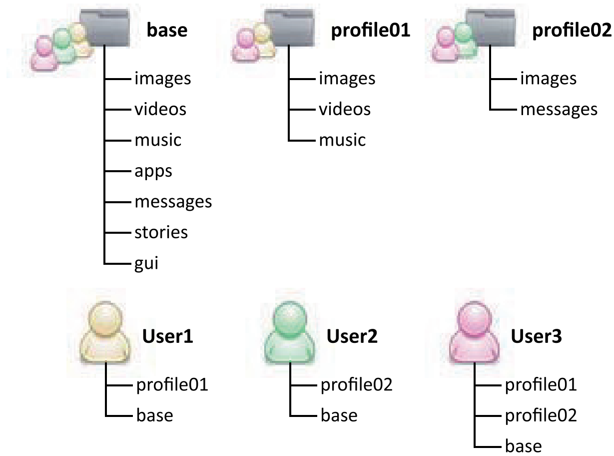


Figure 1. Example of a content folder tree with user assignment.

possibility to setup user-tuned content in order to address the children's interests, however, they lack the focus on how the system can be easily managed and prepared by the caregivers to address that interests [3,4,5]. In this paper we propose a simplified approach to content management based on the File Management System (FMS), and present the results of a usability study conducted with several caregivers.

1. Proposed Approach

For Troc@s we adopted an approach where the caregivers use the FMS for content management. The underlying principle is that much like using the "My Documents" metaphor that is available in all Operating Systems, handling folders and files could be a more familiar operation for caregivers. We believe that the FMS is prone to break the initial challenge of using a new tool such as a dedicated back office.

Figure 1 shows an example of the FMS tree structure that supports this feature in Troc@s. The `base` profile is available as a default for all children, and `profile01` and `profile02` are profiles created by the caregiver and that can be assigned to individual children. Profiles are folders with lists of files (like musics, videos, images, etc) and can have any kind of content or layout. Custom profiles have priority over the `base` profile and there is no limit of profiles that can be created or assigned. Further details about the Troc@s system and framework can be found in [1].

2. Experimental Evaluation

To assess the feasibility of our approach as an easy-to-use method for the customization of Troc@s, a usability study was conducted in a real-world scenario. In our test, each caregiver had to introduce user-tuned content for one child for all the multimedia features available in Troc@s, which help us in evaluating how caregivers perceive the ease-of-use of the FMS, and provides us a real understanding of the main problems of the method we followed. Before applying the test, all tutors attended a briefing, so they could get a basic insight about the FMS structures and underlying principles of our proposed approach, and learn how to use it, not only to be able to guide and support the children during the customization effectiveness tests, but also to learn how to master the customization process. This allowed us to prepare the users to conduct the real-worl tests with the children and perform correctly the user-tuned content adaptation autonomously. A total of 14 tutors were enrolled in this test, with ages ranging from 22 to 55 and with professional experience ranging between 0 and 29 years; 9 of the tutors were special education teachers, while the remaining 5 were speech therapists.

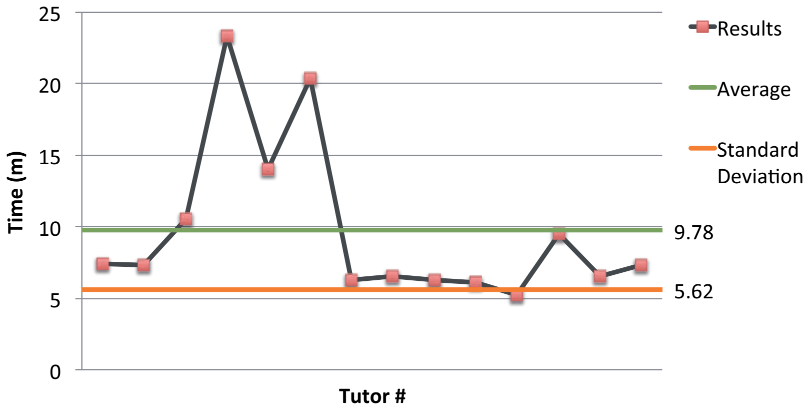
During the test we gathered the time that caregivers took to perform the tasks and the number of errors performed. After they took the test, we asked them to fill the System Usability Scale (SUS) form so we could assess the effectiveness, efficiency and satisfaction regarding this system. Figure 2 presents the main results; we believe the median time of 7.35 minutes to be more representative of the population, since three users were older and less proficient using the computer, requiring twice the median time to finish the test. In the end of the test, we asked users to evaluate the system using the SUS scale. The final score was 74, which according to [6] is ranked as a B- and a positive results given that a score above 68 was obtained.

3. Conclusions

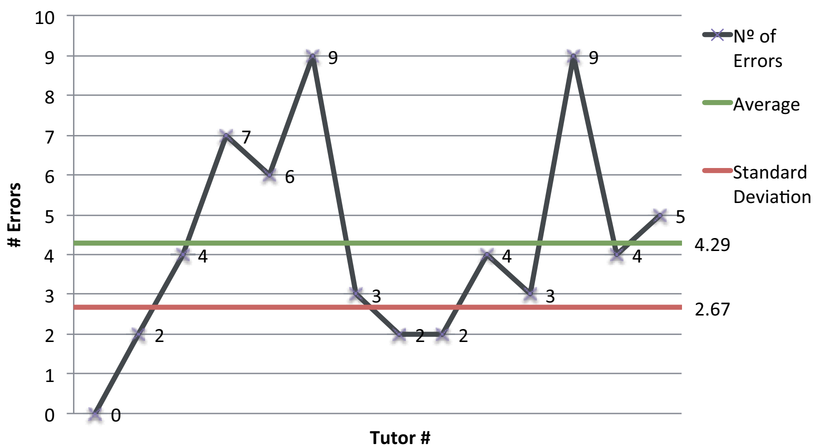
Results have shown our approach to be adequate for regular use, as shown by the average completion time and low number of errors; an experienced user takes 3 to 4 minutes in the customization task. Figure 2 highlights that even with the FMS method some users don't feel confortable using the computer as shown by the 3 cases with higher completion times. When inquired about their computer proficiency, most caregivers said that they were accustomed to using the computer, but they did a very limited usage of it in their routines. Results let us conclude that the FMS is a natural process, completely familiar to most caregivers.

During the test, we observed the caregivers difficulties, and most of them were related with the concept of user profiles. All participants knew how to navigate in the folders, handle the files. Still, all of them struggled when dealing with the profiles. Most seemed to easily forget the differences in the purpose of each profile folder, and how to operate them. The results in the SUS lead us to believe that the biggest problem is bound with the training and motivation towards the use of the platform, which requires some apprenticeship.

This was especially noticeable in the older users. While observing and talking with them, we realized that they had their routines with the children settled for some time, and despite agreeing with the lack of appropriate tools, when confronted with one, did not seem interested enough. Most of the users reported that the system is not complex, but they need some training to use the tool. In the overall the results are positive, showing that most users find the system is well-integrated and simple to use and would consider using it frequently, which is a good indicator of their satisfaction towards this approach. Future work will focus on simplifying the folders structure for profile management in a way that better promotes the ability remember the process and organization.



(a) Time results of the task, with Mean, Median and Standard Deviation



(b) Error results of the task, with Mean and Standard Deviation

Figure 2. Results of the tests

Acknowledgements

This work has been partially funded by Fundação Portugal Telecom, ASUSTeK Computer Inc., and by the Fundação para a Ciência e Tecnologia (FCT) under the grant SFRH/BD/65248/2009 and under project PEst-OE/EEI/LA0021/2013, the support of which the authors gratefully acknowledge.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-326

Word and Sentence Prediction: Using the Best of the Two Worlds to Assist AAC Users

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Abstract. In this article we studied the effect of using Sentence Prediction as a complementary technique to Word Prediction. A mean rate of 21.0 WPM and a maximum absolute rate of 43.4 WPM were obtained for the Sentence Prediction only condition. Combining Sentence Prediction with Word Prediction resulted in a mean rate of 18.8 WPM and a maximum absolute rate of 36.2 WPM. To measure system performance under more realistic conditions we also tested the use of Word and Sentence Prediction under different sentence knowledge conditions: 100%, 75%, 50%, 25%, 0%, and were obtained mean rates of 16.8, 14.6, 10.9, 8.6 and 8.2 WPM respectively. The conditions with less knowledge (25% and 0%) had results close to the Word Prediction only condition, around 8 WPM, which is an indicator that under low sentence re-use conditions it does not compromise user performance. Since Sentence Prediction also proved to have the potential to speed up message composition, we think this technique can be a valuable complement to Word Prediction in AAC systems.

Keywords. Augmentative and Alternative Communication, Rate Enhancement Techniques, Vocabulary Prediction, Word Prediction, Sentence Prediction.

Introduction

Human conversation is a very challenging activity, particularly for those with motor, cognitive or sensory difficulties who rely on electronic devices to communicate. Considering that humans communicate at rates between 125 Words Per Minute (WPM) and 185 WPM during a dialog, and that good typists working on expressive writing can only reach 27 WPM [1], then the difficulties Augmentative Alternative Communication (AAC) users have to face become evident. One of the most popular rate enhancement techniques is Word Prediction. With this technique, every time a new letter is entered the system suggests a list of words that can complete the text the user is writing. If the prediction list contains the desired word then it can be completed immediately leading to keystrokes savings up to 45% [2]. These savings, decrease physical effort allowing users to work longer and with more comfort, however several studies have reported that Word Prediction does not increase communication rate [3][4]. Studies from these authors show that the time saved in keystrokes ends up being consumed searching the prediction list. The research community has been trying to improve the Keystroke Saving Rate (KSR) of

Word Prediction in order to allow communication rates comparable to human natural means but it seems increasingly difficult to raise the KSR above the 55% [5]. As an example, studies on Word Prediction that employ sophisticated techniques like trigram models and topic adaptation report a maximum of 59.3% KSR [6]. This KSRs are however not enough to overcome the prediction list search problem and allow communication rates required in a dialog.

Alm and colleagues point out correctly that we are not always re-inventing new sentences in our daily dialogs[7]. Therefore AAC Devices may store whole user sentences for selection during a conversation[8]. Alm and colleagues explored the concept of sentence re-use in several systems presenting communication rates of 54 WPM[7], 66.6 WPM[9] and 90.1 WPM[10]. These systems have however the drawback of requiring users to navigate constantly through the computer interface or to control filtering buttons to access the intended sentences. As a result, carrying out these tasks will delay message composition as well as prevent users with more cognitive difficulties to use the system.

Motivated by the increasing difficulties of a client from Center of Cerebral Palsy of Beja to keep communicating through handwritten sentences we decided to start studying use of Sentence Prediction to support face to face communication. This client, that is affected by a degenerative disease, is already a user of our Word Prediction system "Eugénio - O Génio das Palavras" (`http://www.l2f.inesc-id.pt/~lco/eugenio/`) for computer writing. Therefore we hypothesized that the integration of such a Sentence Prediction mechanism on an AAC system like Eugénio would increase these systems capability to assist face to face communication. Of course, with both prediction mechanisms offered by an AAC Device, Word and Sentence Prediction, users will have to face the trade-off between message precision, favored by Word Prediction, and communication rate favored by Sentence Prediction.

1. Research Questions

In this first study we start answering questions related to the performance of text prediction AAC solutions that combine Word and Sentence Prediction: **(1) What is the message composition rate improvement using Sentence Prediction? (2) What is the keystrokes saving improvement and hence physical effort decrease using Sentence Prediction? (3) There is a reduction in user errors using Sentence Prediction?** Answers to these questions are fundamental to allow professionals to help their clients decide if they may benefit from using these two techniques in their AAC solutions.

2. Method

To answer the research questions we conducted user tests with our prototype. Language models that support the Word and Sentence Prediction mechanism were trained with sentences collected from two paper notebooks that belong to a client from the Center of Cerebral Palsy of Beja (the AAC User Conversation Corpus). Table 1 provides a description of this language corpus. Eugénio n-gram language models were then trained with this corpus to best match this client communication needs. The result was a real communication solution with Word and Sentence Prediction that this client is using in Center of Cerebral Palsy of Beja.

Table 1.: Summary of the characteristics of the language corpus used in this study.

Characteristics	
Number of sentences	545
Number of words	4551
Mean words/sentence	8.4
SD	5.7
Mean chars/words	4.1
SD	2.6
Type/token sentences ratio	0.965
Type/token words ratio	0.259

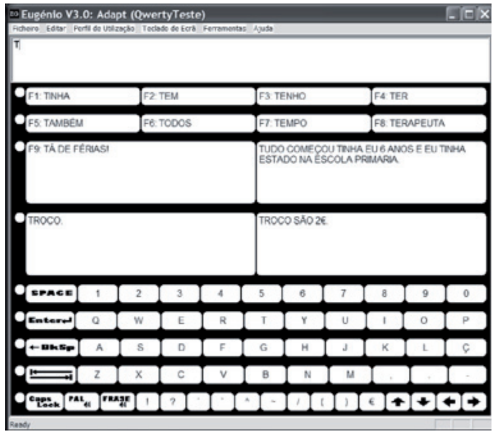

Figure 1.: Eugenio V3 on-screen keyboard layout used in the tests.

The participants in the experiment were this client (Subject A) as well as 40 undergraduate students from our school. The tests were carried out using a general qwerty on-screen keyboard with respectively 8 and 4, Word and Sentence Prediction slots (Figure 1). Subject A used his tablet pc with pen input and the undergraduate students desktop computers with mouse input.

The experiment was composed of two tests, both following a repeated measures design. In the first test (Test 1), users were asked to write 4 blocks of 6 randomly selected sentences from the AAC User Conversation Corpus. Each block of text was written using a different configuration: (1) Qwerty only (Qwerty); (2) Qwerty + Word Prediction (Qwerty_WP); (3) Qwerty + Sentence Prediction (Qwerty_SP) and (4) Qwerty + Word Prediction + Sentence Prediction (Qwerty_WP_SP). In this test the system had knowledge of all asked sentences. Consequently results from this test measured user performance under ideal conditions. Unfortunately real world systems don't have complete knowledge about user sentences. Therefore we carried out a second test (Test 2) to evaluate user performance with a not perfect language model. Five different conditions were tested: (1) 100% Sentence Knowledge (SK_100); (2) 75% Sentence Knowledge (SK_75); (3) 50% Sentence Knowledge (SK_50); (4) 25% Sentence Knowledge (SK_25) and (5) 0% Sentence Knowledge (SK_0). In this test users composed 5 blocks of 4 randomly selected sentences from the AAC User Conversation Corpus, with each block associated with a different sentence knowledge level. In all Test 2 conditions the Qwerty + Word Prediction + Sentence Prediction configuration was used.

3. Results

Table 2 shows Subject B1 to Subject B20 group Mean (M) and Confidence Interval (CI) values for Words Per Minute (WPM) as well as the Keystrokes Savings Ratio (KSR) obtained in Test 1. For comparison reasons results for Subject A are also shown. Table 3 show these values for the Test 2. A Shapiro-Wilk test was used to check for data normality and returned negative for at least one data series in each comparison, consequently

Table 2.: WPM and KSR values for Test 1.

	WPM			KSR(%)		
	SubjA	SubjB1-SubjB20		SubjA	SubjB1-SubjB20	
		Mean	CI		Mean	CI
Qwerty	1.3	8.8	0.7	-124.3	-9.9	3.1
Qwerty_WP	1.2	8.3	0.7	-94.8	33.5	6.3
Qwerty_SP	3.2	20.0	4.0	21.4	67.5	9.2
Qwerty_WP_SP	7.2	18.8	3.6	65.9	68.1	7.3

Table 3.: WPM and KSR values for Test 2.

	WPM			KSR(%)		
	SubjA	SubjB1-SubjB20		SubjA	SubjB1-SubjB20	
		Mean	CI		Mean	CI
SK_100	2.4	16.8	2.6	-39.3	60.9	7.1
SK_75	2.0	14.6	1.8	-30.2	55.0	9.0
SK_50	2.0	10.9	1.5	-14.1	38.4	8.0
SK_25	1.7	8.6	1.0	-43.3	18.7	7.9
SK_0	1.3	8.2	0.8	-103.9	12.4	6.5

data had to be analyzed using the non-parametric Friedman test. Next we'll discuss the main results from this study.

(1) What is the message composition rate improvement using Sentence Prediction? Under ideal conditions, with the system having knowledge of all the sentences the user had to write, there was an substantial improvement in the message composition using Sentence Prediction. Message composition mean rates of 8.8, 8.3, 21.0 and 18.8 WPM were obtained for the Qwerty, Qwerty_WP, Qwerty_SP and Qwerty_WP_SP conditions respectively (Table 2). We found statistical significant differences in the WPM mean between all Sentence Prediction configurations (Qwerty_SP and Qwerty_WP_SP) versus non Sentence Prediction configurations (Qwerty and Qwerty_WP). It is interesting to note that all Word Prediction configurations had always worst results that their non Word Prediction counterparts. On the contrary, configurations with sentence prediction had always better results. Consequently, and contrary to what happens with Word Prediction, the time users spent inspecting the sentence list was worthwhile due to the greater amount of saved chars. For subject A the Qwerty_WP_SP was the best configuration with 7.2 WPM. To measure system performance under more realistic conditions we tested the Word and Sentence Prediction (Qwerty_WP_SP) configuration under different Sentence Knowledge (SK) conditions (SK_100, SK_75, SK_50, SK_25, SK_0) and were obtained values of 16.8, 14.6, 10.9, 8.6 and 8.2 WPM respectively (Table 3). There were no statistical significant differences between most of the adjacent knowledge levels which is a consequence of a gradual decrease on composition time, however there was always statistical significant differences between non adjacent knowledge levels. Comparing the lowest sentence knowledge conditions (SK_25 and SK_0), with the Word Prediction only condition from the first test (Qwerty_WP), we found similar message composition rates, around 8 WPM. This suggests that user performance is not affected when Sentence Prediction is not working at his full power. This is however a comparison made between different groups of test users (Test 1 vs Test 2) and therefore we must be cautious considering it. Results are similar for Subject A with 1.7 and 1.3 WPM for SK_25 and SK_0 respectively, and 1.3 WPM for the Qwerty_WP condition.

(2) What is the keystrokes saving improvement and hence physical effort decrease using Sentence Prediction? In our analysis we found statistical significant differences in the Keystrokes Savings Ratio (KSR) mean between all text prediction configurations (Qwerty_WP, Qwerty_SP and Qwerty_WP_SP) versus the Qwerty only condition. There were also statistical significant differences between the two Sentence Prediction conditions (Qwerty_SP and Qwerty_WP_SP) and the Word Prediction only condition (Qwerty_WP). KSRs of -9.9%, 33.5%, 67.5% and 68.1% were obtained respectively for the Qwerty, Qwerty_WP, Qwerty_SP and Qwerty_WP_SP (Table 2). Configurations with text prediction capabilities all presented positive values. This means that these techniques allow users to save keystrokes that would be needed to compose the same messages using a physical qwerty keyboard and committing no errors. The negative mean value of -9.9% for the Qwerty condition means that participants required more keystrokes when compared with that baseline, probably due to errors and this on-screen keyboard layout. The Sentence Prediction configurations not surprisingly had the better results. For subject A increases on the KSRs were much more substantial when he used the Sentence Prediction configurations. In Test 2, KSRs of 60.9%, 55.0%, 38.4%, 18.7%, 12.4% were obtained respectively for the SK_100, SK_75, SK_50, SK_25, SK_0 (Table 2). All configurations allowed keystrokes savings when compared with an ideal user typing on a qwerty physical keyboard. Both, SK_25 and SK_0, presented very low KSRs values if we have in consideration that Word Prediction was still working. There is a substantial difference between these values and the 33.5% obtained with the Qwerty_WP configuration in the first test but we must not forget that the first test was run with 100% knowledge of user sentences. Consequently the results from this test should be more realistic. Subject A missed several opportunities to complete the sentences suggested in the SK_100 and SK_75 configurations and consequently the results for these configurations stayed below our expectations.

(3) There is a reduction in user errors using Sentence Prediction? Statistically significant differences were not found on the different test conditions for the two error metrics we have measured: (1) Deleted Chars Ratio and the (2) Orthographic Errors Ratio.

4. Conclusions and Future Work

In this study we measured user performance in message composition tasks using different Word and Sentence Prediction configurations. Sentence Prediction only was the fastest configuration with a mean message composition rate of 21.0 WPM. The configuration that combines Word and Sentence Prediction was just a little worst with 18.8 WPM. The KSRs for these two configurations were very similar with 68.1% and 67.5% respectively. These measures were obtained with the system having full knowledge of all the sentences users had to compose. To measure system performance under more realistic conditions we tested the Word and Sentence Prediction configuration with variable levels of Sentence Knowledge (SK_100, SK_75, SK_50, SK_25, SK_0) and were obtained values of 16.8, 14.6, 10.9, 8.6 and 8.2 WPM respectively. Results obtained for Word and Sentence Prediction configurations with low sentence knowledge (SK_25, SK_0) are very similar to Word Prediction only configuration (Test 1), around 8 WPM, which shows that Sentence Prediction doesn't slow down users when predictions have a low success rate. Results from this study will now be considered in our undergoing work that consists on the design and evaluation of a context-aware AAC system with text and pictogram prediction capabilities.

Acknowledgements

This work was partially supported by (1) national funds through FCT Fundação para a Ciência e a Tecnologia, under project PEst-OE/EEI/LA0021/2013 and by (2) "Sistema Regional de Transferência de Tecnologia SRTT Operação: ALENT-07-0262-FEDER-001870".

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-332

Inclusive AAC - Multi-Modal and Multilingual Language Support for All

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Abstract. The Concept Coding Framework (CCF) technology represents a long term commitment to develop and deliver an open infrastructure for multi-modal and multilingual language support for a wide area of applications. In this way the varying needs among several smaller groups of users of AAC (Augmentative and Alternative Communication) may be met as part of an inclusive environment of much wide-spread interest. With support from the EU via the AEGIS project, a "CCF-SymbolServer" has been developed. It can be installed locally on any of the major desktop platforms (GNU/Linux, MacOS X and Windows), or online, to support many kinds of local or web based services and networked mobile systems. In any of these environments the CCF-SymbolServer can provide its multilingual and multi-modal representation services to other applications. Four such applications will be presented: 1) CCF-SymbolWriter, an extension for symbol support in LibreOffice/OpenOffice Writer; 2) CCF-SymbolDroid, an AAC app for Android mobile devices; 3) the new CCF supported version of Special Access to Windows (SAW6); and 4) “Nysnö”, a web based prototype for symbol supported easy to read news text. Future perspectives will be discussed.

Keywords. AAC, Universal Design, AT, Accessibility, Graphical Symbols, Literacy, Cognitive Impairment, Free And Open-source Software.

Introduction

A strengthened awareness is gradually spreading among us who are involved in supporting people depending on AAC for their communication, that the longer-term rights and needs of these individuals can only be well satisfied in an environment where the necessary attitudes, methodologies and tools for AAC support are very well and enduringly established. But this, on the other hand, is not what we have so far seen happening on any larger scale. We may experience temporary and local success stories, but on the whole the situation is still frustratingly unsatisfying and achievements fragile. What specific problems are we facing? What could and should be done to substantially improve the situation? In what ways must we change our approaches to meet the challenges ahead?

If we just focus on the Assistive Technology (AT) aspect, a reasonable hypothesis for responding to these questions and challenges will be: Do all can we to improve the preconditions for a general Universal Design[1] approach to creating an inclusive and mainstream environment for long-term support for AAC needs, which is (and must be) of general value for the environment as a whole. In the Concept Coding Framework (CCF)[2] effort, the ambition is to step-by-step develop an open and free framework technology infrastructure for making multilingual and multi-modal language resources available in mainstream ICT environments as well as in AT.

There have been several attempts to approach these goals during the past two decades. Already in the early 1990:s the Nordic-British ComSpec project (1991-1993) formulated the vision of a generic modular and component based AT platform for AAC software, including a central multi-modal language module[3]. This was brought further in the EU TIDE Comspec project (TP1169)[4] - with partners from Great Britain, Holland, Germany, Portugal, Norway and Sweden – which resulted in the ComLink open and component based Java environment for developing and adapting AAC systems for persons with multiple disabilities[5]. The language component and editor for linking multi-modal language representations to each other is at the core of this environment, and it addresses the needs, and provides tools for end-users, facilitators, system integrators and component developers.

Parallel to this, the visions from the Nordic Comspec project were also brought into (by the Finnish Comspec partner) and developed further within the EU TIDE project ACCESS (TP1001). This project contributed substantially by emphasising the importance of employing state-of-the-art language technologies in the language environment of this kind of a modular AT and AAC environment[6]. Via a couple of intermediate projects, the heritage from the ACCESS project has ended up in the ITHACA framework[7], an open source environment for sustainable AAC products[8]. It includes a language sub-system that is both multilingual and multi-modal, as well as other components and tools with similarities to the Comspec-ComLink system, but depending on the Microsoft COM object technology.

Both the Comspec and ACCESS teams were in touch with, and/or partly inspired by related work by Patrick Demasco and Kathleen McCoy et al at University of Delaware - A.I.DuPont Institute, and their COMPANSION system[9].

We can conclude that neither of these component based and modular systems has managed to attract enough further interest and resources to develop and sustain a critical mass of functionality and advantage to compete with the traditional models of dedicated and mainly proprietary AT and AAC software product development and marketing. Though visionary and in several ways ahead of its time – this was before the popularity of free and open-source software development - these systems were also still limited to the perspective of dedicated AT and AAC development only.

Following the above early attempts to develop dedicated open technology based platforms for alternative communication, the WWAAC project (IST-2000-27518)[10] started in 2001. The baseline was that sending messages composed by symbols and pictures was difficult over the Internet, due to lack of standardised encoding schemes and common practises. WWAAC strove for the introduction of a common, open and vendor neutral multi-modal and multilingual language platform, based on Semantic Web technology standards, to overcome some of these difficulties[11]. A basic set of concepts was created, partly based on Princeton University WordNet and several pictures communication symbol sets and natural languages. The design and definition was published as the first version of the Concept Coding Framework (CCF)[12].

A project that took advantage of this development was the Nordic Symbered project. The aim was to develop an editor that effectively could help produce and adapt web documents based on XML to be presented as text with complementary support from graphic symbols. The CCF technology allowed encoded documents to be presented with symbols from any of the used symbol sets in combination with text from any of the offered natural languages - with possibilities to add new symbol libraries or languages to the database.

The results presented in this paper come from the recently finished EU project AEGIS (FP7, IP 224348)[13], where the CCF Framework has been used to develop components for symbol support in open source software for both mainstream and AT, such as an extension for the LibreOffice/OpenOffice Writer word processor, and AAC support in the Android mobile environment.

1 AAC and Mainstream Standard ICT – Some State of the Art

ICT support for individuals who need AAC has typically been, and still is, provided in the form of dedicated software and/or devices. There will still be room for such, but there is a growing number of reasons for a move towards providing AAC functionality as part of standard mainstream ICT products:

- ICT products and services (such as smart-phones, tablets and mobile communication services) have rapidly become an integrated and often predominant part of everyday life, and are equipped with more general features (portability and usability combined with computing power for running many kinds of full-featured multi-media apps, larger displays of excellent quality etc.) making them suitable and desirable for AAC needs. It is natural that both users and their environment expect and request that a wide range of needs, including the specific ones in the area of AAC and language support, should be well accommodated as part of mainstream products.
- Some previously special functions of AT, such as text-to-speech synthesis, are gradually becoming mainstream technology.
- A solid infrastructure of flexible multi-modal and multilingual language representation technology is needed for good AAC support. There are potentially substantial advantages of such an infrastructure going mainstream, both in terms of inclusion and participation, and in terms of cost and availability – in particular where resources are scarce. More and more parents, (pre-school) teachers and others discover that access to synthetic speech and a range of graphical symbol representations is great for most learners at some stages in early literacy development and early new language learning. This is particularly the case in multi-cultural and multilingual environments.

Some of this integration is now rapidly happening as AAC software is being developed for and/or migrated to mainstream mobile devices in the form of mobile "apps" (though generally still with more limited or specific functionality than traditional dedicated AAC applications and devices). Though this is primarily only integration on the mobile device level, the consequences are still judged to be profound by experts in the field[14]. However, AAC and symbol support within standard activities and services is still a major step to be taken. The Widgit products "Point" and "Insite"[15] are examples of more integrated symbol support on the Web, but these are based on Widgit proprietary technology and lexical resources, and thus not open for a freer and wider range of applications by other developers and service providors.

2 Challenges and Preconditions for Inclusive AAC Support in Mainstream ICT

A major challenge for the AAC field is the general complexity characterising the areas of communication and language in general, further added to by the growing socio-cultural diversity in modern European societies. The AAC area is living on top of this basic complexity, and adds to it by its own fragmentation in terms of a multitude of more or less well founded ideas and preferences about methodologies and tools, including choice of signs, graphic symbol systems, software tools etc. for different target user groups and needs. The reasonable response to these problems is to build AAC technology and resources on mainstream language technology efforts to bridge between languages, and add to that by levelling the ground for smoothest possible integration between different graphical symbol systems and sign language representations.

In other words; there is a need for an infrastructure for inclusive and integrated graphic symbol representation (as well as sign representation) of content and meaning in standard software environments. These infrastructural tools need to be based on open standards, be widely and freely available, and be multilingual and multi-modal so that more language representations may be added subsequently and in a distributed manner by local stake-holders. Components and tools need to be publicly available to make it easy to provide the multi-modal support in a widening range of different services, and for all kinds of potential users.

There are of course some more fundamental conditions and limitations that will create difficulties for AAC support in some environments and services. On the technical side, for example chat and messaging protocols are not supporting graphics. It is essential that a discussion is initiated around how such limitations may be overcome to allow future multi-modal communication also via these channels.

Other challenges are facing us in terms of attitudes, predominance of proprietary resources, and the still slow development of established open standards and resources for multi-modal and multilingual vocabulary interoperability.

We are convinced that the CCF based developments (most recently within the AEGIS project) may serve as one platform and inspiration, among several others, for further European and international co-operation in this field. In addition to the European programs and the international standardisation bodies, it seems sensible to link such work to developing international frameworks like “Raising the Floor” and “GPII” (Global Public Inclusive Infrastructure)[16].

3 Recent Concept Coding Framework Developments

One of the many objectives of the recently finished AEGIS project was to research, prototype and test freely available software services for inclusive graphical symbol support as part of mainstream environments to benefit people with communication, cognitive and multiple impairments. This has resulted in the development of a “graphical symbol server” based on the CCF technology.

The "CCF-SymbolServer"[17] can provide multilingual and multi-modal representation services locally on any of the major desktop platforms; Windows, MacOS X and, more tentatively, GNU/Linux. It is also available online to serve many kinds of web services and mobile devices. The server functionality is central for the planned future developments based on CCF. It communicates with the different CCF applications and different users, and any new CCF application developed according to the CCF API. Users can set up their own local servers, which allows independence from the current development team, and true open-source.

Currently two symbol systems (Blissymbolics[18] and ARASAAC[19]) and four languages (English, Swedish, Spanish and Dutch) are supported, and the design is open to add more. A word in a given language can be sent to the CCF-SymbolServer. The server will look up possible meanings or concepts in its databases, and return these as Concept IDs with available possible symbol representations. If the concept ID is known, the server can directly return alternative representations in other languages and symbol systems.

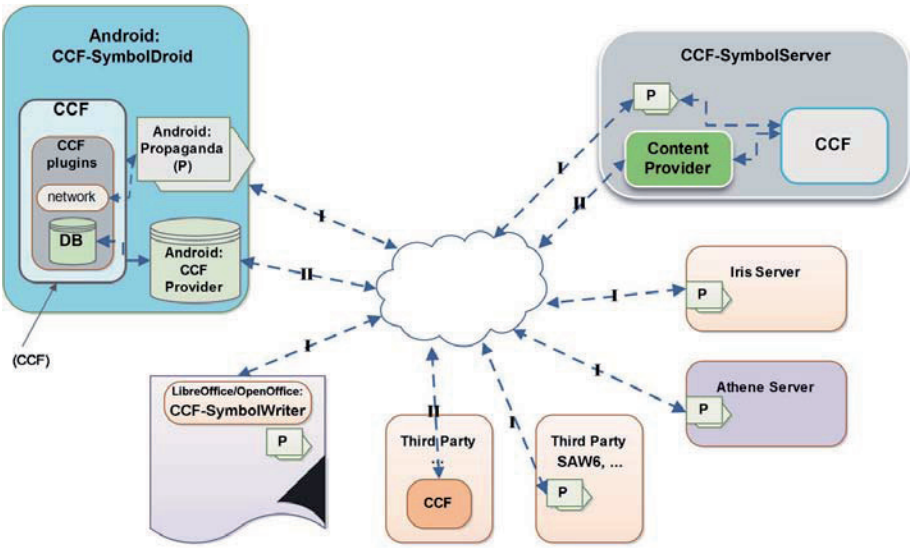

Fig. 1. CCF ecosystem overview.

The scope of the CCF database is built on the vocabularies of the symbol sets used. This means there are about 5,000 concepts that all have a symbol representation. Linguistic data for concepts is extracted from a lexical ontology called Wordnet and stored in the database with links to the different representations. Given results from earlier phases, this process has been optimized and debugged to avoid as many unwanted connections as possible.

Additionally, Wordnet only holds words from the four most common parts of speech; nouns, verbs, adjectives and adverbs. The symbol vocabularies, as well as the everyday language, have additional words like pronouns, prepositions, conjunctions and interjections. The symbol vocabularies also hold more specific words not found in Wordnet, typically connected to the field of assistive technology. All those words have always been handled as a separate part of the database, but since they have no way of automatically being sorted correctly, efforts have been made to provide as smooth and accurate lookup and representation as possible.

Three applications interacting with the CCF-SymbolServer have been developed within AEGIS:

1. **CCF-SymbolWriter**, an extension for symbol support in LibreOffice (or OpenOffice) Writer. It allows graphical symbol support for several kinds of needs:
   a. The needs of struggling text users to support and confirm comprehension while writing and reading text, often in combination with text-to-speech (TTS) support
   b. The needs of AAC symbol users to have access to full symbol representation (as far as possible) with symbols displayed on top of each word (or multi-word phrase)
   c. The needs of helpers (parents, teachers, therapists etc.) to support the above needs by preparing and presenting documents with graphic symbol support
2. A new CCF supported version of **Special Access to Windows** (SAW 6)[20], an advanced free and open-source on-screen-keyboard application that allows the creation of symbol selection charts for the control of any mainstream program on a Windows system
3. **CCF-SymbolDroid**, an AAC app for Android mobile devices, with the following functionality:
   a. Face-to-face AAC with graphic symbols, text and the system speech that is available on the device
   b. AAC for indirect communication via messaging in several forms
   c. Access to the full CCF vocabulary database via the online CCF-SymbolServer
   d. Log in with user ID to access the online CCF-SymbolServer services - save, restore and share local set-ups via the server

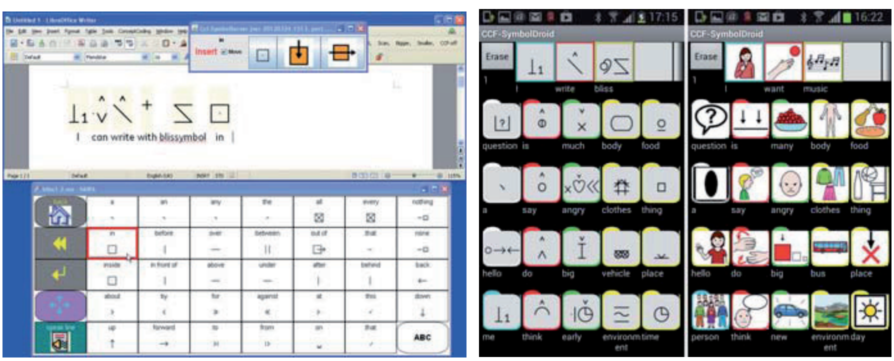

Fig. 2. The CCF-SymbolWriter extension for LibreOffice Writer – with the CCF-SymbolServer display floating on top of the Writer window, and a SAW6 symbol chart for symbol based text input below (left) Two displays of the CCF-SymbolDroid AAC app for Android devices are also shown (to the right).

Given the feedback from end users, experts and developers within the AEGIS user pilot evaluations and later experiences, the CCF services and applications are continuously developed. For example:

The support in the CCF-SymbolWriter extension has been extended and now handles multi word expressions and the possibility to interchange a word for a given symbol. This means that you could write 'dog' to get the symbol for dog in your document - and then replace 'dog' with the name of your own pet. The extension will also automatically identify the language based on your word processor's settings, and ask the symbol server to find that word in the correct language in its databases. All possible meanings and concept linked to that word are returned in form of the concept ID and available symbol representations. The system handles all common inflection forms for all four languages, even if the support for English and Swedish is more extensive.

The protocols, APIs and services of the CCF-SymbolServer and the CCF-SymbolDroid AAC app are also subjects of substantial revisions and upgrades.

So far, at least one application interacting with the CCF-SymbolServer has been developed after AEGIS: **Nysnö** – Symbol supported "easy to read" news texts on the web - aims to develop a web based tool for providing Bliss and ARASAAC symbol support to easy-to-read daily news produced by the Swedish '8 SIDOR' publishing house. The editing tool might also be useful for authors who want to supply information text written in an easy-to-read format with appropriate AAC symbols, in order to enhance comprehension. After project closure, the tool will be available under an open source license.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-340

Combining Research, Theory and End User Experiments for Suitable AAC Apps

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Abstract. The increasing dissemination and wider access to mobile devices, as well as the spread of applications in several areas requires us to rethink the technologies for Augmentative and Alternative Communication (AAC). There are now over a three hundred applications for AAC available on the market, at a considerably lower cost when compared to traditional communications systems. However, the exponential growth of the number of these applications is concerning some AAC professionals about the impact of this new approach and raises several relevant questions. This article considers the challenges of a new era for AAC technology, combining theory and practice on the development process of a specific application named Vox4all®, and also suggests paths, new approaches and mind-sets for future research.

Keywords. Augmentative and Alternative Communication, AAC, Vox4all, mobile devices, AAC applications, Complex Communication Needs, CCN.

Introduction

Communication is a complex and fundamental process to the development of human relationships. When communicating, the most widely used way of expression is speech. Talking not only enhances human interactions, active participation in society, but also development of cognitive and thinking skills, enabling the accomplishment of new and more elaborated learning experiences [1]. However, "a significant number of people is unable to communicate through speech. This includes people totally unable to speak and people in which speech is not enough to meet all the communication roles (...)" [2]. There are several reasons for this, voice misuse and abuse, different levels of disorders such as hearing, cognitive, neurological, emotional and amnesic, cerebral palsy and other brain damages or stroke [3].

So, in order to overcome the need for communication, inherent to every human being, it is important to give these people as soon as possible, an Augmentative and Alternative Communication (AAC) system, in order to replace or increase reduced communication skills [4]. Some individuals may require AAC systems for a short period of time, while others require these systems throughout their lives. Until recently the most advanced systems of AAC were only available for computers or specialized devices, but the wide dissemination and democratization of mobile devices has triggered a new revolution, forcing to rethink technology for AAC.

Given the need to change paradigms and adjust to the new trends in emerging technologies, Imagina® brand working in the areas of inclusion and education, has an on-going research and development project called TOPQX (Everyone Can Learn

Anytime, and Anywhere). The project aims to gather theoretical and experimental resources to create the scientific foundation to discuss and recommend new approaches. As part of this project, we are developing an application for smartphone and tablet called Vox4all®. Vox4all® is an application specially designed for individuals with Complex Communication Needs (CCN). Its main goal is to overcome and decrease communication problems, promoting the development of communication, language and literacy, and consequently to integrate those individuals into family, professional, educational and social environments.

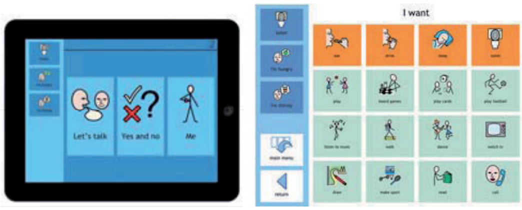

Figure 1. Vox4all application: home screen and example of one communication grid.

The software is based on the principle of communication grids organized in rows and columns. Initially we implemented basic features such as the option to make cells with symbols or photos captured with the device's camera, as well as the possibility to record sounds, associating them to cells. However with the several tests being made by therapists and users in real environments and contexts, we have developed new features and improved others.

1. State of the Art

The AAC has arose and grown from the most basic desire to help individuals with Complex Communication Needs (CCN) to express themselves and interact with the community. Since it's beginning in the 70s in Canada, up today, the AAC has experienced several developments and provided a wide range of options.

Initially people used systems without technology using their body (such as, sign language system), then analogical or low-tech systems (such as books and cards with symbols and images), until high-tech systems (such as communication devices and computer software with text to speech) [5]. This evolution is supported by research showing that the correct use of AAC has positive effects on the development of communication, language and literacy [6, 7, 8, 9], without any risk for speech development [10, 11]. Now, the exhaustive development of mobile devices and applications triggered a new technological revolution, forcing to rethink technology for AAC.

Mobile devices such as smartphones and tablets are widespread, so its supply in the market is growing and their prices are getting more competitive. In addition to providing a large number of communication options, they also give access to books, games, movies, music, Internet and countless applications in many different areas, from education, health, entertainment, culture and tourism [12]. The AAC area is no exception. Currently there are more than three hundred applications developed by companies or independent programmers trying to meet the needs of individuals with CCN. However, the exponential growth of these applications is concerning some AAC professionals about the impact of this new approach and is raising several relevant questions: Who uses mobile devices? For what purposes? Where? Why? How often? Who are the communication partners? What is the impact they have on current prescription and funding systems? What kind of clinical and technical support needs to be involved in the development of these applications? What are the specifications and standards that these application projects must follow to effectively respond to individuals with CCN? Finally, the most complex of all questions: are we, in the name of modernity and media attention, trying to provide these technologies that are ineffective or inappropriate to conditions and needs of people with CCN? [12,13, 14].

Researchers believe that there is lack of research that supports the choices made in the development of these applications. There is little literature and, consequently, few evidences proving the effectiveness of these applications [15]. The popularity, the low cost and easy acquisition process for these applications has led professionals, parents and users to choose too early a certain communication system without first making a survey and comparative study of the applications that suit the needs, abilities and skills of the end user. This phenomenon may have disastrous implications, such as successive trying and abandoning of applications and more seriously the permanent abandonment of AAC [16]. Thus, it is essential to have more research and to create guidelines to help choosing the best system, preventing the abandonment, even in the adaptation stage. Experts argue that the choice of a communication system must be made through a process of evaluation of AAC, whose goal is to identify the skills and characteristics of the individual, as well as their communication needs [17]. With this knowledge, professionals can evaluate the potential of each user of AAC systems and specify the device and the application that best suit their characteristics [16]. Professionals should take into account the goals for short and long term and evaluate the effectiveness of systems through a continuous process [18].

There are no standardized tests to evaluate the best AAC system for a particular user, but there is a variety of tools and resources that can be tested, thereby assisting in the evaluation process. The recommendation of a specific device and accessories must include the reason why this device and accessories will meet the needs of the individual [18].

2. Methodology and Aims

In an attempt to understand some of these issues, Imagina® chose to develop an application for smartphone and tablet in a sustainable way. Basically, the goal is to start with a simple communication system and increase the app performance with features supported by research, experience and observation of real situations. This strategy allows to ensure that individuals who use AAC are supported with tools and resources they truly need.

The planning and development of Vox4all® application involved structured research, using the case study as an exploratory research strategy suggested by Yin [19]. Several authors, such as Yin [19] and Stake [20], mention the case study methodology. A case can be something very definite and concrete, as a person, or a group of professionals, but it can also be something less defined or set on a abstract plane as a program or set of programs, implementation processes or other category that refers to a unit of analysis. It is always necessary to provide three sequential procedures:

1. Definition of the case study;
2. Option for a single case or multiple cases;

3. Deepening of a theoretical problem justifying the protocol for collecting empirical data and lines of analysis of data collected [19].

The studies carried throughout the research work followed closely the assumptions of this methodology. We performed usability tests of the application in laboratory and field environments. We will highlight these last ones as they were carried made with the potential users of the application in real environments. According to Nielsen [21], usability is one component of the acceptability of a system and he also refers to the question of whether the system is good enough to satisfy all the needs and demands of its users.

To verify if the components of usability were achieved, it is necessary to measure them, and before that to define the metrics to quantify them. Nielsen [21] defines a series of metrics, such as: the time the users need to complete a task, the ratio of successful interactions and mistakes, number of mistakes, number of system features which the user can remember, among others. The tests were performed in three Portuguese institutions, both with professionals (speech therapists, occupational therapists, psychologists and rehabilitation technicians) and with end users: users with Down syndrome, autism, fragile X syndrome and cerebral palsy.

3. Research and Development

Vox4all® is based on grids communication systems organized in cells (rows and columns). Initially, this app had as main features voice recording, creation of linked grids and the possibility to create cells with photos taken with the device's camera or with symbols from a library. The library of symbols - which was chosen after a comparative analysis between several systems - belongs to a system of world-recognized symbols, the Widgit Literacy Symbols, confirms the research supporting the benefits of this symbol set [22, 23].

By observing the interaction with the application, by individuals with CCN, therapists and family, it was clear that we should test and introduce new features. On one hand, we are talking about features that facilitate the use of the equipment by users with CCN, for example the possibility to set the activation time of cell contents in situations where the user has little movements' control. On the other hand, we are also taking into account the point of view of the professional regarding the easiness and consequent motivation to create several communication grids. That is, the customization of the communication grids should take the minimum effort and actions for the professional under penalty of discouraging people who make grids and consequently lead to a limited system that does not respond to the needs of the user. In this sense, we realized that including photos only by capturing them directly from the device's camera was very restricted because it did not allowed access to the files of the equipment and photographs taken at another moment. For example, the speech therapist wanted to build a "family" grid with photographs of the user's relatives. However, for different reasons, she could not take pictures of all members of the family and put them directly in the grids. The alternative would be for these relatives to send the photos and later the therapist includes them in the cells. So we realized we needed to implement this new feature on the application.

Another new feature coming from our observation was the text to speech. In some cases the recorded voice of people who are closer to the user with CCN is a stimulus, but in other cases this is completely irrelevant and sometimes a point of distraction.

Thus text to speech should be an available option, making easier the work of those who previous needed to record voice for each cell and, at the same time, giving the user the possibility to have a more versatile voice, ready to convey their communication intentions. These were some features already implemented based on observations. Others are being observed with the idea of their eventual implementation, as scanning and switches' simulation in tablets and smartphones and improving the interface to minimize choices motivated by involuntary movements.

4. Future Research Directions

Today's research points in several directions but there is a bigger issue to deal with: human-machine interaction. If on one hand the touch screen technology and associated actions (swipe, scroll, drag and pinch) are, for most users, easy and natural; for other users they are exclusive [15]. So there is the need of carefully studying of different ways of interaction suited to the abilities of each one.

The access to current mobile devices by people with sensory and motor disabilities remains in large part unsolved in the mobile world [12]. The big challenge is to provide access solutions that meet universal design principles, without prejudicing the mobility that characterizes these devices and that is their biggest advantage. Also there is another issue to be studied: it is a fact that for most individuals with CCN, tablets and smart phones are quite appealing and motivating [12], but the observation during the sessions revealed that individuals with more severe disorders may fear and ignore this equipment. For these individuals the equipment must offer something that gives satisfaction to them so they can interact, before starting new learning.

5. Conclusion

The fact that these applications are less expensive than traditional AAC systems should not be seen as an indicator of inferior quality. The migration of traditional communication systems for applications available on mobile devices is a complex and time consuming process that requires a redesign of AAC technologies and an intense research work. So it is essential to integrate in the planning and development teams of these applications AAC professionals, family members, caregivers and the individuals with CCN, aiming to meet the real needs of end users, and to ensure they are appropriate to their abilities. It is necessary to go beyond the propagandist statements, to effectively test the applications and to discuss the results in order to reach an inclusive and appealing design with features that really matter.

Finally, there should be greater awareness among professionals, parents and end users, but also the general population, which is only possible with more and accurate information about the applications. This requires easy access to demo versions, user manuals, training and web content with clear information about the software features and potentialities.

Acknowledgements

This project is co-funded by Imagina® and Programa Operacional Regional do Centro: CENTRO-07-0202- FEDER-022839.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-347

Development of Versatile Voice-Output Communication Aid VCAN/2A and Its Customizing Support System

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Abstract. We have been developing a versatile voice-output communication aid named VCAN and its customizing support system. VCAN has an innovative feature of being fully customizable in both page design and hierarchical page structure. It was verified to have high versatility in application through several case studies. Then we could apply VCAN effectively to children with a wide variety of intellectual and developmental disabilities. The customizing support system is also effective for middle users to easily design and update VCAN.

Keywords. AAC, Voice Output Communication Aid, Intellectual Disability, Developmental Disability, Assistive Device.

Introduction

Persons with developmental disabilities have speech difficulty and delay in language development and comprehension in general. Consequently, they have severe communication disabilities. Then they need communication support that means support for both speech and comprehension. To achieve such support, voice-output communication aids, VOCA, and/or communication cards and books are used widely for special support education [1]. At present, many different types of VOCA are available, such as single switch type, multi-switch type and computer-based type. Among them, computer-based handheld VOCAs have an advantage of being portable as well as flexible in display design and page structure. The best choice for a user depends on individual educational purposes [2]. For meeting a variety of individual needs, however, presently available VOCAs have several limitations in customization. Recently an open source framework for building component-based AAC applications, ITHACA, was developed [3]. However, this system is a development tool of versatile VOCA for software engineers and/or system developers, not for ordinary middle users having needs for frequent and flexible customization of VOCA.

In order to widen applications of VOCA to children with communication disabilities, we have been developing a PDA-based versatile VOCA, named VCAN/1A,

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fully customizable in various display-design parameters, such as the number of switches within every page and multilayered page structure as well as sounds and pictures attributed to each switch [4], through collaboration of various specialists, such as rehabilitation engineers, speech-language pathologists, occupational therapists, teachers of school for children with disabilities. VCAN system has an innovative feature that even ordinary middle users can easily design and modify VCAN-based VOCA with a wide variety of configurations including complex multilayered structures by the help of its customizing support system with high usability.

In our previous studies, we have carried out 1) development of a PDA-based VOCA customizable to a variety of uses for developmental disabilities [4]; 2) case studies of VCAN/1A for persons with developmental disabilities [5]; 3) extensive use of VCAN/1A for children with communication disorders [6]; and 4) initial design and updating strategy of VCAN/1A [7]. Subsequently, this paper presents; 1) an update of VCAN/1A into VCAN/2 operable in iOS^{R}-based portable information terminals, such as iPad, iPod touch and iPhone; 2) development of a customizing-support system strongly required for optimizing VCAN design for individual users; and 3) case studies of VCAN applications for demonstrating high versatility of VCAN.

1 System Configuration of VCAN/2

1.1 Outline of VCAN System

VCAN system consists of visualization software installed in hand-held terminals, an XML (extensible markup language) file describing entire configuration of VOCA and data files such as image files and sound files. The XML file includes information of every page of VOCA, such as the size and location of every switch, image and sound data for individual switches and the page number linked from each switch. Thus VCAN seems to have a hyper-card like architecture without depending on languages. Such simple structure enables VCAN to have a wide variety of configurations in both apparent design and multilayered structure. Recently, the visualization software functioning under the control of the XML file was completely updated into that operable in iOS^{R}-based portable information terminals, as shown in Figure 1. In addition, we developed a customizing-support system primarily for middle users, described in detail in the next section.

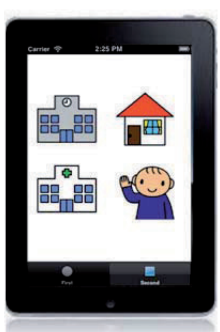

Fig. 1. iOS^{R}-based VCAN/2A.

All data for individual applications created by means of this system are uploaded to a website for VOCA data management via Internet, subsequently being downloaded to user's hand-held terminals from the website.

1.2 Customizing-support System for VCAN/2

This section describes a customizing-support system developed so that VOCA developers and/or middle users, such as co-medicals, teachers and parents, can easily optimize VOCA design according to individual needs changing over time. VCAN/2 is a simple visualization system operated under the control of an XML file, in which VOCA's page structure, page design and switch functions are all registered. Then we have to develop an editing system of the XML file in order to enable middle users to easily modify VCAN/2.

As the first step, we developed a PC-based support system, as shown in Figure 2, by which we can determine and/or edit all parameters registered in the XML file in an interactive manner. This system has a main window consisting of an ordinary tool bar (file, page, palette and mode), the button palette, the page setting section and a preview window. The button palette has several functions to create switches and its attributes such as image, sound and link page in a manner similar to using a painting palette. The page setting section enables us to determine page name, switch layout and background color. The preview window has three different functions, such as 1) visualization of the present state of the page under development or editing; 2) allocation of switches created in the button palette; and 3) an emulator of VCAN/2 operations under the emulation mode.

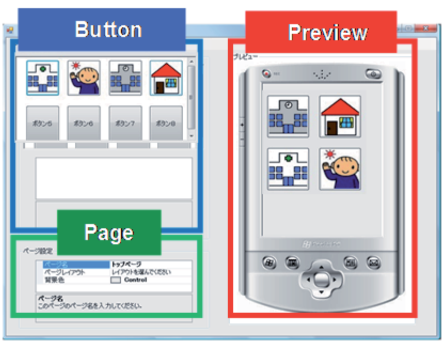

Fig. 2. Customizing support system for VCAN.

2 Field Experiments of VCAN with Several Different Configurations

2.1 Material and Method

The purpose of our field experiments is to validate high versatility of VCAN system having an unlimited multilayered structure and high flexibility in VOCA design. In this paper, I'd like to demonstrate three different cases, *A*, *B* and *C*, to whom we have applied VCAN in an attempt to improve their communication and/or linguistic abilities. Personal information on them is summarized in Table 1.

Case *A* is a male student with malformation, due to chromosome aberration, in his third year of junior high school. He still remained on a four-year-old level in language comprehension, being incapable of speaking most of the phonemes. Then we designed his VCAN as a symbol-based one with a simple architecture of several pages, each having 9 switches, totally including 87 images and 79 massages for assisting his communication in school activities (Figure 3 (a)). Case *B* was a female student with PDD and MR in her third grade of junior high school. She was too cowardly and shy to verbalize her feelings and apt to cry, even though she could speak words and read characters. In attempt to enable her to verbalize her feelings on a sentence level, VCAN was designed to speak a sentence that she selected and to display it on screen simultaneously (Figure 3 (b)). Case *C* was a male student with PDD-NOS in his first year in elementary school. Though his PIQ was on an average level, he was delay in comprehension and capable of speaking only vowels, thus being incapable of speaking most words. In order to make him to study in an ordinary class in a primary school, VCAN/1A was designed for him to have a specific multilayered structure capable of creating three-word Japanese sentences (Figure 3(c)). Its first and third layers consist of several switches regarding subject and verb candidates, respectively, written by Japanese Hiragana characters, while its second and fourth layers had an onscreen Hiragana keyboard for typing object words and one of his favorite figures as a reward, respectively, as shown in Figure 4.

Table 1. Personal information on three different cases *A*, *B* and *C*.

Case		**Case *A***	**Case *B***	**Case *C***
Disease		chromosome aberration (wear in a hearing aid and glasses)	PDD[1] and MR[2]	PDD-NOS[3]
Sex		male	female	male
Introduction phase of VOCA	Age	12	12	5
	Voice output	squeal and /pa/, /ai/ by encouraging	words and sentences	words composed of vowels
	Means for request	gesture and pointing	words	gesture and pointing at Japanese syllabary
	Language comprehension	simple sentences (+)	3-year-old level	4-year-old level
	Visual perception	early 2-year-old level	12-year-old level	5-year-old level

[1]PDD: Pervasive Developmental Disorder, [2]MR: Mental Retardation, [3]PDDNOS: Pervasive Developmental Disorder - Not Otherwise Specified.

(a) Tree-structure type (b) Schedule-table type (c) Composition type

Fig. 3. VCAN/1A with three different configurations (a), (b) and (c) for cases *A*, *B* and *C*, respectively.

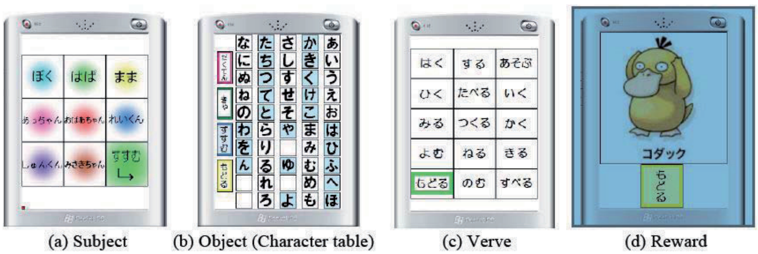

Fig. 4. A multilayered page structure of VCAN/1A for case C to create three-word sentences.

2.2 Results

Case *A* became to be able to 1) call friend's name; 2) to act as the chairperson in daily ceremonies under teacher’s assistance; and 3) to demand more, all by means of his VOCA. Its frequent updates according to the improvement of his communication ability, as illustrated in Figure 4, enabled him 1) to introduce himself; 2) to address questions to a third party; and 3) to enjoy talking even with joking. Consequently, his VOCA had more than 400 images and messages, which were classified according to school and home activities by using the multilayered page structure. His level of language comprehension was improved from a 4-year-old level to a 6-year-old one for two years. He already graduated from high school, presently working for a workshop for persons with disabilities with the help of the ninth version of his VOCA.

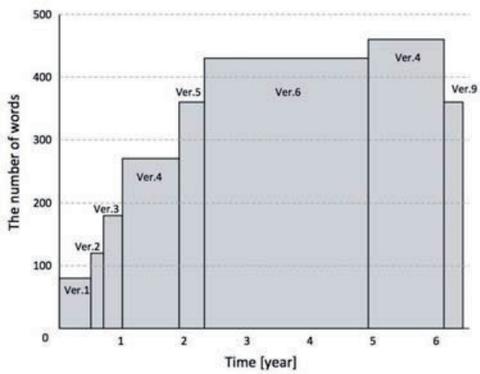

Fig. 5. Changes over time in the number of symbolic words for case *A*.

When Case *B* wanted to express her feelings, she became to be able to use her VOCA voluntarily and to imitate VOCA’s expressions. Finally, she has learned “procedure for doing something” with the help of her VOCA. When she was in trouble, she became to write down “I’m in trouble”, subsequently trying to read it by herself. Then we decided to terminate the application of VCAN to her, because the initial purpose seemed to be attained. Thus she graduated successfully from the use of VCAN.

Case *C* became to be able to speak very often 6 months later after VOCA intervention. Improvement of both phonological awareness and syllable articulation was observed, although serious phonological disorder still remained. Three months later after that, when a picture of blue big shoes was presented to him, he said [ookii] (big), [kutsu] (shoes) and [ao] (blue), while he simply said [ao] (blue) before VOCA intervention. When a picture of a dog washing a rabbit was presented to him, he said [inuga], [usagi], [arau], "A dog washes a rabbit", while he said nothing before. Then we decided to start his articulation training and practice of writing. At this point, he graduated from the use of VCAN. Now he enjoys studying in an ordinary class under the supervision of speech therapists.

3 Discussions

First I'd like to discuss about the outcome of the application of VCAN to cases *A*, *B* and *C*. They are quite different in communication and intellectual abilities. Case *A* demonstrated his demands by means of gesture and pointing even before VCAN intervention. As shown in Figure 5, a drastic increase of his vocabulary after VCAN application demonstrated that his communication competent was improved drastically in the first three years. Accordingly his communication scenes increased gradually. We think that such successful development would be primarily due to frequent updating of AAC intervention by diligently optimizing his VOCA's design, structure and contents according to his development in manual operation and communication. However, such frequent alteration could not easily be done up to now, due to the limitation of AAC devices commercially available.

In case *B*, VCAN was applied to a female student with PDD and MR so that she can verbalize her feelings on a sentence level. As shown in Figure 3(b), her VOCA was specifically designed as that most suited to her educational purpose and updated frequently according to her development. In case *C*, VCAN was used as a device for improving his ability in syllable articulation. Then it was uniquely designed so as to be optimum for his needs. Consequently his linguistic ability was improved successfully within a year into a level without VOCA assistance. Results of these two cases suggested that VCAN could be effective even in utterance training, due to its high flexibility in apparent design and structure.

The above-mentioned three cases required completely different configurations of VCAN, depending on their needs. Thus VCAN with both high flexibility in design and high customizability seems to potentially have high versatility in application.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-354

Monitoring Written Communication Contribute to More Effective Decisions on AAC Devices during Rapid and Progressive Conditions of ALS

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Abstract. Persons with ALS face difficulties in communication due to rapid decline in speech and motor functions. Due to the rapid progression of the disease, intervention in AAC has to be in time and effective. In this paper we suggest that a better comprehension of written communication is important to evaluate communication progression and to decide on better approaches for AAC selection and delivery. We studied a group of ALS patients who used a tablet device with AAC software for text-to-speech communication. Internet communication was stimulated, learning periods and acceptance factors were observed. We monitored speech, handwriting and typing performances, in approximately 3 month-periods during a total period of 9 to 12 months. Results suggest that handwriting and typing functions should be monitored in order to better decide on AAC devices, namely those supported on tablet (touchscreen) or regular keyboard access, and find markers for introducing new interfaces for AAC access. Relevance of this study is to have a better understanding on predictors of acceptance and time markers to effectively manage AAC in a rapid and progressive process of degeneration.

Keywords. Communication, Amyotrophic Lateral Sclerosis/Motor Neuron Disease (ALS/MND), Assistive Technologies, Augmentative and Alternative Communication (AAC), Complex Communication Needs, progressive conditions, neuromuscular diseases.

Introduction

Communication in Amyotrophic Lateral Sclerosis (ALS) raises important research questions for the progression in speech decline and consequent need for Augmented and Alternative Communication (AAC) devices. Early introduction of appropriate communication devices can sustain quality of life and prevent increase of depression in ALS patients [1]. As progression of the disease is rapid for most of the cases, processes for selection, learning and adaptation to AAC, in different stages, have to be short and effective.

Communication systems should take into account the different social contexts of the user and help to fulfill those who are considered most important for each user. Considering different contexts of communication, J. Light et al. [2] have enumerated

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four essential areas for social interaction: to meet basic needs, to share new information, to establish and maintain social closeness with others, and to follow the rules of social etiquette. In spite speech progressive loss strongly affects these areas, communication using written language, namely handwriting and communication related to computer access, is also determinant for participation in these roles of social interaction. Handwriting is frequently used for expressing daily basic needs [3,4]. Besides expressing basic needs in face-to-face conversation, computer access (e.g. speech output devices or internet tools) extends communication with the familiar caregiver to other close relatives and allows greater autonomy, for example in clinical support, decision making and social closeness. Some researchers have indicated that AAC technology is employed selectively to fulfill different purposes [5] and its acceptance may be conditioned by initial symptoms of ALS or characteristics of progression [3], leading to the importance of following writing performance, along with speech, as a marker of communication progression and AAC acceptance.

Rapid progression imposes monitoring physiological variables to mark important stages for interventions in AAC, in order to adapt devices to progression. According to Ball et al.[6], 80 to 95% of ALS patients can't use natural speech for daily communication needs at some point of disease progression. Speech rate and intelligibility have been considered important markers for introducing AAC devices. Ball et al.[7] suggested that speech rate is a good predictor of intelligibility decline. The same authors suggested that 65% of mean speaking rate, measured on a specific instrument, should mark the introduction of AAC, since has been observed that after this marker, speech intelligibility has a dramatic decline. Although speech has been extensively studied in ALS/MND, as the main physiological variable that determines communication loss and indicates need for AAC intervention, in this paper we propose to observe variables related to writing performance, as also important markers for studying communication needs within disease progression.

In the present study, we have longitudinally observed, on a group of persons with ALS (bulbar onset), speech, handwriting and typing rates, as important variables for monitoring communication skills in ALS and support decisions on AAC. We explore a new representation of communication progression based on speech and written communication rates and present data from four persons with ALS, collected during 9 to 12 months of progression. For each participant, communication progression is described and its relation to AAC acceptance and patterns of use are explored. The presented study is part of a research that is being conducted in an ALS clinic, for a larger group of ALS patients, with the aim of studying progression of communication and the impact of modern high-tech AAC on patients' and caregivers' quality of life.

This paper is organized as follows: after Introduction, Section 2 describes the methodology and proposed approach for monitoring communication; Sections 3 and 4 present results and short discussion; main conclusions are presented in Section 5.

1. Method

1.1. Participants

We present results from four ALS patients who were selected by the clinical team of Neurology Department at Hospital de Santa Maria. Inclusion criteria was bulbar onset of ALS, being in initial stages of the disease and having a score ≤ 2 for Speech item in ALSFRS-r [8]. The purpose and procedures of the study were explained to participants and they signed an informed consent.

Characteristics of the participants are described in Table 1.

1.2. Procedure

Evaluations were made in intervals of 2 to 5 months and setup the clinical environment (Fig. 1). In each evaluation, participants had to perform three different tasks: say/write a 10-word sentence (repeat/copy), say/write their own names (familiar words) and say/write a free sentence (spontaneous). All tasks were performed, sequentially, using three modalities: speaking, writing on a paper and typing on a keyboard (using direct access). Data was collected using a laptop, a software application for sound recording, a video camera and a software application for typing log. All participants filled the Communication Effectiveness Scale for Individuals with ALS [9].

After baseline evaluation, all participants started using a tablet device with AAC software for text-to-speech communication. Internet communication was stimulated, by sending them emails periodically.

Data was analyzed for each of the participants. For each task and modality, *number of words per minute* were calculated from sound or video files and typing log analysis. The following variables were derived from the average of the results in the three tasks performed in each modality: *speech rate*, *handwriting rate* and *typing rate*. Score from communication effectiveness survey was also considered. Participants and caregivers feedback on communication needs were analyzed as qualitative data.

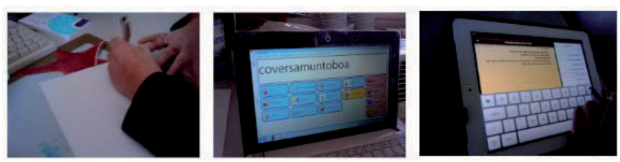

Figure 1. Photos taken during one evaluation for handwriting and typing assessment.

2. Results

Data collected during all evaluation periods of this study was structured as presented in Table 1. All participants (ages between 59 and 73 years old) started using electronic AAC devices with internet access after the baseline assessment. Introduction time, after the baseline evaluation, was delayed for participant C due to her late acceptance of AAC. Baseline characteristics are presented at time T=0 (as presented in the fourth row of Table 1).

Table 1. Data from all participants, collected in 3 to 5 periods, during 9 to 12 months. This table shows participants characteristics, speech rate, handwriting rate, typing rate and score from Communication Effectiveness Scale. All these ALS patients started using AAC devices and text-to-speech software after baseline evaluation (indicated as introduced (*Introd.*) in column *AAC)*. n.u.=*not used due to no functionality*; n.r.=*not registered* .

Subject	Age	Gender	Time (months)	Previous computer regular use	Speech Rate	HW Rate	Typ Rate	Comm. Effect (0 to 50)	AAC	AAC system	Access
			0		37.43	7.64	4.32	19	No		
A	71	M	2m	No	n.u.	n.u.	4.00	n.r.	Introd.	Laptop & *TheGrid2*	Laptop Keyboard
			4m		n.u.	n.u.	7.64	17	Y		
			9m		n.u.	n.u.	7.72	30	Yes		
			0		42.5	21.60	16.59	14	No		
			3m		n.u.	21.43	15.14	8	Introd.		
B	59	F	6m		n.u.	18.75	17.95	16	Yes	iPad & Notepad	Touchscreen
			9m	Yes	n.u.	20	18.31	n.r.	Yes		
			12m		n.u.	10.74	15.00	15	Yes		
			0		86.00	23.74	5.65	50	No		
			3m		92.73	17.50	4.62	27	No		
C	73	F	6m	No	58.78	21.04	4.85	n.r.	Introd.	iPad & GridPlayer	Touchscreen & Stylus
			9m		40.74	18.00	5.63	36	Yes		
			12m		39.12	18.85	9.92	31	Yes		
			0		84.05	34.69	18.26	29	No		
D	68	F	3m	Yes	50.48	36.11	16.13	24	Introd.	Windows Tablet & *TheGrid2*	Touchscreen & Stylus
			6m		n.u.	33.61	17.55	16	Yes	Pen&Paper notepad	Handwriting (regular pen)
			10m		n.u.	35.29	15.89	20	Yes		

Based on collected data, we propose a representation of communication progression in time, measured as rate of speech, handwriting and typing (words per minute), as represented in Fig. 2 for results of the participants presented in this paper. As expected for bulbar ALS patients, for all patients there was a strong decline in speech rate in short time. Concerning handwriting, performance in speed decreased slower than speech. We can also observe that typing rate remained stable for all these participants during 9 to 12 months of evaluations (Fig. 2).

Concerning motivation and support from the caregivers, a qualitative analysis of their involvement showed that caregivers (spouse or husband) of participants A and D showed good acceptance of AAC devices. They often manifested their difficulty in communicating to their relative and participated in AAC delivery and training. Caregivers of participants B and C haven't shown involvement in AAC delivery and training.

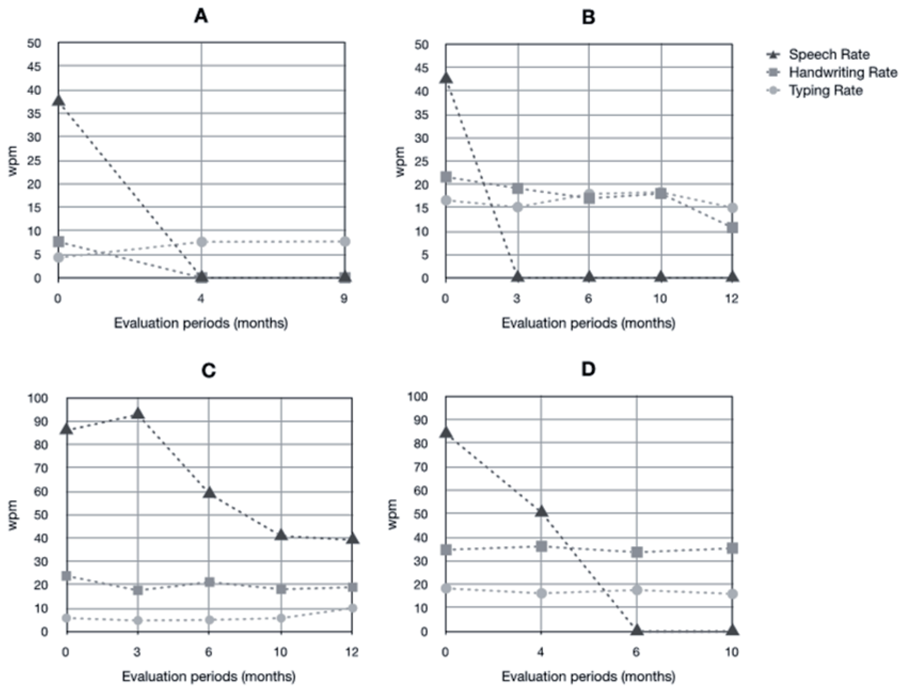

Figure 2. Graphics showing evolution in performance in speech, handwriting and typing, measured in words per minute, along 9 to 12 months for each patient. Points connected by dotted lines represent values of performance, measured in different periods, indicated as months intervals. Data from these graphics is described in Table 1.

3. Discussion

Due to rapid progression of disease, rehabilitation professionals experiment difficulties in choosing AAC devices that can be effective in different stages of progression. Augmenting the actual functionality, though predicting their loss, should be carefully considered when delivering AAC to ALS patients. In this paper, we suggest a methodology for monitoring speech and written communication progression that can support rehabilitation professionals to make decisions on AAC for ALS patients.

Typing is an important function for AAC access, not considered in clinical assessments. Either considering regular keyboards or virtual keyboards (touchscreen), typing function is needed to access to text-to-speech in different kinds of AAC devices and software, before the need of alternative human-computer interfaces (HCI). We could observe that, for one of our participants (A), clinical evaluation for functionality (from ALSFRS-r) was not sensible to typing ability. For participant A, typing function remained constant or slightly improved for several months, even when ALSFRS-r score for upper limbs functionality was 0. This fact suggests that regular monitoring of typing function is relevant for AAC decisions but often not considered in clinical assessments.

We could also observe that patients who were unfamiliar with computers (A and C) improved typing rate, after starting to use an AAC device and during the period of this study. Although progression of typing rate will be, at a certain stage of disease, conditioned by upper limbs motor limitations, these observations may indicate that, as long as typing rate remains in stable values, the use of keyboard or touchscreen is a proper choice for an AAC device. Moreover, this period, where seems to exist a learning process, could be suggested as important marker, specially for those who are unfamiliar to the use of computers. This can be relevant to indicate a period for learning and familiarization to AAC devices, before the drop of typing performance and need of alternative human-computer interfaces (HCI). Further investigation should be conducted to evaluate relation between this learning period and AAC acceptance in further stages of disease.

One of the participants (D, in Fig. 2), in spite of being very communicative, much familiar to computer devices and having a high motivated caregiver (husband), still prefers handwritten messages in face-to-face communication. She just uses text-to-speech for short conversations on the phone. From Fig. 2, we can observe that her handwritten performance is still very good (35 words per minute), which may help to understand why such a communicative person (and much familiar to computers use) chooses handwriting as the main mode of communication - as she says: "it is is faster".

Monitoring handwriting and typing performance can reveal important information that can help on more effective AAC decisions and on understanding different attitudes related to its acceptance. These results suggest that better metrics for handwriting and typing should be developed to support a better comprehension on the dynamics of AAC performance and acceptance, along the course of the disease.

4. Conclusion

In this paper we propose a methodology for monitoring communication progression in ALS, based on rates of speech, handwriting and typing functions. Considering the characteristic rapid decline in speech of the target group (ALS with bulbar onset), we suggest that handwriting and typing metrics are important to be introduced when assessing of communication. A comprehension on the dynamic progression of these variables, in clinical assessments, is important to support in time AAC decisions.

An exploratory longitudinal study of written communication performance (wpm) is presented, from data collected in longitudinal periodic assessments to four ALS patients, on clinical environment. Results suggest that communication assessment should consider speech, handwriting and typing for better support in AAC.

New models for quantifying and integrating these variables should be investigated, to help rehabilitation professionals on a better comprehension of AAC acceptance and help AT developers to design AAC solutions that can better adapt to rapid progressive conditions.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-360

Learning Switch Scanning Skills by Playing with Robots

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Abstract. Manipulating and controlling assistive technology (AT) tools remains challenging for some children with severe multiple disabilities. In the area of communication, for example, augmentative and alternative communication (AAC) via switch scanning may be an optimally viable option for children with significant physical limitations. However, children's acquisition of switch scanning may be hampered by the dearth of evidence-based training protocols and the cognitively demanding nature of the task, diminishing motivation. Introducing AAC scanning skills may be facilitated by incorporating switch-controlled robots. Robot mediated play tasks can be designed such that specific switch scanning skills are trained in a potentially engaging setup. This paper reports the technical developments of physical and software-driven virtual robots controlled using switches to perform different play activities. A robot mediated switch training protocol informed by end-user trials is also reported.

Keywords. Robot, augmentative communication, computer access, scanning.

Introduction

Persons with significant impairments in speech and writing use assistive technology (AT) like augmentative and alternative communication (AAC) devices for verbal communication and/or alternative computer access methods for written communication. Limited physical ability to manipulate and control AT tools remains challenging for children with severe multiple disabilities. For some, single switch control may be the only viable method for accessing AT. To access more than one choice with one switch necessitates using scanning. Instead of directly pointing out a single item amongst an array of choices, a person using scanning uses one or two switches while watching a screen display of all possible choices. For example, in two-switch step-scanning, the person scanning repeatedly presses a switch to make a visual marker highlight each choice, first down each row and uses the second switch to select their target row. Then the person repeatedly presses the first switch to make the visual marker highlight each cell in the row and presses the second switch to select their target cell. Scanning is a cognitively demanding task, involving cause-effect, sequencing, attention, anticipation,

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This work was supported in part by the Glenrose Rehabilitation Hospital Foundation.

and memory skills, which some children have difficulty learning [1]. A review of the literature reveals a lack of evidence-based practice surrounding teaching techniques for switch scanning, and an employment of methodologies primarily based on clinicians' choice [2]. In one study comparing methods to teach scanning to children with cerebral palsy (CP), four children used a paper-based scan method (a partner moved a red cardboard window to highlight the choices on a paper grid) and four children used a computer-based method [3]. Though no children showed improvements from baseline to intervention, the children in the paper-based method experienced learning of skills, but it was not captured in the outcome measure (a computer-based scanning test). The paper-based protocol included play between trials, which investigators felt was beneficial to the children, encouraging choice making and matching with their interests.

Robot control can be done through the use of switches and requires the same basic skills as for switch scanning. In a protocol we have trialed in multiple studies children used cause and effect, inhibition, laterality and sequencing to control the robots in playful activities [4, 5]. Children operated, with one to three switches, both physical and virtual robots in real and virtual environments, respectively. Multiple, individualized scenarios (e.g., knocking over blocks, a prince bringing a rose to a princess, or a farmer bringing hay to some animals) were designed to maintain children's interest [6].

Robots, if designed correctly, are appealing to children [7] and activities requiring different robot control skills, and thus different switch skills, can be devised to keep children motivated. In this way, learning switch skills can be decoupled from the utilization of a computer or AAC device and can be done in a play environment, potentially more engaging to children. Virtual robots can simulate scanning on a computer display and potentially help to bridge the gap between controlling a physical robot and accessing AT. This paper presents the development of a training protocol for learning and practicing scanning switch skills while controlling a physical and virtual robot. It is recommended to involve end users and other stakeholders, including children [8] in iterative design development of technology and interventions [9, 10]. Thus, our protocol was informed by observing children in the training activities.

1. Methods

A training protocol for learning 2-switch step-row-column scanning was proposed. It included practice activities (to generalize previous switch activity learning to the protocol activities) and various activities using the physical robot and then a virtual robot in a scanning grid array (e.g., cooperative activities where the participant moved the robot to a grid cell and then an assistant picked up the item and put it on the robot).

1.1. Materials

Various existing materials were used, including: two Jelly Bean® switches, mounting arms to position the switches, switch-activated toys, a voice output communication device (VOCA), and various game pieces (e.g., Mr. Potato Head®, zoo animals, and small wooden blocks).

1.2. Technical Development

The robot control programs developed for doing the tasks described above [4,5] were adapted to be used such that the robot moved like a visual marker on a scanning grid. Microsoft® Robotics Developer Studio 2008 R3 (MS-RDS), a freely available programming environment, was used to control both the physical (via a Bluetooth remote link) and the virtual robot from a laptop computer. Applications may be created using a Visual Programming Language or C#. The technical details of the robot control programs are presented in [6].

For the physical robot and physical environment, a Lego Mindstorms® NXT 2.0 Tri Bot was placed on a mat (size = 69x69 cm) representing a three row by three column (3x3) scanning grid (Figure 1, left). The mat could also be folded to be 1x3 or 3x1. Items could be placed on the mat, or symbols representing items could be inserted into the plastic sleeves of the mat.

For the virtual robot and virtual environment the MS-RDS simulation environment was used. It includes models for a variety of robots, including the NXT Tri Bot. A virtual environment simulating the real-world physics of the robot movement and the texture of the mat was developed within MS-RDS. Any JPG picture can be imported as a mat into the virtual environment. Hence, a photograph of the physical mat, a hand drawing or a grid created with a program such as BoardMaker® could be used. The grid can be any row x column dimension (Figure 1, right).

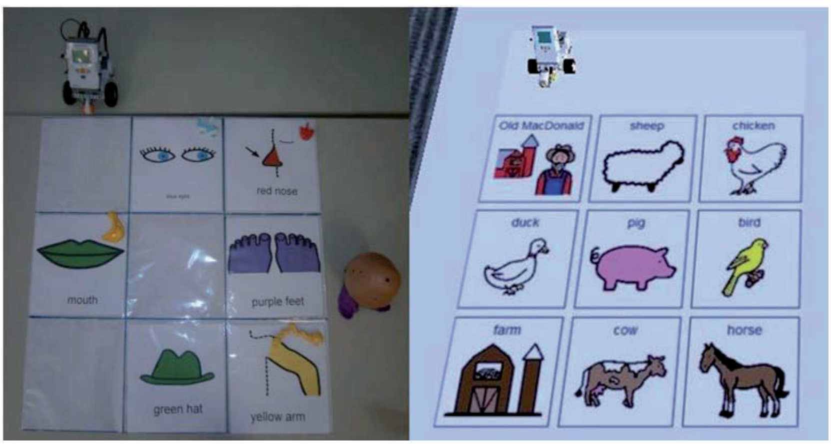

Figure 1. Physical robot and environment (left) and virtual robot and environment (right).

The Graphical User Interface (GUI) service was used to create a console to perform the following functions:

- Set the distance that both the physical and virtual robots move forward in each forward step movement, thus providing a means to adapt to the grid dimension.
- Position the virtual robot to the top left corner of the mat (as in scanning).
- Choose the scanning method:
  - In step mode, the switches behaved as follows: Switch 1 moved the robot down one row with each press (move), then Switch 2 turned the robot towards the row (select), then Switch 1 moved the robot across one cell with each press (move) and Switch 2 spun robot in a circle (select).

- o Inverse, automatic, and directed scanning [11] were implemented, but not tested.

Within MS-RDS, the up arrow and left arrow on the key board were used for "switch hits" (the function of each depended on the scanning method). Two standard Jelly Bean® switches were connected to the computer via a Switch Interface Pro 6.0[i] configured such that the two switches emulated the up and left arrows.

1.3. Participants

Two children with CP participated in the trials. Participant 1 was a 7-year-old girl with dystonic quadriplegia. Participant 2 was a 6-year-old boy with spastic quadriplegia. No formal cognitive assessment was performed. By report they likely had a developmental delay, but the severity could not be specified. They were both non-verbal, and were reported to have previously activated VOCAs and switch adapted toys using switches mounted beside both sides of their head.

1.4. Trials

After obtaining ethics approval, the participants underwent trials of the protocol. Different activities were proposed to each participant in order to evaluate the robotic system and to inform the design of a suitable switch training protocol. We observed if the participants had success or not on trials and the amount of prompting needed, and adapted the protocol as needed.

2. Results

The resulting protocol is shown in Table 1. Participant 1 performed the practice switch activities (Steps 1 and 2 in Table 1) and then used the physical robot in the grid set up (Steps 8 and 9). She did not control her second switch reliably (tending to lay against it), so adaptations were made to accommodate her abilities. Instead of controlling the robot with the switch she used a VOCA to say "that's the one I want" and eye blinks to confirm her selection. In one trial, a 1 row x 3 column grid was displayed on a wall with beads taped to the grid. The physical robot travelled from left to right on a table in front of the grid with a "selection window" placed on top of it (so she could see what bead she would select). This is like the paper-based scanning training method in [3], and was added to the protocol (Step 8b).

Because Participant 1 had trouble inhibiting pressing Switch 2, the robot tasks from [4, 5] were added to the protocol to establish if children understood cause and effect, inhibition, laterality, and sequencing skills with the robot (Steps 3-6 in Table 1). After trialing with Participant 2, the original tasks were modified slightly. In [4, 5] the robot travelled away from the child, but in this study it was placed so that it travelled towards the child (like a visual marker scanning down the rows). In [4, 5] Switch 1 moved the robot forward as long as the switch was pressed, whereas in this study Switch 1 moved the robot forward a distance of 10 cm, thus requiring multiple "steps" of the robot. Also, in [4, 5] Switches 2 and 3 were used to turn by 90 degrees the robot to the left or right, respectively. In this study, one switch was used to turn the robot to its left (i.e., the child's right), thus subsequent forward presses made the robot travel from left to right like the visual marker scanning across cells in a row.

Finally, both participants seemed to enjoy making the robot turn and spin (more than trying to achieve the target task at times). Therefore free play with the robot to allow the children to become familiar with the robot and switches before asking them to concentrate on the tasks was included in the protocol, too (Steps 7 and 10). Also, an assessment to ensure easy, reliable switch activation sites should be performed prior to the protocol.

Table 1. Training protocol for 2-switch step-row-column scanning with robots. NA = Not applicable.

Task	Step #	Skills needed	# Switches	Grid size (row x column)	Example activities
Practice pre-existing switch skills, based on [12]	1	Cause and effect	1	NA	Activate a VOCA to play a prerecorded phrase (e.g., "more bubbles")
	2	Cause and effect -two functions	2	NA	Activate Switch 1 to make an adapted toy walk and Switch 2 to play a prerecorded phrase “Yeah, I made it!"
Robot skills based on previous protocol [4, 5]	3	Cause and effect	1	NA	With robot travelling towards child, press and release switch 1 repeatedly until robot knocks over a stack of blocks.
	4	Inhibition	1	NA	Press and release Switch 1 and stop when robot next to a stack of blocks. Helper puts a block on top of robot. Press and release Switch 1 until reach location to unload block.
	5	Laterality	2	NA	Press Switch 2 to turn the robot towards a stack of blocks placed to the right of robot.
	6	Sequencing	2	NA	After turning, press and release Switch 1 until robot knocks over the blocks.
Physical robot with grid set up (For layout see Figure 1, left)	7	All previous	2	None	**Free play:** The child explores what happens when he presses the switches.
	8a	All previous	2	3 x 1	With robot travelling towards child one row at a time, press and release Switch 1 until the third row of the grid where there is a pile of blocks. Press and release Switch 2 to select it and the robot spins, knocking over the blocks.
	8b	All previous		1 x 3 taped to wall	Each cell has taped to it a different bead for a bracelet. With robot travelling from left to right one cell at a time, press and release Switch 1 to move the robot to the desired cell. Press and release Switch 2 to select the cell and the robot spins to indicate selection.
	8c	All previous	2	1 x 3	Same as 8a, but with robot travelling from left to right one cell at a time.
	9	All previous	2	3 x 3	Some cells of the grid contain Mr. Potato Head parts or symbols (e.g. eyes). The robot faces the child in the upper-left corner of the grid. Switch 1 moves the robot down the row and Switch 2 selects (the first select turns the robot 90 degrees, reorienting it along the desired row, and the second select spins the robot to signal desired cell. The Mr. Potato Head’s part in that cell is added to his body.
Virtual robot with	10	All previous	2	None	**Free play:** The same as 7.

grid set up	11	All previous	2	1 x 3	The same as 8c.
(Figure 1, right)	12	All previous	2	3 x 3	The same as 9.
Communication Device	13	All previous	2	3x3 and higher	E.g., Exploration Wizard Targets, Chase the Rabbit[ii]

3. Discussion and Conclusion

Through the technique of scanning, the ability for children with disabilities to use communication devices and computers for writing for participation in school and leisure activities can become a reality. The robot training protocol can be a potentially motivating and effective training method to help achieve this goal. We developed the software and hardware to support robot mediated play activities to be included in a training protocol to support scanning skills for children with motor impairments. Trials with two children with severe motor impairments informed a protocol to progress from previous switch experience to using physical and virtual robots in grid arrays.

Future research will involve trialing the protocol with children with disabilities for more sessions to build skills to use the virtual robot scanning grid, and finally other AT such as a communication device.

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[i] Don Johnston, Inc. http://www.donjohnston.com

[ii] http://www.prentrom.com/training/courses/devices-m1/where-do-i-begin/exploration-wizard-targets

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Design for All

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P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-369

Localising Assistive Technologies More than Inclusive Design for All – ATbar in Arabic

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Abstract. This paper discusses the research undertaken and challenges met when localising an open source browser-based toolbar in an environment and language not known to the developers. It shows how a framework can be created, based on an inclusive design process that results in a set of criteria to support the development of this type of technology in other linguistic settings and cultures. The resulting toolbar offered Arabic speaking web surfers the chance to personalise webpages, providing additional accessibility options when using their chosen browser. The criteria used encompassed a journey of discovery, translation in its widest sense, creation and development including the need for localised guidance materials to aid sustainability and future development.

Keywords. ATbar, Inclusive Design, Arabic, Disability, Assistive Technology.

Introduction

Planning the development of any assistive technologies involves a team investigating user requirements and drawing up a specification. This can be particularly daunting when the context of use is unknown and the difficulties individual users encounter in their environment are perhaps different in nature, not just because of a disability, but also due to individual context, culture and language along with the availability and knowledge of technologies. This paper covers issues specific to supporting disabled users on the web. There also needs to be an understanding throughout this paper, that the developers are background and developing an Arabic toolbar, so that the language and cultural differences are seen in a particular milieu. However, if one can combine the awareness of linguistic and cultural differences along with the specific requirements that help disabled people overcome some of the difficulties encountered when using technology within particular environments, then a universal framework can be developed.

1 Research and Development

The toolbar development journey began with an exploration phase involving discussions around the issues that might arise with a simple translation of all aspects of

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the toolbar from English into Arabic. The first of the linguistic dilemmas unfolded with the semantics of the language and its orthography. There followed the translation of requirements into a specification and here actual features offered in the English version had to be enhanced, such as offering male and female voices to cope with the gender specificity of the language with a higher specification than was initially available on the English version of the toolbar and completely re-developing a dictionary. Free Arabic text to speech (TTS) voices are at present unintelligible - Arabic has over 30 different dialects [1] and some text to speech samples were found to be unacceptable when tested by different users. From the outset of the project the setting up of a community base with initial testing in a local context was essential. There was also the need early on for supporting materials, wikis, blogs and version controls with bug reporting and a way of maintaining the stream of information being gathered as a result of the research. These materials proved to be invaluable as re-evaluations occurred, but even the tools used had to be adapted. Mediawiki and WordPress worked best in Arabic and English. The decisions at this stage were increasingly affected by linguistic and cultural issues and were based on the work of AlRowais et al [2] and Al-Wabil et al [3] as well as developer and user experiences. The open source development project is on-going and outcomes are available online (https://www.atbar.org/) based on an Inclusive Design Toolkit framework with iterative exploration, creation, evaluation and management processes [4].

2 State of the Art

To date it appears no other open source and free web browser toolbar has been developed in English and Arabic that offers text to speech for reading web pages, whole web page or just text style and colour changes, increased line spacing, spell checking, word prediction, a dictionary and coloured overlays to reduce glare from black text on white. The toolbar can be downloaded or act as a 'bookmarklet' that works with the five most used browsers namely Mozilla Firefox, Internet Explorer, Google Chrome, Safari and Opera. Plugins can be developed by others and users can make up their own toolbar with a variety of plugins to suit their needs. It is also possible to embed a launch button for the toolbar into web pages.

3 Capturing Needs

Research by the Mada Center in Qatar [5], for whom the Arabic ATbar is being developed, has shown that although those with visual, hearing and physical impairments appeared to be aware of, or were using assistive technologies, those with specific learning difficulties (such as dyslexia) or learning disabilities were not aware that some technologies might be helpful when they read web pages. The LexDis project final report [6] in UK also found that those with dyslexia tended not to use their 'heavy weight' assistive technologies when surfing the web and so the ATbar was primarily developed with these users in mind. Since the start of the LexDis project in 2007, many assistive technology companies have now introduced 'lightweight' assistive technology apps and browser based additions. Research by other authors including Kamstrup [7] has also shown that factors such as changes in colour, text justification, line length, font type and size as well as line spacing and even character spacing can aid readability on web pages. Harrell [8] states that readers should be able to make adjustments to correct screen design weaknesses. With these thoughts in mind ATbar was localized with the dual specific contexts of Arabic designed web pages and Qatari user needs.

4 Impact of Culture and Language

The cross-cultural context of web pages has been discussed by Wurtz [9] , citing Hall and Hall's High and Low Context theory of cultures. 'Low Context' Europeans and Americans tend to be more direct, using short sentences with clear statements not requiring additional body language or further explanation, whereas 'High Context' Asian and Arabic cultures require the listener or reader to infer more from a conversation or piece of text that may be fairly long. This can be confusing for those with specific learning difficulties or learning disabilities and even the provision of text to speech may not aid understanding if there is ambiguity. W3C Web Content Accessibility Guidelines (WCAG) [10] request for "the clearest and simplest language" may not fit with the Arabic style of writing and if designs have to be altered to avoid "text that is fully justified … (that causes poor spacing" this may actually affect readability with the bi-directional complex Arabic orthography. If cursive script is fully justified it allows the characters to be stretched, so you can see the diacritics and other marks above and below words, which may help with letter recognition, as does an increase in size from the advised 12pt to 16-20pt [11]. There are times when diacritics representing vowels in words, are not used on web sites and punctuation may be minimal, impacting on text to speech pronunciation, as does the type of voice used – some voices pick up nuances more accurately than others. In English [12] and in Arabic [13] the use of text to speech has been shown to help those with dyslexia read web pages, but if the speech output is poor, user uptake will drop away. Diacritics can add clutter to text on web pages and not all are accurate. For ATbar when highlighting text or changing the look and feel of web pages the increased amount of images and lack of consistent style, as is found more often on Arabic websites, has affected the success rates when controlling the Cascading Style Sheets and it is not always easy to navigate around Flash objects and endless scrolling texts. Both may fail accessibility checks but are culturally acceptable, as is the use of local dialects [14]. Not all Arabic sites use Modern Standard Arabic which means there needs to be a choice of voices for reading aloud. The fact that text may not always be clear to local readers has led to the development of a new stemming Arabic dictionary providing a vocabulary made up of both modern day and traditional word lists with definitions. Evaluations of both commercial and open source Arabic voices have shown users to be very particular about speech output and comments around mispronunciations are high. It is felt that not until localized voices can be developed will satisfaction rates improve. It is intended that a framework will be developed that, at the outset, will take into account: ability/skills e.g. use of technology, user requirements; activity – tasks to be undertaken; language e.g. diglossia issues, orthography, semantics; culture e.g. type of images, gender specific language and web design; demographics for each area. Central to the framework must be the user requirements within the local context, as generalisations tend to result in abandonment of assistive technologies.

5 Conclusions

The creation of any such solution requires an active dissemination and support programme, to ensure that uptake and implementation are efficient and effective. In Qatar it was found that simple localization is rarely successful and developments need to grow within a local community with active support from a local partner to help manage the implementation process. Community needs suggest that training and support materials need to be initiated in a local language, not translated, as the language of learning and the language of business may not be the same. Distribution requires continued marketing and use of a range of techniques to promote the product. This marketing needs to be initiated locally to appeal and support the specific community at which the product is targeted. User requirements change, as do websites and the cross cultural framework will need to take an increasingly flexible approach to development in the future as more ways of surfing the web are developed, technology awareness grows and skills and abilities increase. It is planned that each concept of the framework will be developed with guidelines and examples of usage that are aimed at developers wishing to be more aware of assistive technology globalisation in an inclusive design environment.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-374

Validation of Mobility of Pedestrians with Low Vision and Normal Vision using Graphic Floor Signs in Railway Station

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Abstract. Some people with low vision or elderly people walk looking down at a floor, thus, they often pass without finding or hard to read suspended signs. Therefore, it is required for them to establish a sign system which makes good use of floor or road surfaces in order to provide for more information. This paper proposes a new graphic floor sign system which consists of two designs. A crossing sign is set on a floor of a crossover point, and indicates a direction of neighborhood facilities. A direction sign is set on a floor of a walkway, and indicates a direction and distance to a destination facility. An experiment was conducted at a railway station in order to clarify effectiveness of proposed sign system for people with low vision and the difference of usage between low vision participants and normal vision ones. As a result, it is showed that the floor signs are effective at readability for both participants. However, they have different factors to pass without finding the floor signs.

Keywords. Universal Design, Low Vision, Way Finding, Transport Facility.

Introduction

In order to secure accessibility, sign system standardization in public transport facilities is going on as part of a promotion of barrier-free space in Japan. Guidelines of the sign system describe some desirable font types, font sizes, pictograms, color combinations, and so on. These should be covered visible information such as suspended signs and self-standing signs, however, there is still no guide about graphic floor signs for pedestrians. On the other hand, some people with low vision or elderly people might be walking on a floor while looking down, thus, they often pass without finding or hard to read suspended signs. Matsuda clarifies that people with low vision walk slowly and see closer place than people with normal vision in walking along an indoor corridor, and they tend to see edges on the floor with high contrast [1]. And also, tactile walking surface indicators (TWSIs) for visually impaired provide for distinct contrast against a road surface, thus, people with low vision can use visually. However, TWSIs have only two functions, safe directions of movement and warnings about places or directions. Therefore, it is required for them to establish a sign system which makes good use of floors or road surfaces in order to provide for more

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information.

The purpose of this study is to develop new graphic floor signs with consideration for people with low vision. In our previous study, requirement specifications of the sign system and some graphic floor signs are designed by cooperation with some persons with low vision and administrators of transport policy of a local government, and then, hearing surveys are carried out in two stations [2]. In this study, an experiment is conducted at a railway station in order to clarify effectiveness of the sign system for people with low vision and the difference of usage between low vision subjects and normal vision ones.

1 Graphic Floor Sign System

1.1 Graphic Floor Sign

In Japanese guidelines of sign systems, there are four kinds of functions in signage -- direction signs, location signs, guiding diagrams, and regulation marks. Our proposed sign system is classified into direction signs which indicate directions to facilities along pathways such as stairways, elevators, ticket gates, bus stations, taxi stands. Proposed sign system consists of two designs (Figure 1): "Crossing sign" is set on a floor surface of crossover point, and indicates some directions of neighborhood facilities. "Direction sign" is set on a walkway, and indicates a direction and distance to a destination facility. And also, direction signs are set on regular intervals.

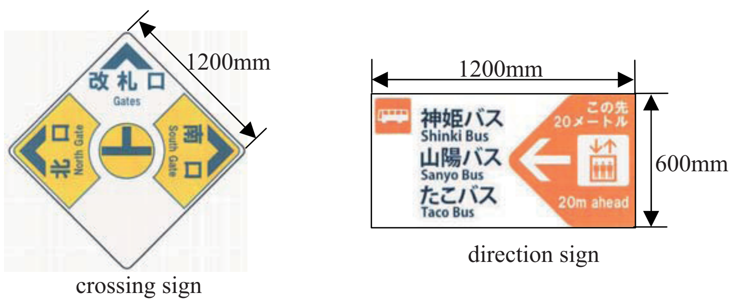

Fig. 1. Graphic floor signs.

These signs refer to font set and pictograms in Japanese guidelines. The colors are decided by visibilities of people with low vision and suggestions of administrators of transport policy of a local government, and the color layouts are designed to evoke "colored arrows" which indicate directions to facilities. The unit size of these signs is decided to 300mm squared because TWSIs and floor tiles in Japan are defined to 300mm squared.

1.2 Sign Installation

Proposed sign system was installed to a railway station where the numbers of users are 5000 per day. The ticket gate of the station is only put into place at second level, while the platforms are on the ground level. There are three bus stations on the north side, south side, and southeast side of the railway station. These bus stations are not able to be visible from the ticket gate, therefore, a lot of pedestrians have to check some signs at ticket gate when they transfer to a bus.

Four crossing signs and eighteen direction signs were set on the floor surface in order to direct pedestrians from the ticket gate to stairways, elevators, an escalator, and bus stations. Figure 2 shows a layout plan of the sign system of south side (four crossing signs and twelve direction signs were set) where an experiment was conducted.

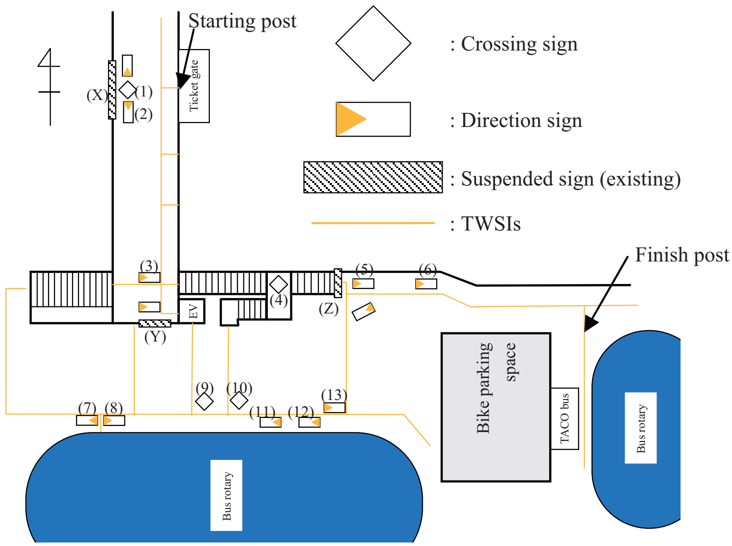

Fig. 2. Location of installed signs (south side).

2 Experimental

An experimental section was set from the ticket gate to southeast side bus station (TACO bus station). This station is not able to be visible from a stairway because of bike parking space. TWSIs are set on the floor from the ticket gate to the destination, and three suspended signs are placed along the pathway as existing equipments. Although there are some routes to the destination, suspended signs and graphic floor signs would direct pedestrians by an optimum pathway. The experiment was conducted at daytime because there were relatively few users of the station.

Experimental participants included five persons with low vision and nine persons with normal vision. They had never used this station and not known where the bus station was. Before starting on the experiment, they did not get a briefing on the presence of graphic floor signs. And then, they walked alone at a time until arriving at the destination even if they diverged from an optimum pathway and got lost on their way. After walking, they were interviewed whether they noticed the signs on their pathway at experimental walking, and they made a valuation of graphic floor signs for themselves.

In addition, low vision participants got an oral briefing on a pathway to the destination because they might not be able to read suspended signs. On the other hand, normal vision participants did not a briefing on the pathway, and they wore an eye tracking recorder in order to record what they were watching while walking.

3 Results and Discussion

3.1 The Low Visions

The participants were five low vision persons. Table 1 shows the profile of them. "Visible distance" of table 1 shows a distance that a participant can distinguish a crossing sign in front of the ticket gate (sign(1) in Figure 2), and it was measured the distance after experimental walking.

Table 1. Profile of the participants.

ID	Disease	Visual acuity (L/R)	Visual field	Visible distance
A	traumatic optic neuropathy	0 / 0.09	Dappled	4.1m
B	pigmentary degeneration of the retina	Less / 0.6	Tunnel vision	* out of range
C	pigmentary degeneration of the retina	0.03 / 0.03	Tunnel vision	3.7m
D	uveitis	0.04 / 0.04	Central scotoma	4.3m
E	nystagmus	0.02 / 0	Normal	4.8m

** It could not be measured distance because B was able to find till back against a wall.*

(a) At a stairway (around sign(4)). (b) At a southeast sidewalk (around sign(6)).

Fig. 3. Experimental scenes.

The low vision participants' discovery rates of graphic floor signs on their pathway are showed by Table 2. The total average discovery rate was 37%, and there was no difference between these rates (from sign(1) to sign(4)). In addition, four out of five participants temporarily diverged from an optimum pathway at points of Figure 4, and at the time, all of them passed without finding a graphic floor sign near these points. Especially, participant B was not aware of crossing sign (4) on a landing because he/she was using and concentrating on a handrail on his/her right side, then he/she turned to right. It is thought that they have difficulty to find a graphic floor sign if they do not know where it is, although they find it easily if they know where it is.

Table 2. Discovery rates of graphic floor signs (Low vision participants).

	Sign(1)	Sign(2)	Sign(3)	Sign(4)	Sign(5)	Sign(6)	Sign(10)	Sign(13)	Total
Passing participants	5	5	4	5	4	5	1	1	30
Discovering participants	2	2	2	2	1	2	0	0	11
Discovery rate	40%	40%	50%	40%	25%	40%	0%	0%	37%

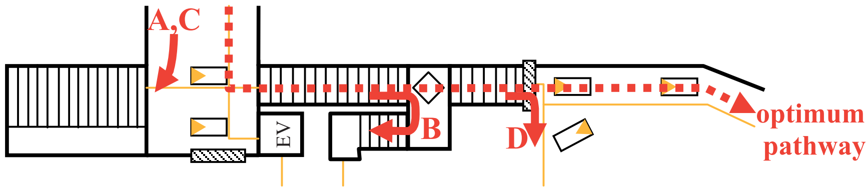

Fig. 4. Diverging points from optimum pathway of four participants.

As a result of questionnaire survey to low vision participants after experimental walking, Four out of five participants answered that "colored arrow" design were easy to understand the direction, and all participants answered that graphic floor signs were effective for themselves. On the other hand, the causes of overlooking originated with visual disabilities were as follows: narrowness of view field, glare by back-lighting, and a lack of visual attentions by concentration of another senses such as tactile sense and acoustic sense.

3.2 The Normal Visions

Table 2 shows normal vision participants' discovery rates, discovery distance, gaze times, and gaze durations, where a gaze is defined by keeping one's viewpoint estimated by an eye tracking recorder on a target object more than 0.1 second (by reference to [1]), and "discovery" is defined to gazing the sign. When normal vision participants walked, discovery rates and gaze times of graphic floor signs were significantly fewer than suspended signs, which meant that the attractiveness of suspended signs were stronger than that of graphic floor signs because the participants did not know the existence of graphic floor signs. In addition, suspended signs had enough information for guiding, so that the participants who found suspended signs had no need to find other signs. On the other hand, there was a tendency that the discovery rate of graphic floor signs set on the last half of the pathway was higher than that of first half. It is considered that a participant finds a graphic floor sign by chance, and then he/she walks paying attention on the floor.

Table 3. Discovery rates, discovery distances, gaze times, and gaze durations.

	Sign(1)	**Sign(2)**	**Sign(3)**	**Sign(4)**	**Sign(5)**	**Sign(6)**	**Sign(7)**	**Sign(8)**
Passing participants	9	9	9	7	8	9	2	1
Discovering participants	1	3	4	4	4	6	0	0
Discovery rate	11%	33%	44%	57%	50%	67%	0%	0%
Discovery distance	3.9m	4.3m	6.6m	10.7m	9.4m	12.2m		
Gaze times	0.33	0.44	0.89	2.29	1.88	1.89		
Gaze duration	1.12sec	2.39sec	4.25sec	2.5sec	2.59sec	4.14sec		
	Sign(9)	**Sign(10)**	**Sign(11)**	**Sign(12)**	**Sign(13)**	**Sign(X)**	**Sign(Y)**	**Sign(Z)**
Passing participants	1	1	2	2	3	9	9	9
Discovering participants	0	1	0	0	2	8	5	7
Discovery rate	0%	100%	0%	0%	67%	89%	56%	88%
Discovery distance		8.2m			7.7m	5.9m	15.5m	12.6m
Gaze times		3			1.33	1.89	1.33	4.25
Gaze duration		4.18sec			10.04sec	5.58sec	5.1sec	7.09sec

As a result of questionnaire survey to normal vision participants after experimental walking, suspended signs were easy to find, and graphic floor signs were easy to read.

Eight out of nine participants answered that graphic floor signs were effective for themselves.

4 Conclusions

As a result, graphic floor sign system got positive feedback and effective at readability for not only low vision participants but also normal vision participants. On the other hand, difficulty of finding them is a point of the design improvement. Moreover, the difference of the transition of discovery rates along the pathway suggests that there are different causes between them. It is expected that it is effective for a pedestrian with normal vision to make a graphic floor sign well known and to emphasize the existence of it at starting point of the direction (using illuminating devices, sound devices, and so on). Meanwhile, it is expected that it is effective for a pedestrian with low vision to emphasize at every point using other sense, for example, adding tactile messages to handrails and sounding auditory signals.

In our future work, we plan to clarify effective combination graphic floor signs and audio assists in order to make signs to find and understand in a short time on walking.

This work was supported by JSPS KAKENHI Grant Number 24760425.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
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doi:10.3233/978-1-61499-304-9-380

Applying Human-Centred Design to Create a Collecting Tool of Needs and Preferences for the Personalisation of ATMs

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Abstract. This paper reports a successful implementation of a Human-Centred Design (HCD) approach, especially focused on accessibility, during the design and development of an online tool aimed to collect users' needs and preferences when using ATMs. It includes initial user research activities (e.g. desk research and field studies) as well as final user experience (UX) evaluations (e.g. user testing and surveys). Results showed an overall 'Excellent' UX with the online tool which was improved along the HCD process for the different user groups involved

Keywords. Accessibility, Interface Personalisation, User Experience, HCD.

Introduction

Automated teller machines (ATMs) play a key societal role by providing access to financial services on a 24/7 basis. However, there are barriers for their use affecting people with different abilities or conditions (e.g. people with disabilities, lack of technology skills, elderly people, etc.). To cope with these barriers, different solutions (e.g. speech technology for talking ATMs), standards and accessibility guidelines have been developed during the last years [1]. Despite all these valuable initiatives, the progress is still moderate regarding the implementation of accessible ATMs [2].

APSIS4all[2] is a project which aims to validate, in real life settings, the impact of different approaches for providing customised interaction modes for Public Digital Terminals. In this context, a pilot on ATM services is taking place in Spain[3].

This includes adaptive interfaces offering users a personalised service adapted to their needs and preferences, and thereby overcoming the existing accessibility barriers.

The process requires implementing user modelling where the needs, preferences and the most appropriate interfaces are covered. The procedure follows four steps:

1. Collection of the user needs and preferences: an online system is designed to gather information about users' capabilities in order to define the User's Needs and Preferences Profile. This Collecting Tool of Needs and Preferences (CTNP) shows an

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[2]APSIS4all is project led by Technosite and funded by the Union's ICT Policy Support Programme as part of the Competitiveness and Innovation Framework Programme. GA 270977

[3]Spanish pilot site led by "la Caixa"

interactive questionnaire that the users have to fill in after getting registered in the system webpage.

2. Coding of the user needs and preferences: a set of data objects are defined to code the needs and preferences of the users, based on the specification EN1332-4 [3].
3. Mapping of users' profiles with user interfaces: produce a series of templates taking into account user requirements (e.g. accessibility and usability features). These templates will be the base of the user interfaces available on the ATMs.

This paper focuses in the first step of this procedure, describing the design and evaluation of the CTNP following a Human-Centred Design (HCD) approach [4].

1 Methodology

A HCD approach with an especial focus on accessibility was implemented, involving users with and without disabilities to play an active role in the development of technical solutions. The process was organized as a set of design iteration cycles aimed at a) understanding users' needs and preferences, b) developing design solutions, and c) conducting different types of evaluations in cooperation with users.

1.1 Understanding Users' Needs and Preferences

The first step for the implementation of the HCD approach is to understand the user needs and preferences when using ATMs, and to gather requirements and specifications to guide user-centred designs which fulfil usability and accessibility needs. This is performed through the following user research activities:

- **Desk research.** The objective is to identify user requirements through the review of representative standards, projects and research literature (e.g. [5] [6]).
- **Heuristic evaluation.** Experts evaluated current ATMs by means of a set of heuristics taking into consideration the results of desk research.
- **Field studies.** Information gathering was conducted using qualitative and quantitative methods to elicit the needs, wants, preferences and desires from different user groups.
  - *Surveys:* A total of 166 users were recruited through specialised portal advertising, associations of disabled persons and other generic communication channels. They participated in web, telephone and face-to-face surveys, consisting of 29 questions regarding 5 sections: disability profile, general socio-demographic information, information about familiarity with ICT, information about ATM usage and information about 'la Caixa' ATMs.
  - *Interviews:* 36 people were interviewed to obtain deeper knowledge and the rationale behind the answers to the surveys. Questions were focused on the frequency of use of ATMs, their reasons, difficulties and preferences.
  - *User testing:* 17 people with different profiles participated in tests, performing usual ATM operations as withdrawing money, checking bank account movements or printing receipts.

1.2 Developing Design Solutions

A first prototype of the CTNP was developed based on the insights gained during the previous phase (Understanding users' needs and preferences). Then, three consecutive iterations were carried complementing design and development tasks with user experience (UX) evaluations. For example, the first version of the CTNP was submitted to heuristic evaluation and user testing, and then redesigned to meet user requirements and fix accessibility issues.

1.3 User Experience Evaluations

APSIS4all has the objective of developing services with high levels of usability and accessibility. Moreover, these services should allow for personalisation according to users' needs and preferences, improving their UX compared with existing systems and providing a satisfactory UX regardless of the user needs and preferences

A framework was created for the measurement of UX, which define a set of five UX indicators based on users' self-reported perception about the systems (See Table 1). These indicators measure dimensions largely explored on the literature analysing the user's experience with a product or service [7]: learnability, perceived ease of use, satisfaction, fulfilment of human needs and, expectations.

The procedure for collecting data from participants included pre-test and post-test questionnaires with 5 and 7-point Likert-type scales. In order to improve comparison and interpretation of the results, an individual score for each indicator were computed and then converted to a 100-point scale. Predetermined thresholds for considering "Good", "Excellent" and "Best" UX were set to 70, 80 and 90 points. See [8] for a description of the statistical rationale of these scales and metrics.

Table 1. List of UX indicators with example items used in the questionnaire.

ID	Indicator	Example items
i1	Learnability	· I successfully learned to use this tool without effort
i2	Perceived ease of use	· The tool is easy to use
i3	Satisfaction	· I am satisfied with the tool
i4	Fulfilment of human needs	· I will feel free to do things my own way and with autonomy
i5	Expectations	· The ATMs personalised services will be easy to use

2 Results

2.1 User Requirements and Specifications

Desk research has provided a large set of 1568 user requirements that were categorized and stored in a spread sheet. Researchers, designers and developers can filter requirements categorized by *Priority* or *User Profile* among other criteria.

Field studies and heuristic evaluations also provided further information on how people with different abilities and conditions access ATMs, the problems they encounter, the potential accessibility barriers and the strategies they use to overcome them. The results show that, in general, people still face some difficulties when using ATMs which turn into severe barriers for specific user profiles (e.g. more than a half of the low vision participants claimed to have problems with screen contrast in ATMs) [9].

2.2 Development of the Collecting Tool of User Needs and Preferences

The CTNP was developed, through three design iteration cycles, to help uses define their needs and preferences when using ATMs. These are the steps of the CTNP:

- After registration, the user selects one of the nine defined user pre-profiles (e.g. mobility problems) offered by the interface (see Figure 1). This information is not explicitly registered in the resulting user profile, and is only used to infer the value of some variables and reduce the number of questions presented.
- Depending on the selected pre-profile, the tool displays a number of questions in order to collect the most relevant user needs and preferences for the personalization of ATM interfaces.
- After filling in all the questions, the basic set of needs and preferences is completed, allowing the user to configure advanced settings and accessing a preview of the resulting personalised ATM interface based on his user profile.

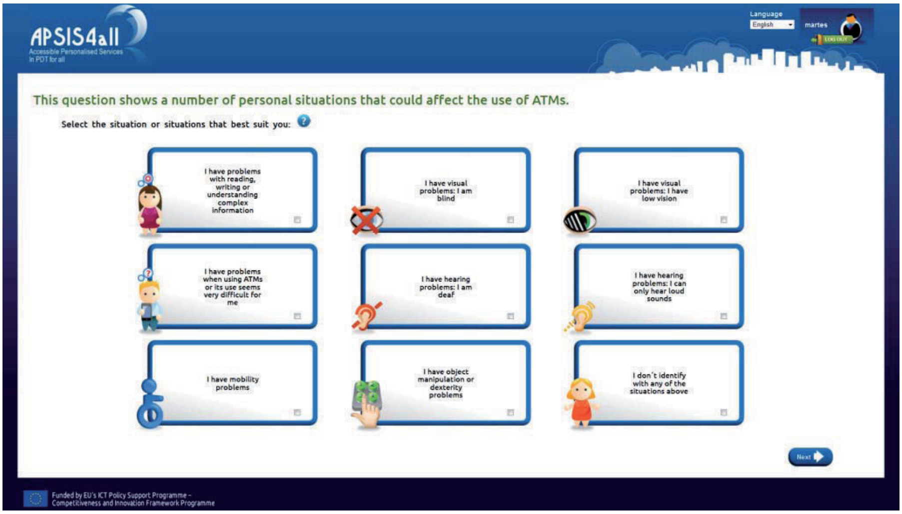

Fig. 1. Selecting user profile between a number of personal situations, mainly related to disability.

Several adaptations were implemented after each design iteration cycle. The aim of these adaptations was twofold: 1) to adapt the questionnaire procedure to the personalisation capabilities of the future pilot ATMs interfaces, and 2) to improve the UX for the different user groups based on the evaluations performed during trials. Following, the main improvements to the CTNP after adaptations are highlighted:

- The number of questions was reduced (5 vs. 8 in the initial prototype).
- Additional previews are introduced in questions to provide feedback for user responses (e.g. when asking about showing a “Sign-language avatar” an example is shown, see Figure 2).
- The personalisation options for certain user profiles were improved (e.g. blind people are now allowed to hide the display while using the ATM).
- The interfaces were simplified, enhancing their usability and accessibility. Some variables could be inferred without asking users. Moreover, some options were shown to be not relevant for the personalisation of ATMs.

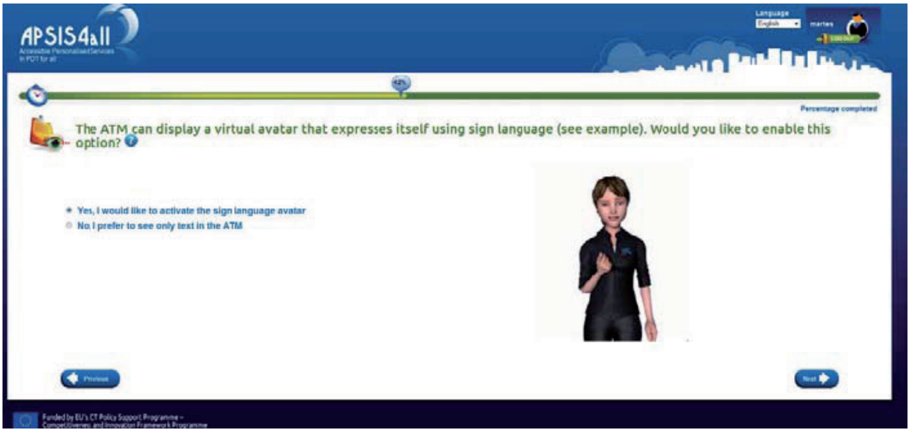

Fig. 2. As a consequence of the HCD process, some questions were improved by including previews.

2.3 User Experience Evaluations

One-hundred users participated in UX evaluations, covering the following user groups: 1) Blind, 2) Low vision, 3) Deaf, 4) Hard-of-hearing, 5) Mobility & dexterity problems, 6) Low intellectual disability, 7) People without disabilities <65, 8) Elderly people.

The analyses of the global responses to UX questionnaires showed a positive user perception and a significant improvement of the UX after each of the design iterations. Concretely, the results show a better overall UX in Iteration III compared with previous iterations (see Figure 3, left). Moreover, the five different UX indicators are above 80 in the 100 points scale, which can be considered an "Excellent" result (see Figure 3, right). These results validate the HCD approach adopted in the APSIS4all project.

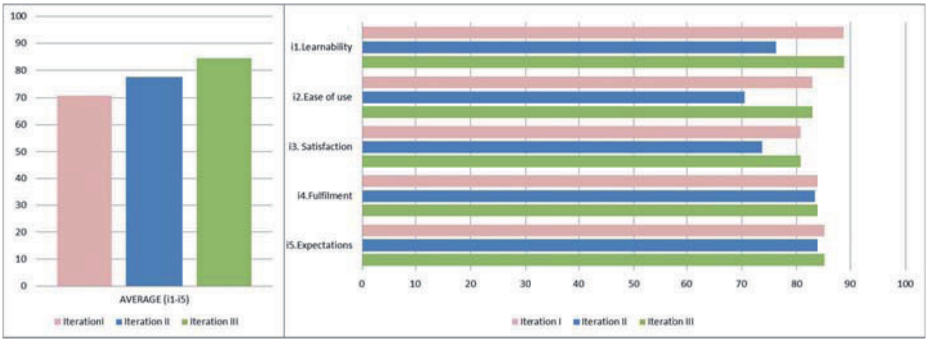

Fig. 3. Results on UX indicators along the HCD process.

Regarding differences between user groups, Figure 4 shows the average UX (i1-i5) for each of them, highlighting the predetermined threshold for considering "Good", "Excellent" and "Best" UX. The results shows that, on average, all user groups surpass the "Good" UX threshold, and four of them (Low vision, Deaf, Hard-of-hearing and People without disabilities younger than 65) have an "Excellent" UX with the CTNP. Taking into account that these data are averaged across the three iterations, it could be argued that the UX should be even better when considering the last version of the system in Iteration III.

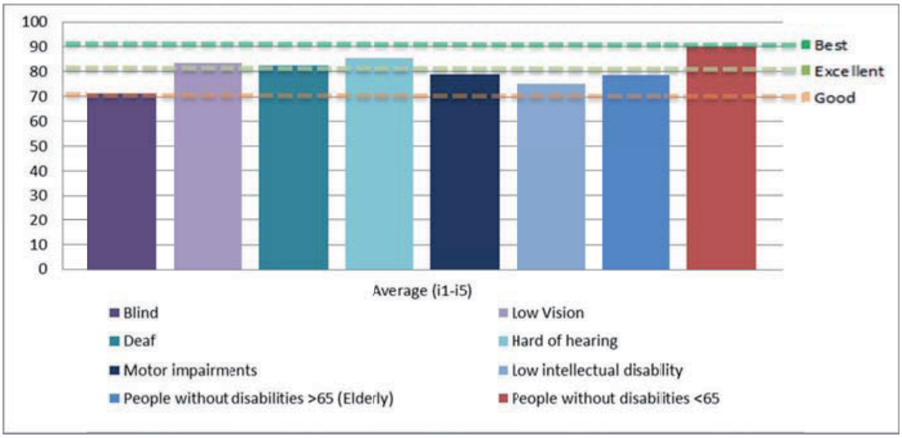

Fig. 4. Comparison of overall UX for each of the user groups considered.

3 Conclusions

The study reported here describes a successful implementation of a HCD approach during the design and development of a Collecting Tool of users' Needs and Preferences (CTNP), aimed to improve user interaction with ATMs. The final system design meets the usability and accessibility requirements of very diverse user groups (e.g. blind people and elderly people). Moreover, the results of the UX evaluations conducted have shown that all user groups value the system very positively in terms of learnability, ease of use, satisfaction, fulfilment of human needs and expectations about their future experiences with ATMs.

Next steps in the APSIS4all include the implementation of the CTNP in a Spanish pilot. The aim is to involve 1,500 'la Caixa' clients in Madrid and Barcelona during the implementation and validation of the ATM personalised features.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-386

English Handwriting Analysis using Digital Pens

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Abstract. Previous studies using digital pens to analyse handwriting have tended to deal with whole pages of writing or individual characters that are captured within single frames or boxes. English cursive script does not lend itself to this type of analysis. Words and individual letters vary enormously; adult handwriting has a personal style that is not easily captured by single letter or word recognition. This paper illustrates how handwriting data captured from 46 university students (22 students with dyslexia; 24 students with no known difficulties) using digital pens was successfully interpreted using newly developed software. The system has a database that holds the xml data collected from each digital pen. This data not only consists of the times for each stroke but also the pauses plus the visual pattern of each person's cursive handwriting. The latter can be broken up into script fragments for tagging and analysis. The ability to capture handwriting in this way has the potential to offer teachers a method for evaluating not only the speed of students' handwriting, but also to gather the pauses between words and characters. This paper illustrates how the system has shown that a group of dyslexic students not only had slower handwriting speeds but also longer pauses when copying, writing from memory and during creative writing.

Keywords. Digital Pens, Handwriting Skills, English Cursive Script, Dyslexia.

Introduction

Over the last twenty years there have been several studies exploring the issues of poor handwriting skills [1]. Results have shown poor legibility and difficulties with speed as well as accuracy when copying. More recently there have been a number of research studies examining the use of digitized handwriting as a method of assessing the differences in penmanship between students who may have dyslexia [2], dysgraphia [3] and Developmental Coordination Disorder (DCD) [4] in comparison to those who have no apparent writing difficulties. The recent research involved the use of tablets with school-aged children writing in one to one situations. The tablet enables to separate the speed of writing to pause time and execution time. Results showed that those with specific learning difficulties tended to pause more when writing which is not highlighted as an issue when a stopwatch is used for timing speed of handwriting as has been done in the past.

This paper aims to illustrate how the use of digital pens can explore in more depth the handwriting skills of those with dyslexia, by providing a comprehensive analysis of digitized scripts, as well as allowing those working with the students to capture data in a classroom situation in a very short space of time.

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There have been a series of digitized handwriting studies with school children using digital pens in Japan [5] where individual handwritten characters were captured within single boxes. These studies showed that variations in the speed of writing and number of pauses between characters tended to relate to age and that the use of boxes did not appear to hinder speed. However, when this method was used with five English students it became clear that it was impossible to ask participants to handwrite individual letters, as if they were Japanese characters within each box. The fact that the words were broken down into single letters slowed the natural writing speed and introduced unexpected pauses.

To resolve the issue of cursive script the analysis of script fragments was introduced. Script fragments can be made up of single strokes written in one sweep of the digital pen and can also be represented by parts of letters when the pen has been lifted from the paper. This means that errors, corrections, pauses as well as speed of writing can be tracked. The system has a database holding xml data collected from the digital pen as well as providing a view of the script fragments for tagging and analysis.

This paper illustrates how handwriting data captured from 46 university students (22 students with dyslexia; 24 students with no known difficulties) using digital pens was successfully interpreted using software analysis unconstrained by individual character boxes.

Method

Fifty cross-faculty university students, with English as their first language participated in this study. 22 students (9 male, 13 female) ranging in age from 18 to 32 (M=22.8, SD=3.7). All the students had at some time received specialist learning support and had dyslexia. 24 other students were recruited as a control group (11 male, 13 female) ranging in age from 18 to 31(M=21.2, SD=3.0).

Anoto digital pens were used to collect participants' handwriting performances. Each pen records the XY coordinate position every 13ms. The shape of the digital pen is similar to that of a large biro with a medium nib. These pens have been shown not to alter writing style or speed [6]. Two types of A4 paper were used; one set had a grid of 5x13 boxes (width 3.50cm, height 1.25cm) for the copying tasks and a dictation task. The other set had 13 lines, each 1.25cms apart used for the alphabet and composition tasks. All the papers had tiny imperceptible dots allowing the xml data to be saved on the pens for transfer to the computer. The participants completed nine tasks but for this paper just three have been discussed. The three tasks are:

Copy writing: A series of copying tasks were administered using words selected from the sentence "The quick brown fox jumps over the lazy dog." The sentence contains all 26 letters of the English alphabet. Eight words from the sentence were given in randomized order. The words were printed on an A4 card in Arial font (16 point). The students had one minute to complete this task. *Alphabet writing*: Participants were asked to write the 26 letters of the alphabet in their correct order repeatedly for one minute. This task was selected from the Detailed Assessment of Speed of Handwriting 17+ (DASH) [7] to assess writing ability from memory. *Written composition*: The free writing task was also based on the one used in DASH +17. This task asked participants to write about "My life" for five minutes. One minute of planning time was provided using a specific prompt sheet with a mind map of ideas.

The 45 minute handwriting session (which included the aforementioned tasks) took place in a group situation. Participants were asked to write using “their normal handwriting style” and the facilitator asked them to complete the tasks “as quickly as possible making sure every letter [or word] is readable”. A stop watch was used to count down the time.

The Simple Measure of Gobbledygook (SMOG) formulae measured the readability based on the number of syllables each word have which is the one aspect of quality of writing [8]. Lexical Diversity Type Token Ratio for all words (a measure of how many different words that are used in a text) was calculated using Coh-Metrix version 3.0 [9].

Each pens’ data was downloaded to the computer application for quantitative analysis, where duration of each stroke and pause between strokes could be calculated. For the purposes of this paper the sum of the duration of each stroke and the sum of the pauses were divided by the number of words or letters (in the case of the alphabet task).

Result

Table 1 shows the three tasks, where it can be seen that those with dyslexia wrote less compared to the control group. However, there was no significant difference in number of words per minute, the percentage of corrections or the score for SMOG and LDTTRa for the composition task.

Table 1. Mean scores of each task.

	Dyslexia(n=22)		Control (n=24)		
	M	SD	M	SD	
Copy (word/m)	25.55	4.60	30.92	5.12	$t(44)=-3.73, p<.001$
Alphabet Writing (letter/m)	83.23	16.50	103.33	17.54	$t(44)=-4.00, p<.001$
Written Composition (word/m)	28.54	5.78	30.58	6.01	$t(44)=-1.17, p>.05$
Corrections (%)	2.55	2.87	1.42	2.24	$t(44)=1.49, p>.05$
SMOG	10.63	2.34	10.23	1.13	$t(44)=.74, p>.05$
LDTTRa	.66	.06	.65	.05	$t(44)=.43, p>.05$

Table 2 shows the mean scores of stroke duration and pauses for each task (temporal variables). Each variable showed a significant difference between the groups. Students with dyslexia had significantly slower handwriting speeds and longer pauses.

Table 2. Mean scores of temporal variables.

		Dyslexia(n=22)		Control (n=24)		
		M	SD	M	SD	
Copy	Stroke Duration (ms)	1190.5	196.5	1076.5	136.6	$t(44)=2.30, p<.05$
	Pause (ms)	1133.1	436.2	866.3	279.9	$t(44)=3.53, p<.05$
Alphabet writing	Stroke Duration (ms)	343.9	61.5	298.8	40.2	$t(44)=2.97, p<.01$
	Pause (ms)	418.6	163.9	305.6	84.3	$t(44)=2.98, p<.01$
Written Composition	Stroke Duration (ms)	1187.2	336.3	959.9	256.5	$t(44)=2.59, p<.05$
	Pause (ms)	1035.9	405.7	742.6	305.2	$t(44)=2.79, p<.01$

There was also a significant correlation between stroke duration of written composition and LDTTRa (Dyslexia r=.55, p<.01, Control r=.60, p<.01), but no significant correlation between pause of written composition and LDTTRa (Dyslexia r=.34, p>.05, Control r=.17, p>.05). This suggests that writers who use a wider range of words (more lexical diversity) take longer to execute strokes during writing but that this does not have a significant effect on pauses between words.

Discussion

In this pilot study the use of digital pens with computer-based analysis was able to show significant differences between the speed of copying words, alphabet writing and written composition. The method used in a group situation was successful and the time taken for the procedure could be fitted within a class time of 45 minutes. This means that standardizing this form of digital assessment of handwriting skills is possible, but further analysis of the data is required to reappraise the written composition task and compare results with previous studies. It is also intended that future versions of the software will allow users to analyze script fragments in more detail.

Conclusion

The ability to capture handwriting in this way has the potential to offer teachers a method for evaluating, not only the speed of students' handwriting, but also to gather the pauses between words and characters as well as annotate and tag script fragments that may in the future show differences between the handwriting skills of those with dyslexia and dyspraxia. It was felt that the tasks provided by the DASH+17 did not stretch the composition skills of the students in a way that would be more appropriate for those in Higher Education. The written composition task resulted in relatively low SMOG and Lexical Diversity scores indicating that simple vocabulary was used by both groups. However, even with these simple texts, students with dyslexia showed slow handwriting speed and the increased length of pauses for copying, memory tasks and composition.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-391

Mainstreaming on Ambient Inteligence and the Role of eAccessibility Networking

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Abstract. Paper describes our experience in activities focused on improving quality of life by mainstream ICT services equipped with an ambient intelligence, often called as ambient assisted living, and respecting the Design for all philosophy. In this meaning these components should work to support people in carrying out their everyday life activities, tasks and rituals in easy, natural way. Developing and delivering of these services and components can be made by supporting end users, students, manufacturers, developers and policy makers through social networks and/or by ultimate online knowledge places and cooperation through networking.

Keywords. AAL, mainstreaming, eInclusion, eAccessibility network, ICT/AT apps development.

Introduction

MonAMI project (Mainstreaming on Ambient Intelligence FP6 project) proved during testing of its developed services offering social care of seniors that they may significantly improve seniors independence, well-being and their safety. [1]

ICT services have become standard part of everyday life. EU informatization and the European Commission's efforts in The Digital Agenda for Europe (DAE) [2] resulted in services that are more accessible. Users of these services i.e. end users, officers, caregivers, developers, policy makers in order to interact with them have to handle with various interfaces, devices and with new information and ICT technologies.

Our experience with e-Inclusion projects (6FP MonAMI [3], 7FP SMILING) was closely related to methods defined in the design for all concept 7FP eAcces+ project [4]. Project outputs as new services and devices had an impact to research in the rehabilitation engineering and at university education as well.

1. MonAMI Services and Results from Trials

MonAMI technology and services were tested thoroughly in the laboratory without and later with perspective users in real conditions. The results obtained from the trial [5] showed that provided technologies and services had great influence on increasing the confidence of elderly and their carers regarding to their safety and to the safety of their

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belongings as well. What we see as a very positive response is that with the usage of the provided technologies seniors became more interested in using the computer and internet due to the new possibilities like contacting the family members abroad, playing internet games or reading online news. Optimistic feelings about the future linked to the security and safety services as well as the services helping in performing of the daily tasks were high. Price often seems to elderly to be high. However, the general comment was positively appreciating the enhancement of social inclusion.

1.1. Development of Services Supporting Social Inclusion and eAccessibility

The legislation support for the ICT social services in Slovakia laid down in the Social law since 2008. The law specifies that social services may be provided (if appropriate) also by other means than field or ambulatory services, particularly by telephone or other telecommunication technology especially for monitoring, signalization and emergency help in risky situations [6].

At present, ICT providers in Slovakia don't offer efficient mainstream social services that could be used by seniors with some functional limitations or by persons with disabilities. However, several social calling centers and small charity or nongovernmental centers already provide simple social emergency services.

MonAMI platform aims to bring a more complex technology in a combined set of services concentrating on social inclusion, and in the same time in tele-health care.

Regarding to power of already available ICT technology, we can also mention communication and positioning system designed for watching a person who is away from home. It is a form of field care service intended for municipalities which wish to provide social supervision. Monitored citizens have to carry electronic guardian mobile phone, device that automatically captures the GPS signal, calculates the current location and sends data to the dispatch center where a person can be localized on a Google map.

1.1.1. Development of MonAMI Services

Services developed in MonAMI platform are focused on three categories - monitoring where beneficiaries and carers are able to monitor different values from components of sensors network such as temperature, luminance, motion or connected electric appliances. This can be done locally and remotely by UIs; remote and automatic control of electric appliances, actuators and switchers mainly used by beneficiaries; an alarm notification of risky or prohibited situations. This notification is done through SMS, e-mail or telecommunication technology.

From the technological point of view the MonAMI technology platform is a three level architecture comprising of sensors, logic and external services and interfaces [7]. The main methodology of the system implementation is based on interconnecting abstraction through set of interfaces also called OSGi4AMI [8] currently accessible as an open source project [9]. They define precisely functions and operations of all devices, actuators on various platforms as well as services – the whole system is implemented in Java programming language based on component oriented architecture OSGi [10]. Therefore new devices, either wired or wireless, may be easily added to the system.

The scalability of MonAMI platform and OSGi4AMI interfaces allows to develop own services adjusted for particular user needs. Services and applications were developed with a “Design for All approach” and are from following areas:

- Home control, personalized communication interface, activity planning.
- Health control, medication.
- Safety and security at home, visitor validation, activity detection.
- Communication and information.

For example, there were developed components as new user interface highly oriented on a touch screen with big sized buttons, using intuitive PCS symbols and/or pictures.

The services developed by MonAMI have been grouped into five packages: AMiSURE for safety and security; AMiCASA for home control; AMiVUE for home status information; AMiPAL for time management and AMiPLAY for games.

Figure 1. a) User Interface at the beginning of UI development. b) User Interface in late phase of UI development. c) Upgraded User Interface on ASUS EeeTOP touch screen x86 PC with sensor network components

1.2. Trials and Results

The primary aim was to assess whether the MonAMI platform and services offered a demonstrable social benefit to older people. The indicators of e-inclusion services evaluation were user’s experiences, confidence with using mainstream ICT, content and relevance, accessibility and acceptability of MonAMI services [11]. Accordingly, a significant number of users began the trials with fairly low levels of e-inclusion. Many users who were interacting with ICT in a limited manner before the trial have started using MonAMI platform UI on a day-to-day basis for services. During the trial, many of users learned how to use e-mail and video conference call and they were happy with the new communication way with relatives who live often far away from them.

The potential of the MonAMI services is that these services are adaptable since they can be modified and upgraded easily. Within the MonAMI project the key services needed for an AAL platform were indentified: remote management to manage central coordination unit (Residental gateway) in order to update the platform; alarm management to centralize every alarm report; personalization management a system used by services to enable adaptation of each service application to user needs; maintenance management to track anomalies in the platform; device management to capture ambient data; external client to extend the system with third party services.

1.3. eAccessibility and Flexibility in MonAMI Project

The advantage of MonAMI platform and its architecture is modularity. Accessibility and adaptation of user interface is important for everyone, especially for vulnerable persons with low digital literacy or peoples with various kind of disability. It brings the issue of user's ability and skills as emotional, motorical, cognitive, and sociological. User interface is one of the typical modules for expanding the variability of usage.

Several user interfaces on different target hardware/devices can be attached and developed without modifying the core platform. It is managed by so called Generic Communication Service module of the platform where all APPs are using the same service (GCS) to communicate with user interfaces. This approach was considered simple to implement, reliable, and easy to integrate. Any new client can be easily developed using the GCS, such a module can be remote client as GCS is using HTTP communication. This approach was well appreciated especially due to the clear separation of concern between the user interfaces and the services. This approach is a direct solution for the management of accessibility. As mentioned above, several types of user interfaces have been designed without any change in the service implementation. The architecture is using a Model-View-Controller (MVC) design pattern which is a way of dividing the code into independent functional areas. The model portion defines the application's underlying data engine (the services APP) and is responsible for maintaining the integrity of that data. The view portion defines the user interface for the MonAMI application and has no explicit knowledge of the origin of the data displayed in that interface. The controller portion acts as a bridge between the model and view and coordinates the passing of data between them. This controller part is designed by the Generic Communication Service API based on HTTP.

This brings an opportunity for easy implementation third-party devices, services and various kinds of end devices with different user interfaces into one accessible point. Also it brings an opportunity for the development of new features in eAccessibility and eInclusion. User interfaces developed in MonAMI project were tested on various devices such as: Smartphone, Tablets, Common PC displays, Touch screens, PDA, Mobile phones, Settopboxes.

We have found that it is very important to bring the most suitable, personalized and customized solution to be accepted by elderly. For example in Slovakia we have used as a HMI Asus EeeTOP PC with 22" wide screen with big sized buttons installed preferably in the household corridor. In the other hand in Sweden all the users preferred to have a smart phone instead of a computer screen as interface [12].

At present, since the installations of MonAMI system is still running, we are trying to extend MonAMI platform by telemedicine services and solutions. For this purpose we have chosen an open-source electronics prototyping platform Arduino [13]. For biometric and medical applications we are developing services for pulse, ECG, blood pressure, blood sugar and patient position monitoring.

2. The Role of eAccessibility Networking in Slovakia and EU

We participate in the 7FP eACCESS+ project which aims to establish and systematically develop a cooperative platform for co-coordinating, supporting and improving the implementation of eAccessibility throughout Europe.

Often, the access to information and knowledge about e.g. how to make services accessible, how to use design for all in development etc., is complicated, often fragmented. This information and knowledge can be obtained from various sources, which can be not only for common end users, developers but also for an expert itself problematic.

Our experience from the competition SS12 [13], which was one of the activities under eAccess+ project and Project: Possibility [14] shown that software developers are able to deliver accessible solution, if they have sufficient information about AT and Design for all concept. The purpose of SS12 is to increase awareness of issues in accessible computing and be educational. Attended students had got 36 hours to work on a creative and user friendly solution for a task from the everyday life of disabled persons. Each team had got one task from a list published in advance. The task was selected by the jury. We had two teams in the final of the local national SS12 competition at our University. Every team consisted from six undergraduate students of informatics and one graduate mentor.

The one of tasks was to build navigation application which would help people with disabilities. For undergraduate students was this event very progenitive and successful. The Android app project called “Accessible Event Guide” serves to indoor navigation using Smartphone’s built-in compass and by Wi-Fi triangulation using the existing infrastructure of WiFi access points, where GPS does not work because of the roofs that interfere with a view of the satellites. This application was designed especially for people with visual impairments. However, by using Design for all rules, it could be offered as a mainstream service for all.

The second task was to develop text reader with built-in dictionary based on graphical illustrations and explanations of meanings of words and phrases. The aim of this project was to support deaf pupils in educational environments, e.g. teaching classrooms in schools..

It is important to mention that our young developers/undergraduate students also used as a knowledge base the eAccess+ HUB [15] which is a kind of reference point about accessibility and different technologies in the Information Society. Within this networking and within the eAccess+ project we were able to start new education activities which provide an opportunity for undergraduate students as well as graduate software developers to make an empowered software projects for ageing population and people with disabilities. Authors believe that this should increase awareness of issues in design for all, ICT/AT potential for accessible services development, and finally to improve the quality of education in this specific field.

3. Conclusion

The reason why there is a lack in developing of accessible ICT/ATs services applications is mainly the fact that not only developers have a little information about accessible ICT/AT usage, standards etc., but also end users (elderly, students) are not able to imagine what they can obtain and what advantage can be reached by the use of accessible ICT/ATs. This could be improved by raising the knowledge base and support of eInclusion/eAccessibility networks and education of students, developers, policy makers, also awareness of the end users including the practical demonstrations.

Acknowledgements

The research leading to this results was supported by the national grant VEGA 1/1162/11 „Theoretical principles, methods and tools of diagnostics and rehabilitation of seniors mobility“, and EU grant 7FP, CIP-ICT-PSP-2009-3, 250568, eACCESS+: the eAccessibility network“ ICT for health, ageing and inclusion.

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e-Accessibility/e-Inclusion/AT and Cloud Computing

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-399

IT-Support Direct from Project to a National Service

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Abstract. Many people need support to manage IT in daily life. Some people have relatives or others who help them, others lack that kind of support. For this reason, a service, IT-support Direct was created and a pilot project was launched. The results indicate that the need is huge and the service can play an important role to realize e-Inclusion for all..

Keywords. IT-support Direct, Older Persons and People with Disability, e-Inclusion, “Black Spot”, Field Trial, National Service.

Introduction

Sweden has a population of 9,6 million people. Acording to the publication “Svenskarna och Internet”[1] (In English “The Swedes and Internet”) around 89 percent have access to Internet. About 1.250.000 million people do not use Internet.

22 percent of people in Sweden between 66 and 75 years do not have access to the Internet.[2] 13 percent have Internet access but do not use it. Five percent use the Internet once a month. This means that 60 percent of this age group use the Internet more than once a month. 28 percent say they are not knowledgeable at all when it comes to computers and the Internet, while 30 percent say they are not very knowledgeable. The rest, 42 percent, believe they are very or somewhat knowledgeable on computers and the Internet.

In the age group 76+, 61 percent don`t have access to the Internet, 7 percent have Internet access but don`t use it and 4 percent use the Internet only once a month. This means that 28 percent have access to the Internet and use it more than once a month. 63 percent say they are not knowledgeable at all on computers and the Internet, while 22 percent say they are not very knowledgeable. The rest, 15 percent, believe they are very or somewhat knowledgeable.

There are large groups of older people who use computers and the Internet and according to self-evaluations don`t have sufficient knowledge. Adding to this there are older people who don`t use Internet currently but who probably would like to use it with the help from a support service.

In total there are around 1,8 million people with disability in Sweden.[3]

Similar figures can be found for all EU.

e-Commerce increases continuously, 84 percent of Internet users practice e-Commerce. Many older persons do not pay their bills via Internet. Half of the

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[1] Svenskarna och Internet (2012)
[2] Olle Findahl (2012)
[3] Funkaportalen (2013)

population lack e-ID.

A questionnaire was sent in 2008 to the private and public providers of Assistive Technology (AT) in Sweden including suppliers of AT. The result shows that around 8 of 10 responds that there is a need for a supplementary IT support addressing basic knowledge in computer handling among the users and their relatives and close friends. The support provided by the public and private actors are only related to the products, services and methods they provided themselves. All stakeholders had identified this "black spot". First paragraph.

1 State of the Art on the Market in Sweden

There is IT-support provided on the market by several actors like broadband companies, telecom operators, suppliers of hardware etc. The price is quite high, it's about 2,5 € per minute. The services each and everyone of these companies are delivering are normally limited to the needs consumers face when using the service or product bought from the specific company.

The same limitation goes for providers of assistive technology regardless they are private companies or public service providers of AT making very personalized installations when it comes to IT.

A wide helpdesk comparable with IT-support Direct is not available on the market. IT-support Direct works with both a wider field than the market players and have trained the staff in how to communicate with people without basic knowledge about IT. Some local companies offer home visits for an initial cost of 50-55 € and then a variable cost for the time needed.

2 Value Added with the Project IT-support Direct

IT-support Direct meets the needs of people who are uncertain about their technical environment, they have difficulties to express their problems, they don`t have someone to ask and they are older or have a disability which makes communication and handling more complex. The target group does not phone a help desk in the market if they don`t know what it will cost them and if they don`t know if they can understand the instructions. Companies selling help desk services are not interested in customers if the call passes the cost barrier. Normally the companies do not market their services to customers that are unprofitable.

Although there are support available for persons using AT linked to the computer and support from the supplier of the computer, there is at the moment a "black spot" when it comes to support about the basic knowledge concerning the computer. This kind of basic knowledge support is not available today.

The project has had contacts with the companies already on the help desk market. If the Government makes money available to support those who need IT-support Direct, most of the market players are interested in establishing a service like IT-support Direct. The companies support the project's aim to initiate a procurement which will constitute an even level playing field for this kind of service.

Several studies have shown the importance of relatives and friends when it comes to support all the way from advice when buying a computer, deciding on subscription of broadband, installation of the computer, daily handling of practical problems etc.

The thing is that many people do not have access to this kind of “support from a relative”.

3 Field Trial

A goal was formulated initially; deliver both a consumer appreciated service and deliver it to a viable price from a financial perspective. The Swedish Institute of Assistive Technology (SIAT) has been running the project IT Support Direct since April 2009 in co-operation with user organizations.

Beside user organizations and SIAT, a large customer service company and municipalities concerned are also involved as partners. The first year 3 municipalities were involved. Presently 7 municipalities are partners. The municipalities being partners of the project during the second period represent around 6 % of the total population in Sweden. The project has been supported by grants from the Swedish Post and Telecom Agency (PTS) and the Swedish Inheritance Fund Commission.

The aim is to make it possible to continue after the project time. SIAT has had no ambition to run the service after the project period, it aims for a market solution. Already a study has been initiated on different business models with the purpose to find a viable financing in the long run for this technical support via the phone. It could be a combination of user charges, local, regional and national funding.

The service is presently provided to persons with disability and older persons in the chosen municipalities. The cost for the user has been the charge for the local phone call. The framework of the service delivery was defined as “a standard package”. The standard package contains

- Purchase of computer
- Installation (programme, hardware, ..)
- Web browser
- Internet and services
- E-Identification
- Security and protection
- Problem solving e.g. taking over customers computer

It also covers mobiles and digital TV boxes. The standard package was the basis for cost calculations and estimations of time lengths of phone calls and the number of phone calls during the testing period in some participating municipalities. Initially it was believed that the service would be constituted by a 1st and 2nd line using the concept developed by customer service companies. So far almost all calls have been successfully handled by the 1st line.

What do people ask the help desk about? The three dominant areas are deployment-installation, E-mail and printing issues.

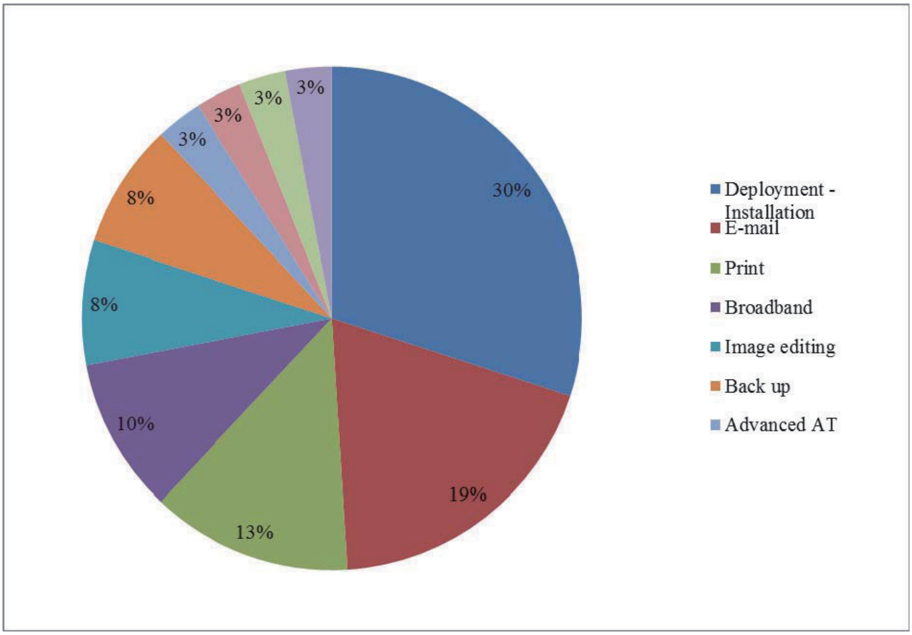

Figure 1. Subject for phone calls.

4 Is the Service Needed in the Future and Is It Worthwhile?

Many older persons and people with disability don`t use the Internet today, but you can expect that more and more will do so. For the foreseeable future IT-support Direct will be needed. The benefits for the Society of increased digital inclusion for all members of society are numerous. This can itself justify a continued community support to facilitate e-Inclusion. The municipalities, the County councils and authorities will increasingly offer e-Services, a support service will be a facilitator during a transition to new means of communication with ALL citizens.

There are some studies analyzing both the economic benefits of increased use of the Internet and welfare gains for the individual[4].[5]. Especially Litan deals with groups of older persons and people with disabilities. Åke Dahlberg[6] summarizes among others the following:

> "There are strong economic reasons for the increased use of Internet and other IT services, according to international studies (...). The economic arguments should be particularly strong regarding elderly, where the benefit of certain services can be assumed to be greater than for younger groups (...). Conceptual estimates in the UK and USA as applied to the Nordic countries shows that the potential revenue from the increased use of IT services for the elderly amounts to 100 billion and up."

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[4] Litan R E (2005)
[5] PricewaterhouseCoopers (2009)
[6] Åke Dahlberg (2012)

5 Can Everyone Be Helped over the Phone?

More than 95 percent of those who use have used the service in the pilot programme have been helped. Sometimes IT-support Direct faces situations when the computer requires specialists with physical access to computers to solve problems. Most of these problems are about hardware problems, the computer needs to be reinstalled or dealt with in a more comprehensive way.

For those who can`t be helped via phone IT-support direct, there are plans that organizations within the Communities of the target groups will contribute with home visits as a part of their own activities.

A Customer Satisfaction Index demonstrates high figures, 4,9 of 5,0.

6 Procurement of a National Service Is Being Prepared

The production and delivery of the national service IT-support Direct will be traded on the market. The financial support from the Government can make it possible for older persons and people with disability to benefit from a support service. This addition to the market will ultimately be good for the industry. In the short term, some customers today using existing support providers can switch to the procured service thereby withdrawing demand from established companies. All of the established companies though have an equal opportunity to compete for becoming a supplier of IT-support Direct. The industry is positive to a procurement of a subsidized nationally available IT-Support Direct Service. The project management has discussed the issue with representatives of both the IT and telecom companies and the organization for the Customer Service Companies.

7 At the Conference

At the Conference results like the costs, the need of the service, customer satisfaction, status of the procurement including the service delivery to the target groups will be described.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-404

Atlab: An Accessible Cross Platform Gaming Framework for People with Disabilities

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Abstract. Being able to develop accessible cross platform applications by having a single codebase is a major advantage for software-engineering. However it is difficult to overcome the diversity of operating systems, the different interaction paradigms on mobile devices and desktop computers while still being able to adapt to the users special needs. Being able to exchange game data or game content between devices and to manage users is also a big issue. In this paper we describe our approach to create such a framework, the current results and the experiences we gained during the development process.

Keywords. HCI, Mobile Devices, Game Accessibility, Alternative Input Devices, Cloud Services.

Introduction

Today's common hardware and software-systems available for people with disabilities are quite cost intensive. This is a result of often small target groups with diverse requirements demanding a high amount of work and resources when developing stable, safe and effective products for people with disabilities.

Modern tablet devices show potential to considerably lower the price of assistive solutions. Including off-the-shelf products and development based upon elaborated frameworks allow a considerable reduction of development and integration costs. Thereby, they should also allow access to a much broader amount of digital learning content for training and therapy for people with disabilities due to cross platform support. However, the adaptation of software from one platform to another (e.g. from MS Windows to Apple iOS) is still quite complex and not always feasible. This limits the amount of software that is available for each platform and increases the costs of software development compared to developing for a specific platform. Still, assistive solutions need to be adapted and optimized for every platform specifically.

The Assistive Technology Lab (ATLab) project aims at building a software development framework that eases and accelerates the cross platform implementation

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of accessible applications running on tablet PCs. It puts its primary focus on educational software for people with learning disabilities, limited motor skills or speech impairment (AAC users).

The software development framework will allow creating applications in a more efficient and cost-effective manner by making them available cross-platform from scratch without asking for adaptations. The system consists of the following components:

1. Software framework for an easy and fast development of accessible content for disabled people on different platforms
2. Software components for an easy integration of specific hardware input devices (e.g. Microsoft Kinect, Integra-Mouse, Hip, Eye-tracking, Tagged Objects, push-button-control)
3. Cloud services as a basis for the implementation of novel educational concepts and for the specific support and connection of disabled people, in particular for an adaptation of content and the interface for individual users

An important aspect of the framework is that it is based on cloud services which allow applications to exchange data and content and thereby to adapt to the requirements of individual users. In addition, the cloud also hosts a user management system that allows applications to manage a teacher-student or user-supporter relationship to enhance therapy or learning games implemented with the framework. Teachers, therapists and support workers are able to manage their classes within the cloud and can supervise the progress of their students.

1 State of the Art

Intense state of the art research has shown that only very little know-how related to frameworks for the development of accessible applications or games exists. Although, a generalized approach and ideas for the generalization of accessibility of computer games has been presented by Miesenberger [2] or Archambault [1] it has never been implemented.

During our research we could only find one project that deals with the creation of accessible applications on different devices called ÆGIS Project [3]. This project aims at embedding support for accessibility into every aspect of the solution - including the pre-built user-interface components, development tools, software applications and the run-time environment, and via dynamically connected Assistive Technologies (AT). ÆGIS develops an open source accessibility framework, upon which accessibility interfaces and applications for the users as well as accessibility toolkits for the developers will be built. Three mainstream markets are targeted by the framework, namely the desktop, rich Internet applications and mobile devices/applications market segments [3].

The ATLab framework, as outlined, expands the capabilities of the ÆGIS Framework with the use of cloud services to synchronize user data and profiles between devices and different applications and by supporting the management of the teacher/therapist/supporter and student relation. Beyond that, the ATLab framework focuses on the development of accessible content and games for learning and an easy integration of new alternative input devices like the Microsoft Kinect [4] rather than on the creation of all kinds of applications like the ÆGIS Framework.

2 Framework Overview

One core requirement, as mentioned earlier, is that the framework allows deploying applications on different platforms (e.g. iOS, Android, etc.) with just one code base. A considerable number of software platforms exist that allow implementing cross-platform applications. After an extensive evaluation phase of cross-platform frameworks the Adobe AIR [7] runtime was chosen. The core reason for this was the extensive developer support available and a slightly better performance than the other approaches. It is sufficient for 2-D games but not for graphic intensive 3-D applications. All in all it proved to be the more mature technology.

As seen in Figure 1 the ATLab framework therefore has been based on Adobe AIR. To overcome the differences between the supported platforms that were not solved by the AIR-Runtime itself we developed so called "Native Extensions". Native Extensions for Adobe AIR are code libraries that contain native code wrapped with an ActionScript API. By this, device-specific libraries and features can be accessed.

The whole framework and its components are based on Robotlegs [5] and Apache Flex [6]. Robotlegs is a framework that provides tools to ease communication tasks within the application, structuring the project and managing dependency injection. Flex SDK is an open source framework for creation of web apps that run on Adobe AIR. This environment allows rapid deployment of applications that can be operated by everyone and that run on the most popular mobile devices and desktop systems.

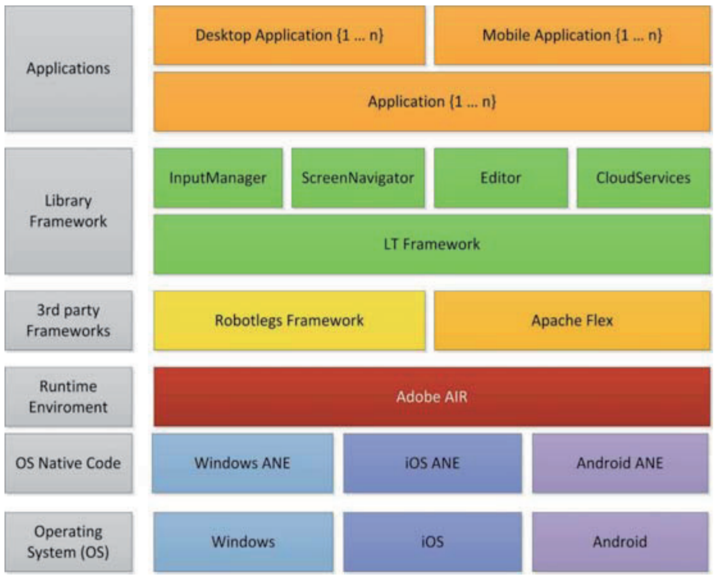

Figure 1. Framework Architecture Overview.

The framework hosts several components supporting the developer:

- InputManager: This component takes care of the user's interaction with the application itself. All input that the application receives is interpreted by it before it reaches the application.
- ScreenNavigator: The ScreenNavigator unit is in charge of the construction and deconstruction of the screens and handles the flow through the application.

- Editor: The editor allows an easy creation of new game content with a user friendly interface.
- Cloud Services: Cloud services provide user a account management system and provides the framework with mechanisms to exchange and to store data among devices.

Every application that is created by the framework is based upon those components.

3 Framework Components

3.1 Input Manager

This component takes care of the user's interaction with the application itself. All input that the application receives, whether by touch, by keyboard, by switch or by any other input devices is forwarded to the InputManager before it reaches the application. Depending on the user's preferences (e.g. hold time, lock time, ...) and the currently activated input method (e.g. touch, scanning, ...) the InputManager evaluates the input. To deal with this issue the framework also allows configuring a hold-timer and blocking-timer. The hold-timer triggers the action only when the finger touches the screen for a user-defined period of time. User interactions which might be caused by unintended touches are filtered out. The additional blocking-timer defines a period of time where any user input is blocked. If the input is valid it is forwarded to the user interface which handles the input. By this, a user interface can be build that can be operated with many different input devices without the need of adaptation when the input method changes.

3.2 Screen Navigator

All applications built with the LT Framework are screen-based applications. Every screen encapsulates a unit of meaning, e.g. an intro, a menu or a mini game. The ScreenNavigator unit is in charge of the construction and deconstruction of the screens and handles the flow through the application. Therefore it uses a predefined XML document which describes all available screens and offers logical statements as sequences and switch-by conditions. It is also possible to modify the screen list on the fly.

3.3 Editor

The provided editor tool enables users to create customized learning material. By this, also persons without experience in programming are able to create game content for everybody. It works with any given user interface template that meets a few defined criteria (such as only a defined set of user interface elements may be used). This makes it possible to include the authoring tool in any game. Additionally, a stand-alone editor tool can be created. Due to the fact that the user interface templates are defined using XML they can be updated using the cloud service which does not make it necessary to redeploy the authoring tool each time a new template exists.

3.4 Cloud Services

Our cloud service tackles different areas of application, namely:

- user profile and account management
- storage and sharing of data
- service-side computing including thumbnail generation and calculation of user statistics

User account management allows users to create a cross-application user account. A user profile which contains input device settings and other configurations is bound to that account. Once the user profile is created it is available on all applications that were built with the framework and all devices. This makes life easier for carers as they do not need to configure a new application for a user or reconfigure an application when the user changes.

In addition, the cloud services provide data exchange and storage consumption management to keep track of cloud user data storage and multimedia data sharing. The exchange of multimedia data allows users to share their content with other users in a controlled way for different audiences: private, shared and public.

As seen in Figure 2, the underlying user management allows controlling data access by means of different roles to map a teacher-pupil relationship.

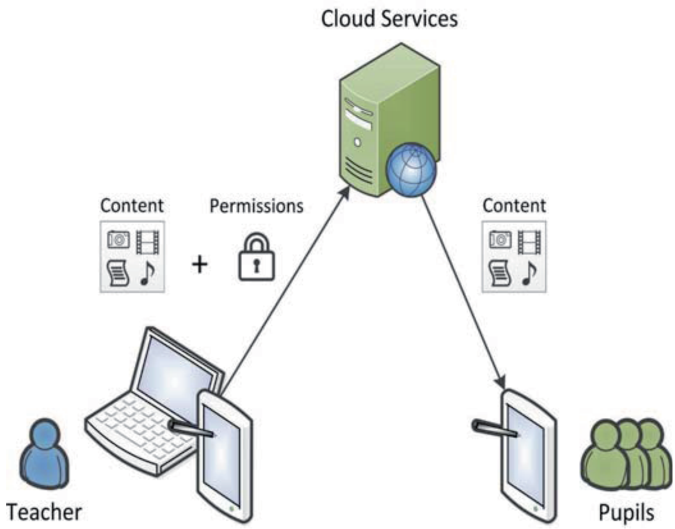

Figure 2. Basic Workflow.

Teachers are able to create new learning content and share it with their pupils which makes it very easy for them to distribute homework or new tasks.

4 Current Results and Future Work

Currently the first application that emerged from the framework called “SwitchTrainer” is published for iOS. With this application people with motor or cognitive disabilities should learn to operate applications with hardware switches or touch screens.

A group of seven people with certain disabilities like rett-syndrome, down-syndrome, cerebral palsy or tetraplegia were selected as test users for our user study. The users had to operate our first application with the different input methods that our framework provides. Evaluations showed that the framework and its concept are working as expected. Depending on the user's disability some input methods are more suitable than others. Users that were able to touch the screen but did not possess the accuracy to hit a button exactly favored touch scanning as it is a more intuitive and direct approach than scanning with external hardware-switches.

Another result of the user studies was that some users preferred different input methods depending on the task they had to fulfill within the application. For tasks where less touch precision was needed some users preferred to operate the application with touch input. For tasks where a high level of precision was required users preferred scanning to control the input.

Cloud services and the sharing of user profiles and game content are not yet supported by this application. Those services are currently under development and testing and will be part of the project's next application.

Since learning applications are a key aspect of the practical application of the framework in the future, we plan to automate the generation of user statistics giving insight how users are interacting with applications, how their interaction characteristics change over time and after training, and how users are interacting with certain applications compared to other users of the same user type. This should provide very specific and precise data for user studies and knowledge on the interaction principles of users with disabilities using various kinds of input devices and support a better selection of the input device for a specific group of users and better user settings for specific interaction characteristics.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-410

eACCESS+ and ETNA: Two Different Approaches Conquering the Low Take-up of eAccessibility

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Abstract. Within the last decades, eAccessibility has established a solid body of knowledge, including guidelines, methodologies, techniques, training and reference materials and examples how to implement eAccessibility in Information Society products, systems and services. This consolidated body of knowledge is intended to be applied to mainstream design as an integral part of systems and services in society.
However, eAccessibility seems to stay confined to its domain of origin, despite the fact that a) Awareness and acceptance of eAccessibility as a fundamental human right is growing, as can be seen in the UN Convention on the Rights of People with Disabilities [1] and in many EU directives, and in national and international legislation; b) eAccessibility is a key business concern due to the considerable and still growing number of citizens who are dependent on or benefiting from eAccessibility; c) eAccessibility is crucial in dealing with the growing pressure on social systems due to an aging population, correlating with increasing occurrence of disabilities. Finally, the ongoing investment in many initiatives, programs and projects all demonstrate the need, the feasibility and the viability of eAccessibility.

Keywords. eAccessibility, Assistive Technologies, Assistive Solutions, Accessibility Hub, Database, Information Repository, Service Delivery Systems

Introduction and Research Idea

Although key mainstream players in eAccessibility are involved in a huge variety of research and development activities, application in day to day practice is scarce. Facing the gradual step by step improvements in the uptake of eAccessibility in the light of the exploding application of ICT in society [2], this situation gets even more imbalanced. This is true for areas receiving much attention, such as Web Accessibility (e.g. [3],[4],[5]), but it is even worse in other eAccessibility domains [6].

Another important issue and crucial for everyday work in support centers for people with disabilities as well as for the peer group (or their carers) itself is the provision with information on already existing assistive solutions. Most often, people working in the field of providing assistive technologies or assistive solutions to people with disabilities or their carers face problems in staying up to date: They are in most cases not involved in research and development after getting basic education in this field. A Europe - wide unified, accessible, comprehensive and usable portal on assistive

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solutions could fill this gap and raise the level of proficiency on all fronts, from researchers, developers over providers and support centers to users and their carers.

Obviously, it might be impossible to design THE perfect AT service delivery system that is applicable in every country (or at least in the EU) as provision of AT is just one element of each country's healthcare and social support policy, that is related to its social, geographical, historical, political and legislative context. Thus each country needs to implement systems that are best tailored to its context, having in mind that experiences and views help to understand to what extent "good practice" might be imported from other regions and get a better understanding of what prerequisites and key principles make an "almost ideal future AT service delivery system" and finally what direction should be envisaged in the future [7]. Additionally, concerning use cases and user paradigms, it is necessary to mention that the UN Convention performs a shift from "medical model" to a mere "citizenship model" of disability. People with disabilities are necessary experts and therefore important part in any decision making process on issues relevant to them, including the design of service delivery systems - asking in turn for implementing accessibility to the full extent from the very beginning.

Reliable up-to date information, combined with a web 2.0 based community style of a portal enabling all involved key players to review and evaluate proposed solutions and their appropriateness for diverse user groups would help raising both, quality and quantity of flexible, user centered and efficient assistive solutions.

The thematic network project ETNA (EU funded within the framework ICT-PSP) dedicated its 3 year work to this topic and built up – in cohesion with two other projects in this field (EASTIN and ATIS4all) a portal for exactly this issue to be able to foster the future uptake of eAccessibility complementing the project eAccess+ and its work.

1 State of the Art, Methodology and Contributions to the Field

1.1. eAccess+

European institutions reacted to the situation outlined above with actions such as the EC Communication 2008 "Towards an accessible information society" [8] and related feedback such as that from the European Council [9], aiming at improving the situation and calling for related activities [10]. One of these activities has been the founding of the eAccess+ network driven by 25 European core members. eAccess+ (http://www.eaccessplus.eu) has established and is systematically developing a cooperative platform for coordinating, supporting and improving the implementation of eAccessibility throughout Europe by involving all stakeholder groups in the associated value chains and analyzing the present state in order to identify the obstacles or missing links hindering the uptake of eAccessibility [7].

In addition, eAccess+ is actively present at key mainstream events to advocate for eAccessibility and reach stakeholders able to act as "ambassadors", following the dissemination of innovation theories [11].

Furthermore, a roadmap is being developed to find appropriate future actions and identify the most promising players as well as the necessary prerequisites in order to be able to envisage a successful and sustainable implementation of eAccessibility.

Out of the wide range of topics related to eAccessibility, eAccess+ focuses particularly on fostering the implementation of:

- Web Accessibility
- Total Conversation (Accessible communication, documents and iDTV)
- Self-Service Terminals (SSTs) and related devices for banking, financial services, public transport, tourism, cultural heritage as well as e-government.

1.2 ETNA: Guided Access to Accessibility through a Web 2.0 Enriched Information Portal on Assistive Solutions

Research, development, dissemination, provision and use of ICT-based assistive solutions involve many stakeholders, each having particular needs according to their personal and professional profile. Each stakeholder may have different expectations and "search strategies" when consulting an information system.

The consortium contributing to the network ETNA started with a study to identify the various stakeholders involved and map their information needs, such as end-users of Assistive Technologies, professionals in health, social services or education as well as manufacturers and developers, policy makers and academic/researchers, the network ETNA identified thirty most possible “search profiles”, each related to a specific information need, that may be used, implementing a specific body of information for every profile.

This study provided insight in the users´ expectations, guiding the design of the portal, stemming from the existing Portal of the European Assistive Technology Information Network (EASTIN), enriched by contributions brought in by the ETNA project and its co-operating partner project, the Thematic Network ATIS4All.

The future audience of the portal includes a wide variety of stakeholders. Their categorization may be very detailed in terms of roles, professions, background, environment (academy, industry, policy, service provision etc.), and in turn, each stakeholder may have a variety of reasons to search in the Portal, depending on circumstances.

The final categorisation in stakeholder groups was done by clustering all stakeholders round five main target groups, evolving from the specific role they have concerning the use of the portal [12]:

1. End-users (actually using assistive solutions, typically looking for consumer information or other consumers´ experiences)
2. Professionals (working in the provision of services to persons with disabilities and their families, looking for information to keep up to date with the evolving AT market)
3. Manufacturers/suppliers (from companies producing ICT-based products or resources or services, whether mainstream or assistive, that can be part of assistive solutions, looking for business cases, involving an analysis of the size and the profile of the potential target population and a comparison with other products already available on the market that could be competitors or potential partners)
4. Researchers / Developers (involved in research and development of new ICT products, resources or services, whether mainstream or assistive, that can be part of assistive solutions. Research and development may be carried out in academic institution as well in research centres, in service-oriented organizations or in industry. Researchers and developers typically look for best practice, unmet needs or the state of the art in a given domain)

5. Policy makers (suggesting or deciding on policies related to research, development, provision and funding of assistive solutions, looking for information on the ICT AT environment, ongoing projects, market offers, involved stakeholders, best practice, possible lacks / new needs within the policy and legislative framework and its implementation and impact)

This categorisation is based on the role a person is playing in a given context: for example, a person with disability working in industry may in certain occasions approach the portal as a user (looking for a solution for him/herself), in other occasions as a developer (realizing the prototype of a new device with built-in accessibility features), in other occasions as a professional (in case the industry supplies AT products, assessing the customer for recommending the most appropriate solution).

2 First Results, Conclusions and Planned Activities

2.1 eAccess+

The consortium collaborating within the eAccess+-network identified and consulted relevant stakeholder groups, analyzed and involved them to discuss the state of the art, supported stakeholders in adopting eAccessibility and disseminated experiences and knowledge all over Europe.

The most important tool in mainstreaming and disseminating eAccessibility and present best practice examples is the eAccessibility HUB, an extensive one-stop information repository on eAccessibility that – different and additionally to already existing initiatives that mainstream policies or monitor the implementation of eAccessibility throughout Europe – provides accurately fitting information bundles for a number of stakeholders that were identified as key stakeholders in taking up eAccessibility, for example policy makers, information providers, institutions working for people with disabilities, experts for the needs and for counseling people with disabilities and their carers, soft- and hardware-providers and educators.

This information is not reinvented a second, third or another and yet another time, nor simply collected and doubled from other sources but researched, evaluated, cited, edited and compiled to fit diverse information needs as well as diverse proficiency levels, from developers over policy makers, industry to end users.

Additionally, the consortium developed and compiled guided tours through the HUB presenting different aspects and application fields of eAccessibility.

This way, there is not only a vast variety and number of information to be searched and browsed, but a fully tailored, easy access to eAccessibility.

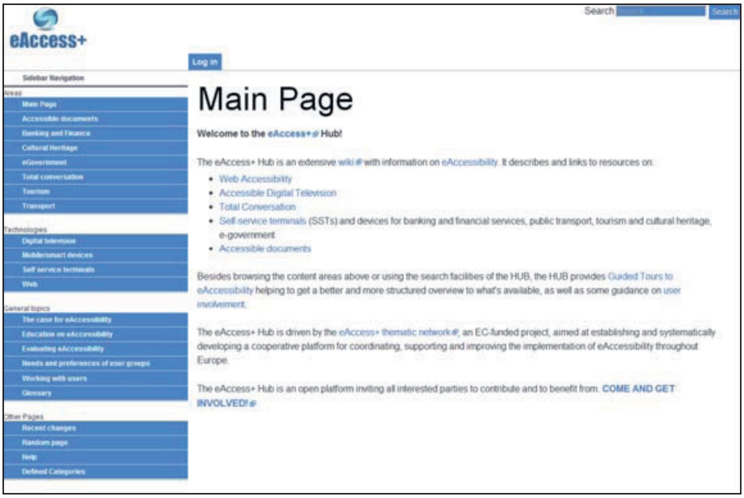

Figure 1. Screenshot of eAccess+ HUB showing different topical areas and information bundles.

The HUB deals with a most diverse set of topical areas, use and business cases for eAccessibility. Its guided tours and subject areas range from ATMs over IPTV and accessible documents to accessible websites – including most important use cases and research fields like e.g. education, banking, tourism and cultural heritage.

The most important issue to take care of within every information repository and community based tool is to attract traffic, keep information up-to-date and assure sustainability after the formal end of the project. Concerning eAccess+ and its core product, the eAccess+ HUB, there is already a lot of useful information and interest with considerable impact on the traffic of the eAccess+ site (based on Drupal 6.19, Apache 2.2.9, PHP 5.2.6 and MySQL 5.0.67 with 50.000+ hits in mid 2012) and the eAccess+ HUB (3000+ hits since early 2012), powered by accessible MediaWiki.

At the moment – and before a major redesign and relaunch, the versions used are MediaWiki 1.16.2, PHP 5.2.12 (apache2handler) and MySQL 5.0.18

2.2 ETNA

The success of the Portal primarily depends on how far it meets various information needs, asking for a detailed understanding of the topics to be covered, as well as of type, depth and format of the information to be provided. An investigation was carried out leading to the identification of the following sub-domains [13]:

- Stand-alone products and Non-Stand- alone products
- Resources for development and e-Services

"Assistive" reflects the concept of design-for-need (to meet with specific disability-related needs) contrasting to "mainstream" that bases on the concept of Design for All [14][15].

A still open discussion is if (accessible) mainstream products should be considered. Assistive products can easily be identified: They have been purposely designed to meet disability-related needs. The extent to which a mainstream product can be considered “worth mentioning” is questionable. In an ideal world, all mainstream products should be accessible, making specific information systems to find them needless; however, in real world the line drawn between "accessible" and "inaccessible" is often blurred and depending on the way the product is configured and used.

Furthermore, depending on accessibility regulations in use, a product considered "revolutionary good design" in one country may be considered uninteresting in another which has more advanced regulations and more advanced products.

In the next few years, there will be a growing pervasiveness of ICTs in every aspect of daily life, thanks to infrastructural advancements that will expand the use of technology in terms of space and audience [16]. In parallel there is a trend of enhancing the spreading of ICTs in everyone´s life enhanced by policies aimed at supporting e-Inclusion asking for sound, reliable and easy to access information.

Together with the information and findings from eAccess+, this two information repositories provide an excellent information source by complementing one another and give – despite the different approaches they used and the different (formal) projected goals they aimed at – a unique chance to get both: sound information on prerequisites, strategies and best practice examples to implement eAccessibility as well as extensive information on necessary tools for eInclusion and eAccessibility.

Acknowledgements

The networks eAccess+ and ETNA as well as EASTIN and ATIS4All are supported the European Commission through its ICT Policy Support Programme.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-417

The Global Public Inclusive Infrastructure, Cloud4all and Prosperity4all

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Abstract. As access to ICT is becoming mandatory for meaningful participation, independence, and self-sustenance, we find that we not only are nowhere near providing access to everyone who needs it, but we are actually losing ground due to reasons such as technical proliferation across platforms, increasing product churn (breaking existing solutions), decreasing social resources to address it, and an inability to effectively serve the tails of these populations because of the higher cost to do so. At the same time the incidence of disabilities is increasing as our population ages. This paper describes the Cloud4all and Prosperity4All projects and progress in building the Global Public Inclusive Infrastructure, an infrastructure based on cloud, web and platform technologies that can increase dissemination and international localization while lowering the cost to develop, deploy, market, and support a broad range of access solutions. Abstract goes here.

Keywords. Universal Design, Inclusive Design, Digital Divide, Cloud computing, Auto-personalization

Introduction

Access to information and communication technologies (ICT) and services is increasingly becoming essential for everyone, leaving those who cannot effectively access and use these technologies at risk of exclusion from education, employment, commerce, health information, and almost every other aspect of daily living and civic participation [1]. Those at risk include those who cannot use ICT and services due to disability, low literacy, low digital-literacy or aging related barriers [2].

In the past those who could not access these technologies could get by, avoiding technology entirely. However, ICT is now becoming so engrained in all aspects of society that this is no longer an option. If we don't / can't provide access to these groups they soon will be unable to participate in education, employment, commerce, our health system, transportation, or even daily independent living. This need to ensure that everyone is able to access and use ICT however is occurring at the same time we are facing something of a perfect storm in accessibility; where a number of factors are all coming together at the same time to create a fatal combination.

As access to ICT is becoming mandatory for meaningful participation, independence, and self-sustenance, we find that we not only are nowhere near providing access to everyone who needs it, but we are actually losing ground. Reasons

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for losing ground include: technical proliferation across platforms, increasing product churn (breaking existing solutions), decreasing social resources to address it, and an inability to effectively serve the tails of these populations (i.e. individuals with rare disabilities or combinations of disabilities) because of the higher cost to do so (due both to the diversity the tails represent and the inability of AT vendors to generate sufficient revenues to support serving these groups with our current infrastructure and assistive technology ecosystem).

Though technological solutions have been researched and developed for ICT access for individuals with disabilities, lack of a mechanism for moving these research results through to commercial and clinical availability leaves many of these developments in laboratories or journals rather than reaching the market and consumers/users who need them. Users are often unaware of available solutions [3] and small and medium sized vendors are financially limited in terms of the disabilities they can serve.

However, the very advancements in ICT that present the barriers also present an opportunity to make ICT more accessible to individuals with disabilities. The National Institute of Standards and Technology (NIST) defines cloud computing as a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction [4]. Cloud-based auto-personalization taps this unprecedented ability to pool resources and match demand with supply enabled by the Cloud. It allows for ease of setup and use that can result form the use of personal preference profiles to allow delivery of instant personalization of interfaces to every individual where they need it, when they need it and in a way that matches their unique requirements; automatically so that they do not need to negotiate, explain, qualify or justify. For most of us this can just make things easier to use. But for many this would allow them to have interfaces that were usable to them for the first time.

Global Public Inclusive Infrastructure (GPII), Cloud4All and Prosperity4All

To address these issues, an international coalition of organizations and individuals has come together and proposed the development of a global public inclusive infrastructure (GPII). The GPII is a new international collaborative effort to build a sustainable infrastructure based on cloud, web and platform technologies with a goal of helping create an ecosystem that makes access to all digital technologies more technically and economically possible, and to allow access even in countries with no assistive technology infrastructure [5].

The GPII is based on three main pillars (Figure 1):

1. Providing a way for people to easily learn about, and determine what solutions/features would help them and then to store that information in a common, portable, private, and secure manner.
2. Providing a way to use their stored preferences (and permissions) to invoke and configure the accessibility and usability features, assistive technologies, and/or services that they need - anywhere, anytime, on any device they need to use.
3. Providing the tools and infrastructure needed to allow diverse developers and vendors to create new solutions for these different users and platforms and to easily and cost effectively move them to market and to users internationally.

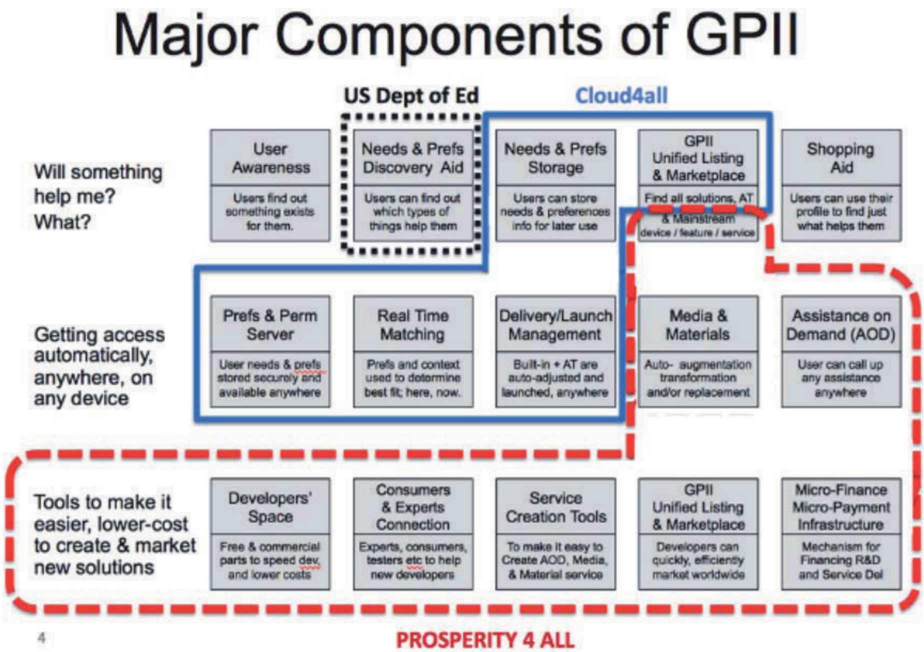

Fig. 1. The Global Public Inclusive Infrastructure and its relation to Cloud4All and Prosperity4All.

Each of the rows in figure 1 represents components in the infrastructure needed to achieve the one of three major functions. Cloud4all focuses on the key components needed to enable auto- personalization from user (needs and) preferences a PFP). Prosperity4All focuses on lower row(s), building the infrastructure needed to grow a new ecosystem that is capable of addressing the key factors preventing us from being able to create solutions for all the need them – and to reach them in a manner that is affordable to users, schools, libraries, companies and society.

Cloud4all

Work on the GPII goal began with the FP7 project Cloud4all. Cloud4all is an international project funded by the 7th Framework Programme of the European Union that will advance the concept of the Global Public Inclusive Infrastructure (GPII), building the knowledge base and algorithms needed, and evaluating the ability of the concept to work across platforms, technologies and applications. 24 partners and 3 collaborators from 9 European countries plus Canada and USA have joined the effort that will hopefully give us a chance to provide meaningful access to all those who need access, including those with little or no resources, making it possible for all citizens to participate in the new technological society.

The ongoing Cloud4all project is building the initial pieces of the infrastructure necessary to allow instant auto-personalization of software, devices, media, materials, and services based on user needs and preferences (stored in the cloud or on a personal device). See Figure 1. This infrastructure allows assistive-technology and mainstream-product manufacturers (software, hardware, media materials and services) to create products that can automatically change their interface or format to accommodate the needs of each individual as the individual encounters them. The long-term result can be a world in which each of us would find that essentially every device we approach would instantly and automatically change into a form that we are able to understand and use.

The Cloud4all project is well underway with mainstream and AT companies already demonstrating their products being auto-configured to user preference sets, that are retrieved from the cloud or a personal key-token (a USB stick, or an NFC tag or ring worn on the hand, facial recognition in the home, etc.).

Table 1. Technology Implementations of Auto-personalization underway in Cloud4all.

Prototypes			
1	Linux/Gnome	11	SuperNova Suite of low vision and
2	Microsoft Windows	12	Maavis (cognitive aid)
3	Microsoft Internet Explorer	13	Mobile Accessibility (mobile phone AT)
4	Mozilla Firefox	14	ReadWrite Gold & BrowseAloud
5	Simple phone (JAVA)	15	Allan eC (communicaton system for deaf,)
6	Smart phone	16	eKiosk
7	WebAnywhere (Cloud/online based AT)	17	Microsoft PixelSense Platform ('surface' touch-based technology)
8	SAToGo (run from server AT)	18	Smart-house
9	Online banking web application	19	DTV(iTV)
10	ASIT Social networking application		

This Cloud4all/GPII instant auto-personalization provides many advantages to consumers including making individualization of ICT possible in a quick and very simple fashion. However auto-personalization cannot address all of the problems cited above.

Prosperity4all

This Cloud4all/GPII instant auto-personalization provides many advantages to consumers including making individualization of ICT possible in a quick and very simple fashion. However auto- personalization cannot address most of the problems, such as the lack of solutions for all types of users, access features for all technology platforms encounter, cost, etc.

Prosperity4All (P4A) is a European Union funded inter-disciplinary international effort and represents the next step in the development of the GPII that seeks to address these problems by creating an infrastructure that will allow a new ecosystem to develop where these problems of ICT access for all can be addressed. It seeks to address these problems by creating an infrastructure that will allow a new ecosystem to develop where these problems can be addressed. The infrastructure will be based around cross-platform development techniques and that employ modern techniques such as crowdsourcing and gamification to both enable new strategies for the delivery of accessibility services and to enable an entirely new approach to accessibility solution development.

The objectives of Prosperity4All are:

1. **Reduce Costs:** For developers, vendors, service delivery personnel, public access points, consumers, companies, and governments.

2. **Address the full range of users:** including disabilities, literacy, digital literacy, and aging
3. **Address the tails and the tails of the tails:** We can no longer ignore the tails and focus only on serving the larger groups where it is easier, where there is a larger market, or where there is more return on investment. We need some mechanism to shrink the "unprofitable" so that special measures are affordable to reach them.
4. **Address all technologies:** All platforms, OSs, devices, systems, ebooks etc that a person encounters, or will encounter in their lives where they have to use them in 5, 10, and 15 years.
5. **Provide a plan/mechanism for creating a vibrant, profitable, assistive-technology market:** Although it would be ideal if all mainstream products could have interfaces that could adapt to the needs of any user, we do not currently know how to do this in any commercially practical fashion, across all disabilities and technologies. We will need AT and will need it for a long time.
6. **Decrease costs and expertise required of mainstream companies:** We cannot possibly afford to provide special assistive technologies and interfaces for everyone who has an interface problem, nor do we need to. Built-in accessibility is increasingly possible for many but we need to figure out how to make it practical.
7. **Do a better job of moving research and development to market:** Currently most eInclusion R&D reaches life's end at project review or publication, and is not making it to market and into the hands of users who need it. We need to address the reasons behind this. We need to direct research energies better and make it easier to get good ideas out.
8. **Involve consumer and consumer expertise in product development:** This is easy to say but hard to do in commercial development processes. This needs to be easier and more effective.
9. **Be based on realities, business cases, and value propositions:** although equal access to information technologies is rapidly being recognized as essential for equal participation in education, employment, health, and society in general, progress in this area is not likely to occur if there is no business case or value proposition for the players that are expected to carry it out.
10. **Recruit and engage more and different players:** We currently do a poor job of enticing and engaging much of the best scientific and technical talent in our society. We need to be able to tap the best and brightest, not only in accessibility or inclusion, but the best in other focused scientific and technical areas as well.
11. **Not forget documents, media, and services:** Information and communication technologies take many forms and all of them must be accessible to individuals with disabilities. Access to both, equipment and content is required.
12. **Provide both technology and human accessibility service support:** Any ecosystem must recognize that technology cannot possibly meet all of the accessibility needs of all of these populations today, particularly where cognitive or complex aging issues are involved. Any ecosystem must therefore, be able to seamlessly integrate human and technology based assistance alternatives.
13. **Work across all domains of life:** any ecosystem must also develop solutions that work across all of the domains that we must operate in as a part of daily life. This includes communication and daily living, work and commerce, education and e-learning, health and safety, mobility and transport, and access everywhere a person goes.

14. **Be applicable, and work internationally:** any ecosystem must be able to create solutions that can be applied internationally. This means that the ecosystem must support solutions that work across languages, cultures, economies and fiscal systems, and legal systems (e.g. copyright, privacy, entitlement etc.)

Conclusions

Society is facing a looming crisis where access to ICT is becoming required but we do not have access solutions for all nor do we have anyway to deliver solutions to all that need them in an affordable manner. In order to meet the demand we are going to need a new ecosystem that can develop deliver and support solutions to a much wider range of users at a much lower cost. The GPII consortium has come together that is beginning to address this problem. The Cloud4all project is building the initial pieces of the infrastructure necessary to allow instant auto-personalization of software, devices, media, materials, and services based on user needs and preferences. Prosperity4all in turn aims to develop an economic ecosystem that is based on economic realities and hard value propositions for the implementers. With these key pieces, we hope to develop an effective and affordable way to provide solutions to the full range of people who face barriers to accessing ICT due to disability, literacy, digital literacy, and aging.

Acknowledgements

This work was funded by the National Institute on Disability and Rehabilitation Research, US Dept of Education under Grant H133E080022, and by the European Commission under FP7 Grant # 289016. The opinions herein are those of the authors and not necessarily those of the funding agency.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-423

Accesibility Increase to E-Readers and Tablets through Wireless Remote Control

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Abstract. The aim of the project here presented is to develop a wireless remote control that enable users physically challenged to manage e-readers and tablets through devices adapted to their needs, by providing an alternative to the use of buttons or a conventional touch screen. The remote built acts as an interface between the reading device and the control system suitable for each user, joysticks pedals, blowers, etc. greatly increasing the accessibility to these technologies.

Keywords. Accessibility, reading device.

Introduction

Electronic text technologies are changing dramatically the way how people access information. The increase in the ownership of e-readers and tablets, and their use for reading is growing exponentially in recent years [1]. The use of e-books in education, and particularly in higher education is also becoming a common place [2], proving very good results [3]. The advantages of such devices for people with disabilities are enormous, including [4]:

- Devices are lightweight: users don't have to haul a big stack of books on their travels or back and forth to the library.
- Users are better able to manage use and access from home: devices reduce the need to travel to libraries or bookstores—for those with mobility limitations.
- Devices offer scalable font sizes and light levels: users can adjust the settings to meet their unique vision needs.
- Many devices offer audio features: audiobook functions appeal to those who prefer or need to listen to books.
- Some devices offer newspaper and magazine options: users are better able to keep up with favorite magazines and newspapers.
- Free Wi-Fi or 3G access: For users without a computer, some devices provide basic Internet access.

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However, their accessibility is far from optimal [5]. Industrial research efforts in e-reader accessibility have been mainly oriented to blind users [5, 6], but the accessibility of e-readers and tablets by severe physically disabled users is considerably limited, because the usual adaptations they use for computers (modified mice, stylus, blowers, etc.) are no longer operative on touch screens.

Concerning these devices, the most recent standards were developed by NISO in 1999 [7] but since then, there has been a lack of updated accessibility performance specifications for e-books and e-texts. However, useful descriptions of what makes an e-book or e-reader device accessible can be found in the functional performance criteria published by the federal Electronic and Information Technology Accessibility Standards and the W3C Web Content Accessibility Guidelines 2.0 (WCAG) [8]; a summary of all these standards can be found in [9]. The system here proposed is not an e-reader itself; therefore the aforementioned standards do not apply directly. However, what could be evaluated is how the addition of the system here proposed (eventually) increases compliance with accessibility guidelines.

1. Methodology

The methodology used for this project is represented in figure 1. It started with an information step in which several associations of people with disabilities were contacted in order to establish a first list of requirements.

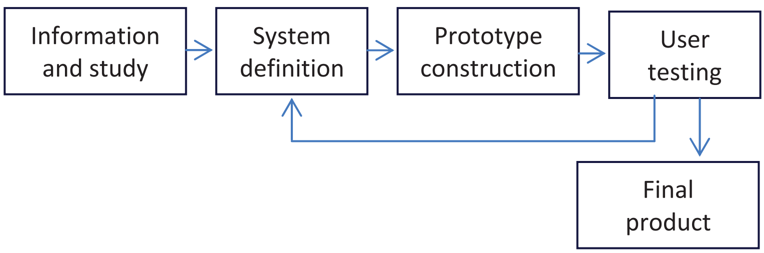

Figure 1. Outline of the design and construction procedure.

With these ideas in mind, a first version of the product was designed. The main characteristics of this design are (i) wireless connection through Bluetooth standard and (ii) software running over Android operating system. Then a first prototype was built. At the moment of presenting this abstract, the project is at this stage, the testing phase being planned for the very near future. Depending on the results of these tests, the product may become the final design or go back to reconsider basic elements of the system definition.

2. Results

The result of this project, until the present moment, is a prototype of remote control for e-readers and tablets (see figure 2). The device incorporates a joystick and four buttons; however, it is intended to act as interface with more specific, user adapted actuation systems such as pedals, blowers, different joysticks, etc.

There are only two requirements for a reading device to be connected to the designed remote control: (i) have Bluetooth connectivity and (ii) Android operating system. Then it is possible to introduce in the device a piece of software that, upon Bluetooth connection, enables the remote to take control of the basic functions of the device.

A first set of tests demonstrates that the remote works well with different devices, although a more extensive and systematic test of different brands is still needed. Besides the technical tests, also an extensive set of test with real users is being planned. We have already contacted several associations of persons with disabilities and the tests to be done are being discussed with them. Probably at the time of the conference some results from actual users could be presented.

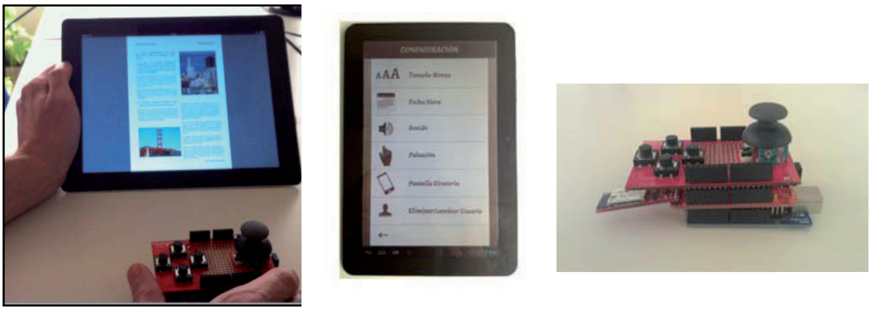

Figure 2. Image of the alpha version of the gadget.

3. Discussion

Tablets and e-readers are very useful tools. They are a very important entertainment and business tools, therefore is necessary that everyone can use them. The main contribution of this project is to facilitate people managing tablets and e-Readers through different types of drivers, allowing access to leisure and education to people with different disabilities.

The fabricated device provides a replacement control system to those of the original piece of equipment (tablet or e-reader), providing a net increase of its accessibility. It does not offer any functionality related to voice (voice control, text to speech), but it will not prevent them from working when provided by the tablet itself. Besides, the existence of physical controls alternative to the touch screen ones may ease its handling for blind or visually impaired users.

Electronic reading devices are compact ones, merging in the same place the reading and the controlling interfaces, being the screen itself in many cases. The remote control provides a spatial separation possibility for these two functions. This separation is a great advantage for people with reduced mobility, which can be seeing the screen in a comfortable position for reading while controlling it with the remote placed at a handy position.

The possibility of using the remote as an interface to more specific actuators like blowers, switches, or even eye tracking systems, expands its use to people with severe mobility difficulties. Other alternatives to the same problem can be found, like Access4Kids [10] or Tecla [11]. Access4Kids is focused on a particular actuator specially designed for children with limited upper-body motor control. The system here proposed would act as interface with such kind of devices. Tecla product seems to offer a solution very similar to the one we are proposing. We will precede to benchmark it as soon as it becomes available.

Summarizing, the designed system largely increases the accessibility of e-readers and tablets, making them usable for a wider range of users with disabilities.

4. Conclusion and Further work

We have presented the design and construction of a first prototype of wireless remote control for tablets and e-readers. The device will work in all tablets and e-readers with android operating system and Bluetooth connectivity.

It is anticipate that the built remote control significantly increases the accessibility of electronic reading systems for a wide range of users, including people with visual impairments or blindness, people with mobility impairments or motor control difficulties.

The next steps in the project are, in the short term, to perform a set of tests with real users, and in the longer term to expand its technical capacities enabling it to work with operating systems different that Android.

We are really convinced that this system can help to bridge the gap to electronic reading for many users.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-427

Enhancing Web Accessibility through User Modelling and Adaption Techniques

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Abstract. User-adapted interaction based on user modelling is a well known methodology that can be applied to enhance accessibility. To this respect, the structure and content of the user model is a key issue to ensure adequate adaptation. This paper describes the use of Web mining techniques to create user models that allow adaption of the Web interaction pattern. The main novelty of this system is the application of machine learning techniques to extract and structure information for the user model. Diverse adaptation techniques have been implemented for the specific user needs modelled.

Keywords. Web accessibility; Adaptive interactive systems; Machine learning; Web mining; User modelling & model-based system adaptation.

Introduction

User-Adapted Interaction has proved to be a valuable approach to enhance accessibility, because adaptation allows avoiding many of the accessibility barriers to interaction with computer applications encountered by many users with disabilities. For instance, adaptive interfaces allow users to be provided with alternative modalities that are better suited to their characteristics and preferences [1].

User-Adapted Interaction and User Modelling are not new techniques. They have been extensively used in the Artificial Intelligence area. Many research groups currently apply these techniques in the design of human-computer interfaces, mainly to improve the interaction of people with diverse types of restrictions [2]. Adaptation has also been applied to Web accessibility [3, 4]. The objective is to collect user characteristics into user models that allow the adjustment of Web navigation and presentation to each user's specific features, preferences and likes [5, 6], as well as the characteristics of the user device [7].

This paper describes the application by our research team of User-Adapted Interaction techniques for enhancing accessibility in automatic Web accessibility evaluation and automatic user modelling. The objective is to combine these experiences

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to create a large adaptive framework to allow user models to be shared and exported. In this way, the knowledge gained about the users by different adaptive applications can be used by other applications that lack this information.

1. Personal Accessibility to the Web

The problem of Web accessibility is usually treated from the Design for All or Universal Accessibility point of view. For instance, the WAI initiative published diverse sets of design guidelines to help designers to produce websites that are accessible for all users [8]. In addition, most countries that have promulgated inclusive legislation base the fulfilment of Web accessibility on compliance with WAI (or similar) sets of accessible design guidelines. This approach is most appropriate for ensuring the civil rights to electronic inclusion of people with any type of disability. Many methodologies and tools have been created to apply these guidelines. These include the use of automatic accessibility evaluators to try to verify the maximum number of guidelines screening the code, but some guidelines are not reflected in the code and therefore they cannot currently be automatically verified.

EGOKITUZ developed an Automatic Accessibility Evaluator, called EvalAccess [9], and built as a Web-service in order to allow its usage from a broad range of development frameworks used by the designers of mainstream applications. EvalAccess was one of the first evaluators able to evaluate diverse sets of guidelines. We also developed a tool to allow the creation of new machine-readable guidelines. In this way specific purpose guidelines were possible, including the verification of the coherence of the look and feel of a large website.

The possibility of creating specific guidelines or selecting subsets of the WAI guidelines allowed us a change of direction: from universal accessibility to personal accessibility [10]. Using EvalAccess, it was possible to evaluate subsets of guidelines that concern users with specific disabilities. It was therefore possible to find websites that were accessible for a specific user, even if they were not universally accessible; i.e. they were not compliant with the WAI guidelines.

Another advantage of EvalAccess is that it provides all the statistical data necessary to create quantitative accessibility metrics. Most accessibility evaluators produce qualitative scores (such as 0, A, AA, AAA) based on the subsets of guidelines that are fulfilled. Qualitative evaluations are useful for legal issues, but for practical navigation more accurate scores are required. Thus, the accessibility of two different websites with a score of “A” can be fine-tuned, allowing the selection of the better option from the accessibility point of view. Using our quantitative metrics we created a tool called EvalBot [11] that allowed the results of Web searching robots to be sorted by accessibility, following accurate quantitative metrics such as those proposed in [12]. EvalBot can be used by people with specific needs in order to select the most accessible website from a list of results provided by the search robot.

This approach can be called personal Web accessibility, as opposed to universal Web accessibility. In the next section a way to collect, manage, use and share user models to be applied to personal Web accessibility is presented.

2. Web Mining for user Modelling

The aim of user modelling in the context of the Web is to profile users' preferences, abilities or requirements to be used for Web Personalization; i.e. for defining a set of actions that are useful for dynamically adapting the presentation, the navigation schema and/or the contents of the Web. Nowadays, many research projects in the context of e-Commerce and e-learning focus on this area. Brusilovsky et al. [13] propose three main approaches for Web Personalization. The first approach consists of tackling the problem manually by obtaining the information on the user explicitly. This can be done, for example, by using a form to be completed at the time of registration and then using this information combined with the demographic profiles. The second approach, the content-based filtering approach, uses the history of each specific user to build a model that describes her characteristics (needs and preferences). The last approach estimates the features of the users based on the knowledge acquired from other users with similar characteristics. This last option is called the collaborative filtering approach. Although the three approaches mentioned can be complementary, the first two can be too biased towards the specific user, too subjective and very often static. The third approach does not have the drawbacks mentioned.

The use of Data Mining techniques to find patterns in the context of Web applications is called Web Mining [14] and it can be used with many different objectives: information retrieval and Web search, link analysis, Web crawling, structured data extraction, information integration, opinion mining, user modelling, etc. All these applications can be classified into three categories depending on the nature of the information analyzed [14]. It is called Web Content Mining when the information is related to the content of the Web pages; Web Structure Mining when the information used is related to the website structure (pages and hyperlinks); and Web Usage Mining when the aim is to find use or interaction patterns in the Web that allow modelling of the users' behaviour.

The usage information is essential in order to build user models but it can also be combined with structure or content information to obtain further knowledge about the user. The Web Usage Mining approach can be used to discover patterns such as sets of users that access similar collections of pages, users with similar difficulties, or objects or resources that are frequently accessed by groups of users.

3. A User Model for Web Accessibility

We implemented the two main stages required to build user models in a Web Mining process (see figure 1): data acquisition and pre-processing [15], and pattern discovery and pattern analysis. Data acquisition and pre-processing are complex tasks that can infringe users' privacy [16], something that has to be taken into account during the entire Web Mining process. This is the most time consuming and computationally expensive step. We acquired and pre-processed two types of data: usage data obtained from Web server logs and content data extracted from the website.

Machine learning techniques are only applied in the pattern discovery and pattern analysis phases, in order to find sets of Web users with common Web-related characteristics and the corresponding patterns. In this context, the most commonly used machine learning paradigms are unsupervised learning (or clustering), association rules, and paradigms used to find frequent patterns such as frequent episodes. In this first approach we used sequential representation of user sessions, PAM (Partitioning Around Medoids) [17] clustering algorithm and SPADE (Sequential PAttern Discovery using Equivalence classes) [18] to build user navigation profiles.

Once the machine learning algorithms have been applied, there is a phase of selection of the most meaningful patterns found. This selection could be made manually by experts in the area or, as in our proposal, it could be made based on the parameters of the machine learning algorithms used, so that the number and quality of proposed patterns is limited [19, 20].

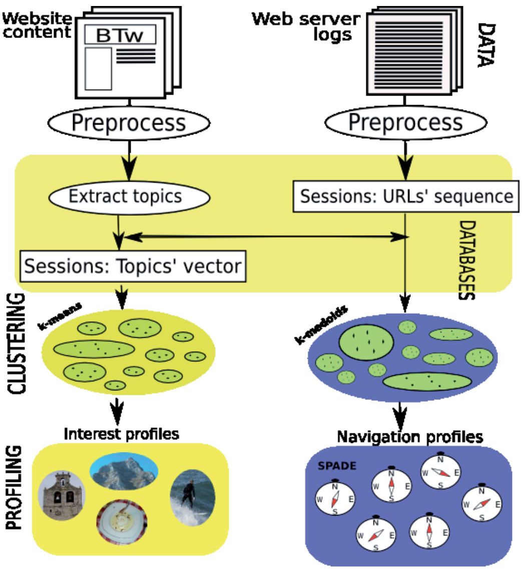

Figure 1. Description of the Web Usage and Content Mining processes implemented.

In our system we combined the output of the Web Usage Mining Process with Web Content Mining techniques to obtain more information about the users. The process of Web Content Mining also requires a data acquisition phase, which could be done by obtaining the HTML files of the whole website and extracting the text contained using an HTML parser. Natural Language Processing techniques (for instance, Topic Modelling [21]) then have to be applied to extract semantic knowledge from these texts [22].

We used this information to enrich the user navigation profiles generated based only on usage information [23] and to profile the interests of the users navigating in the website.

The user models we built using these techniques are useful for tailoring the interaction with the Web. We are currently studying the possibility of sharing or exporting these models in order for them to be used by adaptive interface generators in other contexts [24].

We are currently working on profiling functional abilities of the users, using data extracted from their Web interaction. With this aim we defined some variables containing information about the user abilities that could be automatically extracted from the server log data. For instance, for each user and session we extract information such as the number of different URLs visited, the average time spent on each URL (taking into account if the page is of authority type or hub type), the maximum and/or average depth of each session, the diversity in semantic content of the URLs visited, etc. We use these types of parameters to make assumptions about the possible limitations of the users (specific disabilities, how lost they are, etc.). The results can be used to enrich the recommendations generated using other strategies.

In addition, we have gathered information about techniques for adapting Web interfaces. The techniques have been classified into three general groups: those involving changes in the content displayed in the interface; those involving style changes in the interface layout, and those dealing with interface structure, navigation and behaviour. The total number of techniques identified and classified in this process was 99. We have implemented a Web service that applies these adaptation techniques. Up to now 48 techniques are fully implemented. We are currently investigating the relationships between user abilities and adaptation techniques to apply for improving their navigation experience in the Web.

4. Conclusion

In this paper we have presented a research work aimed at enhancing Web accessibility for people with temporary or permanent physical, sensory or cognitive restrictions. This is done by adapting the interaction system to the features, needs and likes of each particular user by means of user models. These models have been populated with information collected by Web mining techniques, avoiding preconceptions based on medical classifications. The resulting system creates different navigation and presentation schemes, tailored to each specific user, by reasoning about the model content.

As a future work we aim to develop a framework to allow not only the creation, population, and management of user models, but also sharing them [25]. The main objectives of sharing models are to avoid the proliferation of different user models for diverse applications and to provide user-adapted interfaces to supportive services provided through various technologies (including Ubiquitous Computing and the Web).

Acknowledgements

This research has been partly funded by the Spanish Ministry of Science and Innovation (ModelAccess project, grant TIN2010-15549) and by the Basque Governments SAIOTEK program (Datacc2 project, grant S-PE12UN064). EGOKITUZ belongs is funded by the Department of Education, Universities and Research of the Basque Government (grant IT395-10) and ALDAPA is funded by the general funding for research groups of the University of the Basque Country (grant GIU10/02).

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-433

Roadmap for Accessible Virtual Learning Environments

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Abstract. In this paper we analyze the future research topics that would have to be emphasized to improve the accessibility of Virtual Learning Environments (VLE). The analysis starts from the few previously available surveys on VLE accessibility and then complements this data by a questionnaire-based study with experts from industry and academia. The final results are mapped to the research lines and areas found in the EU Cardiac project showing that these provide a very good coverage of our requirements.

Keywords. AT Policy, Education and Training in AT, eInclusion.

Introduction

A Virtual Learning Environment (VLE) is basically a system designed to support teaching and learning in an educational framework. A Learning Management System (LMS) is a very related concept, and both terms are usually considered equivalent.

People with disabilities, obtain a great advantage from access to eLearning, regardless the educational modality: face-to-face, blended-learning or distance learning. However, as with many other products and services, they find important barriers, as Virtual Learning Environments (VLE) and their associated contents are not delivered in forms adapted to their needs and preferences.

VLEs are supported by a set of different technological layers. Those layers can interfere with the student's learning process performance. Conflicts with user agents, assistive technologies and the delivery format of the resources are among the most commonly found problems. VLEs are often used for communication with peers and tutors, sharing resources and collaborating on assignments and for assessments. As a result, the impact of an inaccessible VLE on a student's learning experiences and academic results can be very high [1]. Currently most educational institutions use VLEs, as part of all their courses and thus the impact of their inaccessibility in education must not be underestimated.

VLEs include most of the web's major tasks: collaboration and communication tools and final user generated content which are now aspects of Web 2.0. As such, the accessibility of current VLEs, a mature technology, provides a very interesting case study regarding the types of problems that can be encountered by users in current and next generation web applications [1].

This fact, together with their network based nature, was the main reason to propose VLE as a case study to contribute to the development of a roadmap for promoting e-

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inclusiveness in relation to accessible and assistive ICTs in the framework of the EU Coordinated Action on Research in Accessibility (CARDIAC) [7].

1 Methodology

This paper uses a two-step methodology. Initially we study what is currently available in standards and literature on the accessibility of VLE. For the standards we searched on the commonly accepted web accessibility standards (W3c/WAI), the common LMS standards (IMS) and the formal international standards (ISO). For the bibliographical study we searched the IEEE and ACM digital libraries as well as PUBMED and MEDLINE for accessibility and either VLE or LMS. These searches were used to select the previously available studies on VLE accessibility.

After conducting this analysis we found that there were an important number of unanswered questions. Thus we needed a method to solve them and look for further research topics in the area. The general approach in the Cardiac project was the use of online structured dialogue [8]. Our initial expert selection target was to get an equally distributed sample among eLearning researchers (from theoretical and/or practical perspective), eLearning strategists (including advisors, head of learning strategy departments,...), eLearning designers (teacher, tutor, content designer, content developer,...) and eLearning platform developers. The group we finally selected included 11 experts (4 researchers, 3 strategists, 3 designers and 1 developer).

After making the expert selection, providing them with the required background material and considering their real availability we had to change our approach and base the second part of our study on a questionnaire and a systematic analysis of the answers provided by the experts.

In the current survey we analyze the following VLEs: Blackboard (commercial, proprietary, popular), Moodle (freeware, open source, popular), and dotLRN (freeware, open-source, widely used). Initially we tried to include ATTutor in the survey, as this VLE was designed considering accessibility issues from the beginning but we found that only those experts with wide experience in VLEs but limited accessibility experience had very limited knowledge regarding this environment.

2 Bibliographical Survey

In our survey we analyzed relevant Standard and Guidelines as well as previously available published studies on the accessibility of the targeted VLEs.

2.1 Standards and Guidelines

After a search on the previously mentioned standard organizations the following specifications were considered relevant for the accessibility of VLEs:

- W3C Web Content Accessibility Guidelines WCAG 2.0 (accepted by ISO as ISO/IEC 40500:2012), Authoring Tool Accessibility Guidelines ATAG and W3C User Agent Accessibility Guidelines UAAG.

- IMS Guidelines for Developing Accessible Learning Applications GDALA, IMS Learner Information Package LIP, and Access For All v2.0 (accepted by ISO as FDIS 24751)

Legislation in several countries also has a very important effect on VLE accessibility. The best-known example is US Section 508. Most of these laws are broadly based on the W3C guidelines.

2.2 VLE Accessibility Surveys

As a result of our bibliographical search we found a set of journal papers related to accessibility of VLEs. In general we found two types of usability and accessibility related papers about VLEs: those based on survey and interview approaches [3]; and those based on empirical analysis [1],[4],[5].

Most of the outcomes of these papers are summarized by one of the most recent survey on the subject [1]. According to this study the main conclusions on the current state of accessibility in VLEs are:

- There are some serious accessibility issues related to the use of current virtual learning environments. Each tested VLE had accessibility problems that did not allow some users to continue when they were performing some basic tasks. These problems would greatly affect the student's learning possibilities and his or her evaluation results unless a mitigating strategy (probably based) on more direct contact with the tutor and providing personalized content in alternative formats is applied.
- All virtual learning environments had customized components and styles associated to the institutions in which they were deployed. In many cases, it was difficult to separate the problems associated with these 'in-house' styles and those of the VLE itself.
- There is a clear need to educate the individuals developing, deploying and procuring these environments about accessibility and which criteria have to be taken into account when adopting a VLE.

Some authors [2] have tried to develop a systematic approach to deal with the complexity of the eLearning Life Cycle and the difficulties associated to the management and integration of the afore-mentioned specifications and standards. This approach is based on the methodology described below:

- Categorization of the potential learners, in terms of disabilities.
- Identifying the content types contained in each didactical module. For every type of content, the methodology analyzes its impact on each of the categories of the learners in terms of physical accessibility and accessibility from a cognitive point of view.
- Inserting alternative content that corresponds to the critical content under consideration for the required category of learners.

2.3 Literature Survey: VLEs Accessibility Analysis

There are not many studies that deal directly with the accessibility of VLEs despite their clear importance for universal access and for providing equal educational opportunities for all the citizens.

In a general study [6] higher education stakeholders were asked to answer an online questionnaire and after analyzing the results the involved researchers planned a series of interviews. According to this study the most important reasons for the lack of accessibility in VLE were:

- Lack of technical knowledge by content's producers.
- Lack of accessibility of linked external contests.
- Insufficient and non-systematic testing.
- Accessibility of the base VLE platform.

A recent study concerning VLE accessibility [1] analyzed three commonly used VLEs: Moodle (version 1.9), .LRN (version 2) and Blackboard (version 8) using a two-stage approach. First, a heuristic evaluation of these platforms based on WCAG 1.0 guidelines was carried. In this initial evaluation all platforms got similar results bellow the single A accessibility requirements. The results show in general a similar number of accessibility violations in all three systems.

The second stage of the study was a limited end user evaluation using the same instances of the tools. Four blind, screen reader users, were asked to undertake a set of well-defined representative tasks in the VLEs. The results of this experimental study comply with guideline-based evaluation expectations in most cases. In this study generally Moodle and .LRN were better rated in this user based second evaluation than in the first one carried out by experts applying directly the WCAG 1.0 criteria.

3 VLE Accessibility: Questionnaire based Analysis

In order to complement the analysis based on literature review, a survey has been undertaken in the framework of the CARDIAC project research lines [7]. As a result of the literature review we considered that it was essential to answer the following question: "What mechanisms would ensure successful integration of accessible and assistive ICT products, services and standards in VLE and eLearning?"

To answer this question we selected a group of eleven experts from the academic and industrial fields, specialized on eLearning and/or Accessibility. Each expert was asked to reply to a short (5 questions) alternative based questionnaire [9] but also to provide his or her own personal suggestions to each topic.

One of the most accepted conclusions was that to have a successful accessible VLE (or, in general, any other accessible web 2.0 app or service) it is essential that accessibility is built into the design tools. In general the experts made clear that if the system tools did not made all the material added by the users "accessible by construction" it would be impossible to keep the VLE accessible even if it did pass accessibility evaluations at some stage or even periodically. This conclusion is directly related to research lines 9 (advanced design methodologies and tools) and 10 (test and evaluation methodologies and tools). More specifically research actions 9.2 (Tools to facilitate the creation of digital accessible material by non-accessibility experts) and the more generic research action 10.1 (Methodologies and tools for the development of accessible ICT) are essential to solve this problem.

A related issue is the problem of the inclusion of external material (not produced with the tools provided on the VLE). To ensure the accessibility of this material accessibility checker tools should be as automatic as possible and, as it is clear that as fully automatic checking will not be possible in the near future a crowd sourced based approach were users with the required characteristics are asked about those checks that can't be done automatically and are encourage to introduce their suggestions to accessibility problems could be a very useful alternative if this can be implemented in a way that is well accepted by the users. Apart from the already mentioned research actions 11.1 (methodologies to analyze collaborative accessibility) is very interesting in this context.

The experts also emphasized, the well-known fact that legislation (push or pull) may play in the future of accessible systems. This is related to research action 13.2 (ethical, legal and social implications).

Currently most mainstream VLEs already provide or are developing support for providing good quality mobile access to the environment. In general this is based either on html5 or in native mobile apps for the main smartphone platforms. This trend of accessing internet based services in general and VLEs in particular through different devices, which requires all kind of contents to be accessible through them, presents clear opportunities, as well as challenges, for accessibility. In general these aspects are specifically related to research action 5.9 (Enhance and universalize web 2.0 accessibility). As the main idea is being able to use the educational tools everywhere and even being able to select or adapt the contents according to the user location research action 6.1 (Mobile technologies as access interfaces for public and private ubiquitous environments) is essential for this purpose. Research action 7.3 (Interoperability of devices networks and services to enhance accessibility to ubiquitous computing environment) will be needed to guarantee that VLEs are kept accessible in these mobile scenarios. These complex scenarios may require adapting the user interfaces according to the context (Research action 5.6) and may lead to excluding some user groups (research action 1.2).

Many VLEs are already using cloud-based services and, in the near future probably most will be deployed through public or private clouds. This requires identifying the impact of cloud platforms on accessibility (research action 1.5).

Most experts from industry considered that it is not possible to go in a single step from the current situation to the ideal of having fully accessible virtual learning environments. Thus, they consider that intermediate situation in which only those modules of the system and those contents, which are considered more important, are guaranteed to be accessible. These tradeoffs require very good understanding of the user needs (research action 8.1), understanding clearly who may be excluded (1.2) and simplifying the user interaction while keeping the functionality (research action 3.3)

The need for open interfaces (Research action 7.6) on VLEs is not only related to the possibility of interfacing to AT devices but also to devices needed for other educational situations such as laboratory equipment.

4 Conclusions

We have presented the results of a bibliographical review and an expert based survey on the accessibility situation, requirements and needs for Virtual Learning Environments. We have also shown that the requirements for these environments are similar to many situations found in web 2.0 applications and services. Finally we have shown that to provide good accessibility to VLEs in situations that are already commonplace or will be so in the near future, the research requirements are covered very well by the research actions recognized in the Cardiac project.

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Education and Training in AT

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-441

Introducing Assistive Technology in the Formal Education of Healthcare Professionals

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Abstract. The paper addresses the issue of a curriculum innovation for nursing and allied health professions and presents the inclusion of assistive technology as a mandatory subject of the formal education of future health professionals.

Keywords. Assistive technology, training, health professional's education.

Introduction

During the last decades, the social movements in favor of the citizenship rights, the demographic pressures, the legislative changes and the increasing importance given to the quality of life had strong implications in the evolution of the concepts related to disability. These must be understood, nowadays, in accordance with an integrated and inclusive perspective that should take into consideration all the existing resources external to the individuals. Furthermore, the technological developments, namely in terms of information technologies (IT) had provided a broad range of resources with the potential to increase the freedom of choice allowing all citizens to participate in society with full rights, diminishing inequalities (transparent access to universally available opportunities) and to facilitate the inclusion of disadvantaged groups (*e.g.* elderly or disabled people) [1].

In order to take advantage of the on-going technological evolution, all the society, in general, and the healthcare formal careers, in particular, should be aware that assistive technology can represent facilitators to improve the person's functionality and help them to overcome environmental barriers. If the action of a health professional should not be evaluated just in terms of the performed procedures but also in terms of outcomes, then it is essential that they should be aware of the available resources.

The future healthcare professionals should acquire strong competencies in dealing with disability and, in particular, assistive technology should be included in their formal education.

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Although assistive technology is part of the formal education of some professions (*e.g.* occupational therapy) is hard to find references of formal education of assistive technology in medicine, nursing [2] and other allied health professions.

There is evidence that the professional practice can be improved if the health professionals have adequate training related with assistive technology [3, 4]. However there is also evidence that the healthcare professionals have insufficient knowledge related with assistive technology delivering [5]. Azevedo *et al.* [3] state that assistive technology training was more developed and explored in the formal education of rehabilitation engineers than in the formal education of health professionals.

The training in assistive technology is a concern of the European Commission that, in 1999, proposed a specific courseware (Increasing the Impact of Assistive Technology - Courseware for European Caring Professionals [6]) and, in 2006, supported a report with guidelines for assistive technology education and training [7].

In Portugal the only institution that has structured and systemized the inclusion of assistive technology in the formal education of nursing and allied health professions is the Health Sciences School of the University of Aveiro, which started its academic activities in 2001, with the following degrees: Nursing, Physiotherapy, Speech Therapy, Radiology and Gerontology. At the time, the Health Sciences School faculty decided that formal training on assistive technology should be present in the curricula of all the degrees. The formal training in assistive technology is part of a course called Special Needs that is composed by mandatory components, common to all degrees, and optional components tailored to each degree.

The Special Needs course intends to prepare the students to understand the up-to-date concepts related with disability and functionality. Furthermore, it emphasizes the added value introduced by IT to the assistive technology development, in terms of functions, size, weight and cost [7]. Additionally, the course emphasizes the variability and specificity of the needs of the potential users of assistive technology. This demands a user centered perspective, with the involvement of different stakeholders, not only transdisciplinary professionals, but also informal care providers, namely relatives, to correctly identify all the factors that should be considered for achieving the final solution.

This article aims to explain the conceptual framework of the Special Needs course and to describe its syllabus.

1 Conceptual Framework

The use of assistive technology by elderly and disabled people has the objective to contribute to the effective enhancement of their lives by helping them to overcome functional problems in order to increase their independence and autonomy and, consequently, to contribute for their integration within the family and society [3]. Independence, autonomy and quality of life should be important criteria to consider in rehabilitation or social support.

The devices related with assistive technology range from low-tech aids (*e.g.* built-up handles on eating utensils) to high tech devices (*e.g.* computerized communication systems) and they solve a broad range of daily problems [7]. Regardless of their type and function, these devices can improve the independence and autonomy of elderly and disabled people in their homes, self-care, mobility, communication, leisure activities and participation in major life areas as education, work or relationship.

The concept of assistive technology must be considered in conjunction with the design for all concept. Assistive devices represent an adaptation of the person to the environment, including technologies to overcome the environmental barriers or some limitations in a specific activity. Design for all is the adaptation of the environment to the person, it concerns to the products, services that should be developed and implemented to address all population. In the perspective of the International Classification of Functioning, Disability and Health (ICF) [8], assistive technology and design for all promote the elimination of environmental barriers. Recent studies reveal that there is a growing recognition that the role of environmental factors changed the focus of the interventions [9]. Disability is no longer understood as a single category, but rather the result of an interaction between an individual's health condition and environmental factors. Therefore, the environment where an individual lives must be inclusive.

The adoption of the ICF by the World Health Organization implied a paradigm shift in the way health and disability were understood and measured [10]. The ICF describes the health and health-related states of an individual and indicates the facilitators and barriers of the interaction between the individual (with a health condition) and the contextual factors (environmental and personal factors). The ICF model replaces the negative focus of impairment and disability by a neutral perspective embracing all components that promote or hinder the execution of the individual functions, both biological and social [8, 11]. With this paradigm shift, the disease is no longer seen as the only factor responsible for disability and impairments, but as one of the factors influencing health, such as environmental, social and personal factors [12]. The ICF emphasizes the importance of interaction between the health condition, the individual and the surrounding environment and highlights opportunities for technology and design solutions to support activities and participation.

Accordingly to ICF, assistive technology is classified as an environmental factor and has the objective to improve the performance of a person in specific activities and participation. Therefore, ICF is used as the theoretical framework of the Special Needs course.

Additionally, considering the strong impact of the IT in the development of assistive technology, the IT systems and services are strongly emphasized during the course. It is generally recognized the key role of IT solutions to enable innovative solutions, namely in what concerns to environment control, access to services and information, interpersonal communication or training and work activities. In order to improve the performance of an individual with limitations in activities or restrictions in participation, the use of IT based systems and services can be decisive to assist him/her in all areas of life. These systems and services play a key role in the interaction of users with the surrounding environment [13].

2 The Special Needs Course

The major objectives of the Special Needs course are:

- To understand the principles and concepts of ICF.
- To understand the added value of assistive technology.

- To apply comprehensive approaches to elicit the needs of their patients or clients and to propose and evaluate assistive technology interventions.

To achieve these objectives the course was organized into four modules:

- The disability concepts and their evolution.
  The concepts of impairment, disability and handicap according to the International Classification of Impairment, Disability and Handicap (ICIDH) [14] are introduced, as well as Fougeyroullas' disability creation process. Finally, the International Classification of Functioning, Disability and Health (ICF) is presented, namely its objectives, structure, application, universe, concepts and classification units.
- Assistive technology: evolution, characterization, models and solutions.
  The definition and characterization of assistive products is presented according to the ISO 9999: 2007. This module also includes the evolution of the concepts related with assistive technology, particularly the evolution from assistive products to assistive technology. Furthermore, the delivering process (acquisition and financing) of assistive technology is presented, as well the particular case of IT based assistive technology.
- Assistive technology and the major life areas: activities in daily life, communication, education and work.
  This module presents different possibilities to access IT systems and services and different solutions in terms of assistive technology to solve or improve activities and participation. In particular, home automation, augmentative and alternative communication or teleworking can be used as examples of how assistive technologies impact on the major areas of life.
- Environmental factors.
  Within the environmental factors module it is analyzed how the environment can improve the autonomy and functionality of elderly and disabled people and the relevance of design for all principles to achieve an environment with less barriers and more facilitators. Furthermore, the concept of Ambient Assisted Living (AAL) is introduced as an environmental factor that has impact in human performance and functionality. AAL enables the utilization of systems and services and the provision of distance services such as health care, helping to achieve autonomy and independence [13]. The AAL services and products are also presented as a solution of assistive technology [15].

The Special Needs course has been operational for almost 12 years and was taught to a total of 1673 students (Nursing: 740, Physiotherapy: 254, Speech Therapy: 233, Radiology: 253, Gerontology: 193).

3 Conclusions

The teaching experience with the Special Needs course has revealed that the health students are not aware of the conditions of elderly and disabled people. This can be partially explained due to their lack of maturity and life experience and, therefore, it is necessary to use strategies that allow them to engage to this subject.

The strategy used was to emphasize the added value of IT in assistive technology. This approach has succeeded because the students feel more willing to discuss technological solutions and understand the use of IT based assistive technology in specific contexts. This led the students to progressively reflect about the issues related with disability.

As future work, the authors are preparing an experimental study to evaluate the impact of the Special Needs course on the attitudes of the students related with disability.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-446

ADL Task Performance in Mobility Impaired Older Dyads: Preliminary Data from the *CG ASSIST* Pilot

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Abstract. The 'Caregiver Assessment of Skill Sets & Individualized Support through Training' or 'CG ASSIST' project is a feasibility study that was designed to adapt, implement and evaluate a comprehensive hands-on skills training program with family caregivers of older adults who required assistance with transferring and/or positional change during daily activities. Specific objectives were to (1) field test a comprehensive in-home intervention delivered by a clinical expert which included training in caregiving skills and provision of assistive technology; and (2) to compare two needs assessment procedures (caregivers' subjective self-reports of dyadic performance during ADL task execution and objective, observation-based ratings made by Clinical Experts as part of the comprehensive assessments in the CG ASSIST pilot study.) Ratings of ADL performance in 4 domains were examined using percent agreement (*P*++, Cohen's Kappa (*K*) and the intra-class correlation coefficient (ICC). In general, concordance was poor but varied by task and domain for: level of assistance (ICC=.36, *ns* -.84, p<.005), safety (*P*++ = .11 - .53; *K* = -.07 - .11, *ns*), satisfaction with skills (*P*++ = .42 - .75 *K* =.11 - .23, *ns*); and reports of assistive technology and environmental supports present (ICC = -.01, *ns* - .60, *p*<.005) and used appropriately (ICC = -.06, *ns* - .53, *p*<.05). All dyads received AT and training on the safe and appropriate use of the equipment until the caregivers felt comfortable with their ability to use the AT and the Clinical Experts rated appropriate device use as 100%. These data point to the importance of the periodic assessment of ADL task performance and evaluation of assistive technology used by dyads for ADLs.

Keywords. Assistive Technology, Telerehabilitation, Aging, Caregiving.

Introduction

1 Application and State of the Art

The increased prevalence of chronic, debilitating or disabling conditions in the aging population brings with it a concomitant rise in the number of family Caregivers (CGs) required to provide daily assistance to allow older adults to remain in the home. Caregiving can extend over many years and becomes increasingly more demanding as health and independence of care recipients (CR) decline. Caregiver research repeatedly concludes that, although caregiving can be a positive experience, it is,

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none-the-less, hard work and highly stressful [1].

The very large majority of caregiving research comes out of the field of human development and has been guided by stress and coping conceptual models, with resultant emphasis limited to the psychosocial aspects of caregiving. A wide array of interventions has been evaluated, such as face-to-face support groups and psycho-educational programs to reduce caregiver burden [2-4]. While helpful, these endeavors do little to mitigate the heavy burden posed by objective stressors related to the performance of basic activities of daily living (ADLs) such as bathing, dressing and toileting.

Caregivers providing ADL support to mobility impaired older adults fulfill what is essentially a clinical role for which the majority of them have had no prior skills training or practical experience [5]. Without appropriate resources and support CGs must strategize the most expedient solutions for helping complete these fundamental tasks each day. The resulting improvisations derived from the utilization of personal and environmental resources at hand, while admittedly quite creative and resourceful, frequently lead to one of two equally deleterious outcomes: (1) iatrogenic and excess disability in the care-receiver as a result of the CG providing a greater level of assistance than clinically necessary, or (2) injuries for one or both members of the dyad as a result of the caregiver providing a lower level of assistance than is clinically warranted. Both of these scenarios have the potential to exponentially increase objective burden and stress and in turn, exacerbate subjective burden and distress.

This paper examines concordance between caregiver appraisals of ADL task performance and objective observer-based assessments by a clinical expert. Supporting data are from the *Caregiver Assessment of Skill Sets and Individual Support through Training,* or *CG ASSIST,* Pilot Study, an in-home, hands-on, environmental, and educational skills training program for caregiving dyads which builds off of prior research efforts of the authors [6-9].

2 Methods

The *CG ASSIST* Pilot utilized a two-phase (baseline, post-intervention), two-group (intervention, no-intervention) design. Telephone interviews were completed with CGs of older adults to obtain baseline, self-reported measures of caregiving outcomes and processes including caregiver appraisals of assistive technology (AT) and environmental supports, CR dependency levels, safety, and satisfaction with skill sets for four ADL tasks. Following the interview, participants were randomized to an in-home intervention group or a no-intervention control group. Those in the intervention group received three home visits from an OT or PT Clinical Expert (CE) to (1) independently observe and evaluate the environment and dyadic ADL task performance (2) deliver the intervention and (3) reinforce the intervention. Follow-up interviews were conducted four weeks later.

The intervention consisted of in-home training in hands-on caregiving skills, provision of assistive technology (AT) and home modifications to support caregiving and reduce excess disability. The interventions were individualized according to the physical characteristics of the home environment and the care-partner dyad as well as the ability level, skills sets and personal preferences of each dyad. Specific problems that were targeted by the intervention included: A mismatch between appraisal of dependency level and amount of support provided, caregiving techniques that did not foster use of preserved abilities, inadequate AT or environmental supports, use of the existing AT inappropriately, and techniques that compromised comfort and/or safety.

3 Results

Nineteen female, spousal caregivers completed the intervention arm of the study which is the focus of this paper. Age for the caregivers ranged from 50 to 86 (*M*=71, *SD*=9.7) and 66-94 (*M*=71, *SD*=6.9) for their care-partners. Close to ¾ of the dyads were Caucasian. Almost all of the caregivers were retired or had left their jobs due to either their own health problems or the increased responsibilities of caring for their spouse. Over half the sample (52%) provided care for a CR with a diagnosis of dementia. CRs had an average of 4.0$\pm$1.2 health conditions and CGs reported 2.3 $\pm$1.4 health problems of their own.

We examined Caregiver/Clinical Expert concordance for the four ADL tasks each with seven possible levels of dependency rating using the intra-class correlation coefficient (ICC) with a two way mixed model and measures of absolute agreement treating raters as a fixed factor. We included ICC coefficients for single ratings as well as the mean of the ratings (which produces a coefficient virtually identical to Kappa). Significant ICCs indicative of CG/CE concordance ranged from .36 (*ns*) for toileting to .84 (p<.005) for dressing. Although the ICC coefficients appeared to indicate concordance between CG and CE ratings many of the confidence intervals included 0 and there was a great deal of disagreement for individual subjects as evidenced by scatter plots.

To better demonstrate the disparity in CG and CE ADL dependency ratings we collapsed the seven levels into three clinically meaningful categories of assistance: >50%, <50% or No Assistance needed. For in and out of bed the absolute agreement (*P*++) was .64 meaning CGs and CEs agreed on 64% of the cases, but Kappa (*K*) was .06 and not significant (*ns*). Likewise for dressing, agreement was .53 but *K* was .11 (*ns*). For toileting and bathing assistance absolute agreement was .65 and *K* was .43 (p<.005) but the concordance distributions looked very dissimilar for the two tasks even with identical (*P* ++) agreement and *K* values.

Figure 1 is a graphical representation of a cross-tabulation of the collapsed dependency ratings by Caregiver and Clinical Expert for each of the ADL tasks. There was 0% agreement across all tasks on the "No Assistance" category; therefore this category is not shown in the graphs but did represent a number of cases across tasks rated by the Caregivers, but not the Clinical Experts.

The CEs rated safety concerns for each of the activities after observing the dyads perform the tasks. The safety concerns composite measure ranged from 0 to 11 ($\bar{x}$=4.1 $\pm$ 2.5). Overall, concordance for ADL task safety between the Caregivers and Clinical Experts was low. For in and out of bed safety there was absolute agreement (*P* ++) for 33% of cases and Kappa (*K*) was .11(*ns*). There was equally poor concordance for dressing (*P* ++ =.53, *K* = -.06 *ns*); toileting (*P* ++ =.27, *K* = -.07, *ns*); and bathing (*P* ++ =.25, *K* = -.03, *ns*). The non-significant values indicate a lack of agreement (beyond chance) between CG and CE in terms of safety ratings. In fact, some of tests resulted in a negative *K* coefficient which means not only **failure** to show agreement beyond chance but indicates two observers agreed **less** than would be expected by chance.

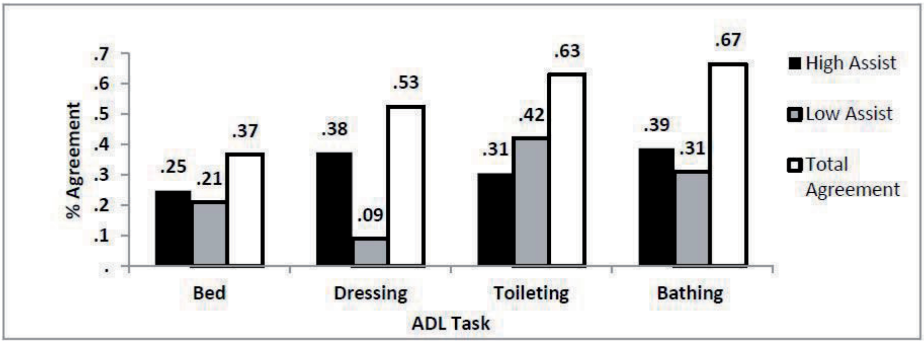

Fig. 1. Caregiver/Clinical Expert Agreement for ADL Assistance by Task.

We also examined CG and CE concordance for the number of environmental features present and used within the home. These included AT such as grab bars or bath benches as well as other environmental features within the home used to facilitate each task. There was poor concordance on features present (r=.21 or used r=.38). With the exception of getting in and out of bed, the Clinical Experts rated more features as being present within the home than did the Caregivers. The greatest discrepancy occurred for toileting. Toileting also showed the greatest discrepancy for mean number of features used appropriately with Caregivers rating more features as being used than the Clinical Experts recorded through direct observation of the tasks.

The Clinical Experts composed adaptive prescriptions for each dyad after the in-home assessments. Recommendations were made in four categories: Equipment and AT devices (i.e., grab bars, bed rails), physical modifications (i.e., moving throw rugs, re-arranging furniture), adaptive methods (employing different strategies and methods to facilitate assistance and increase safety such as triangle of efficiency or new transfer method) and energy conservation (slow down, avoid tasks when tired). The CEs made a total of 729 recommendations across the four functional activity tasks. There was a great deal of variability in the number of recommendations within and between recommendation category (0-29). On average the experts made recommendations for 7 ± 4 physical modifications, 13 ± 11 adaptive methods or strategies and 10 ± 10 energy conservation methods.

The therapists provided between one and nine new devices to each dyad ($\bar{x}$= 4.1 $\pm$ 2.2) for a total of 78 devices delivered. The CEs delivered a variety of different devices to the intervention dyads. All dyads received at least one device; 89% of dyads received more than one type of device and 42% received more than one of a given device. **Figure 2** illustrates the percent of dyads receiving the assistive technology devices by device type.

All dyads received training on the safe and appropriate use of devices until the Caregivers felt comfortable with their ability to use AT and the Clinical Experts rated appropriate device use as 100%. Provision of AT and training on appropriate use led to significant improvements in safety concerns and self-efficacy (data under review).

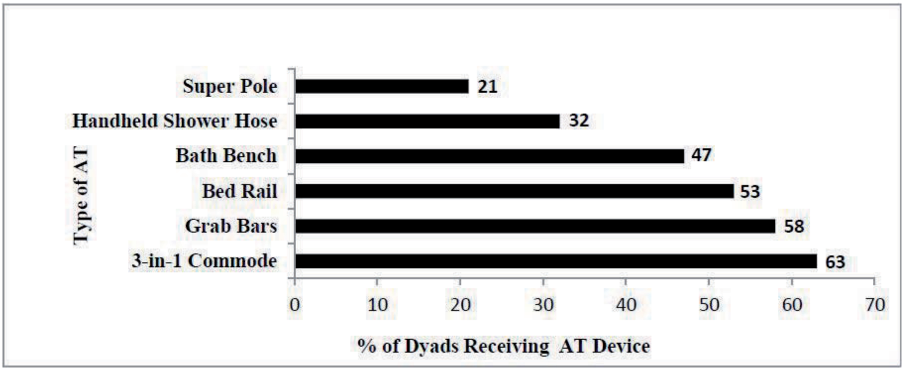

Fig. 2. Assistive Technology Devices Provided by CG ASSIST.

4 Contributions and Conclusions

These data point to the importance of the periodic assessment and evaluation of ADL task performance as well as the assistive technology used by dyads to perform daily tasks. Only two tasks had fair to moderate concordance for level of CR dependency or amount of assistance provided. The other tasks had poor to very poor concordance. There was equally poor concordance for safety concerns, and environmental features present or used appropriately. The collective lack of concordance for multiple aspects of ADL task performance between the Caregivers' subjective appraisals and the Clinical Experts' assessments is concerning for many reasons. If a mismatch exists between capacity and performance such as these data suggest for dependency level, a CG can provide alternately too little or too much assistance which can lead to injury for one or both members of the dyad. The lack of concordance for safety appears to be explained by the CGs reporting more safety concerns than the CEs. This could be because the majority of the CGs in this sample aged into the caregiving role. These were not acute injuries or newly impaired CRs. Thus, like many older caregivers, these subjects had no frame of reference for performing these tasks. Having moderate to extreme safety concerns while helping perform these very basic and necessary activities of daily living day after day has major implications for erosion of confidence and self-efficacy. This in turn, can exert a deleterious impact on subjective burden and depression in caregivers – both predictors of injury, illness, mortality and institutionalization of the care receivers.

None of the CGs in the sample reported receiving any training prior to the *CG ASSIST* Pilot intervention. While these findings are exploratory due to the small sample size, the large number of dyads we had to turn away when enrollment ended as well as the amount of both AT and training provided to the dyads demonstrates the tremendous need for an in-home training program. After the CG ASSIST Pilot, caregiver assistance was eliminated entirely for some tasks freeing up these tired CGs for other activities (or the chance to sleep in). Finally, report after report from the CRs made it clear that they relish their independence and wish to do as much for themselves as they are physically able (and have the necessary AT) to do for as long as possible.

5 Planned Activities

Sustaining CGs and their ability to provide care at home is crucial to our health and long-term care systems. Furthermore, and of equal importance, Caregivers are often the key to aging in place (or with choice) for many elders who can no longer independently care for themselves. Results from the *CG ASSIST* Pilot led to successful funding for a four-year randomized, controlled trial (RCT) currently ongoing. The primary objective of the RCT is to document that participation in the *CG ASSIST* Program will result in improvements in caregiving processes (i.e., skills) and outcomes (i.e., safety) compared to the current standard of care and have beneficial direct and indirect effects for both members of the caregiving dyad. Secondary objectives are to determine the effects of the program on CR and CG self-efficacy and subjective well-being (depression, quality of life) and to compare the relative effectiveness of two validated implementation modalities, the traditional in-person approach and real-time interactive video tele-conferencing (VTC). The addition of the VTC arm draws upon our previous research efforts [6-11] and will potentially reduce the costs associated with this labor intensive intervention allowing a greater number of dyads to be 'seen' and served by therapists.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-452

Presentation Software: Is It One Way to Make Games with Educational Purposes?

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Abstract. Since 2000 we encourage our students, future therapists or support teachers, to make personalized educational activities and games, in particular when commercial products are not available. So we aim to describe this experience and, through an on-line questionnaire, we analyze the professionals' opinions about the impact of learning how to use presentation software to make games in the present-day. Most former students mentioned that they design and implement part of the didactic materials used in their work with the clients and families. The main pros of this skill are the possibility to individualize the materials to the users and, in the long run, the time savings (just adapt the materials template). The main con was the time consuming of the initial prep work.

Keywords. Presentation software, games, pedagogic activities, independence

Introduction

Since 2000, we encourage our students, future psychomotor therapists or support teachers, to make personalized educational activities and games, in particular when commercial products are not available. Presentation software is a familiar tool to students as a way to make presentations, and it is available in most educational and rehabilitation settings. So we aim to describe the experience of using presentation software to make educational activities and games. We also analyze the professionals' opinions about the impact of this skill in their professional life. We aim to contribute to the awareness of presentation software as one additional resource to help practitioners that support people with some kind of activity limitations or participation restrictions.

1. Presentation Software and Games in the Literature

There are few studies relating presentation software and games, but the power of games and fun in the learning process is well documented. Here we are going to refer to some different approaches to this problem inspired in the literature.

Hadgood and Ainsworth [5] explored the potential of games in the learning process of children, in particular the value of intrinsic integration games, and concluded that "the value of and relevance of this issue as worthy of future investigation within the field of game-based learning" [5, p. 202].

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In [1], the authors state that games, humor and fun activities are the proposal for a more effective teaching in nursing and midwifery professionals' education. They also review the benefits and limitations of using humor in education, concluding that for the younger generations it's fundamental to provide a meaningful and useful learning experience at the same time that teaches the future professionals coping skills.

Other authors suggest the use of spreadsheet as a tool to replace commercial games "by combining the multimedia capabilities of current spreadsheets with their primary forte of transparent calculation, complex games scenarios can easily be prepared" [3, p. 300].

The use of gaming to improve English literacy is the proposal of Walsh [13] that proved the students engagement in English through activities of research, gameplay and design of digital games. The same results were found in a similar study made by Beavis and O'Mara [2].

Homemade PowerPoint Games is a concept defined and researched by Siko and his team [10-12] exploring the software potential to be an instructional tool that they believe it can be applied in a variety of classrooms. They propose a 3 stage progression, where students initially play existing games, than modify existing games and finally create their own PowerPoint games in teams.

Other way to use PowerPoint in the classroom is presented by Price [9], embedding slides in "immersive environments" created with computer game software like UT2004. This process is named as UnrealPowerPoint© by the author, and he advocates that the process has great potential to produce educational material, and help to understand individual and collaborative learning (via log files of the students' activity).

Kwon [8] is researching the implications of the use of educational/training computer games in students with disabilities and concludes that: there are tools available for nonprofessionals to develop games with home computers with low or no budget; thus enabling teachers, clinicians, parents and practitioners to develop more individualized games and activities and probably more adequate to respond to the variability of needs of this population than mainstream games.

2. Our Work

In late nineteen ninety's, we were involved in European projects concerning the design and use of new technologies by elderly people and children/teens with visual or intellectual disabilities. We were the users' needs experts' partners that made the liaison with prototype developers. Our partners were mainly technical experts that spoke a foreigner language: engineer jargon. To better understand the communications problems with our engineers' partners, allow us to tell a little anecdote: We participated in an European project to develop assistive technologies to support learning and mastering work tasks by people with intellectual disability. Within this context, it was agreed among the Portuguese team to adapt a netbook to be used with an interface of only one button. The first prototype had seven 'must have' buttons, the second five 'essential' buttons … and after many trials and prototypes we got the two buttons' (one hidden) final version. Thus, we learned that working in a multidisciplinary team, gets the work done and produces good results, but can take some time and lots of iterations of negotiation (and learning new 'foreigner' languages).

During the Euro introduction, people had lots of problems and resistances associated to this new currency. At that time, we were working with a group of elders that asked our help to learn how to use the Euro, as well as how to use the ATM. First we thought of going to our technological partners, but that probably would take too much time within the available timeframe. So we look for other alternatives that would be compatible with our own limited technological skills and even more limited budged.

As teachers, we used presentation software daily, and suddenly we realized that it could be the solution we were looking for. Making a long story short, we were able to produce the game that could teach the use of Euro currency, and also we were able to produce an ATM simulator with the help and resourcefulness of our students (fig. 1).

Figure 1 - ATM simulator

A new skill and tool was discovered: presentation software could be used to produce games and simulators with some imagination and the help of hyperlinks and animations features. So we began to teach how to use presentation software and other office tools to produce games or other didactic materials. We suggest to our students to design and implement at least one pedagogical activity to a person or a group with some kind of activity limitations or participation restrictions. In this way they can learn the process of producing the activity with our supervision and then evaluate the success and difficulties created by their own proposed solution. The work is done by a group of students and the feedback of the people that play their game or activity has always been consistently positive. The students produce a great variability of games and activities: develop from social to motor or cognitive skills; group or single games; interaction with peers, family members or friends; to collaborate in the follow up of the activity; the potential is only limited by the imagination of the students or professionals (see examples in fig. 2 - 6).

The literature shows that computer games and pedagogical activities can be considered as working tool to teachers and therapists, and this is also our personal believe [1-13]. Yet, till today, we did not measure the real impact of learning this specific skill in the daily practice of the professionals. Also no study was found in the literature similar to the work presented here.

3. Method

To measure the impact of our work we designed an on-line questionnaire open to all former students. The study variables were: gender, age, professional experience (number of working years), professional situation (unemployed or working in a different area, student, and work partial or full time in the area). The opinions asked were about the: importance and difficulty level of learning how to create pedagogical activities in computer; benefits and barriers of self-design the materials and finally the frequency of designing and applying games and pedagogical activities in their practitioner life.

Figure 2 – Activity to teach some basic sign words and sentences to children.

Figure 3 – Recycling game.

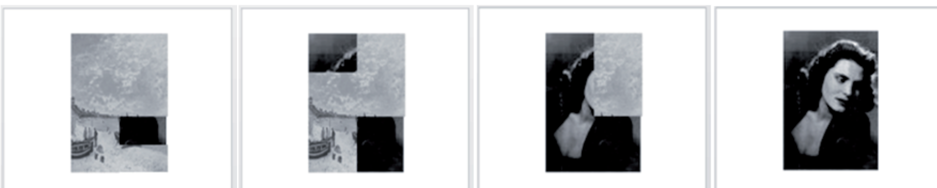

Figure 4 – Sequence game design to an elderly group (identifying famous people).

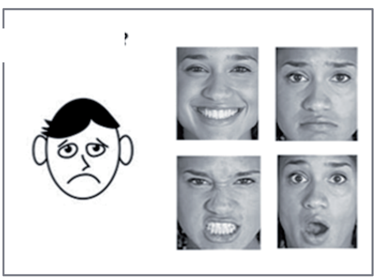

Figure 5 – Identifying facial expressions game.

Figure 6 – Social skills game.

3.1. Sample

We had approximately 430 students of 'Special Education' and 'Psychomotor Rehabilitation' higher education courses, so most of them are now therapists and some are support teachers. From those former students, 48 answered our on-line questionnaire. The sample gather participants from the initial class of 2000 to the latest of 2012 (M=2006.85, SD=3.21), and also most of them are women (90%) just like we normally have in our classes. Ages ranged from 21 to 36 (M=28, SD=4) and were in the working market for at least 6 years in average (SD=3). Regarding the practitioner situation, the majority is working full time in the degree area (67%), 8% also work in the area but in partial time, 19% are presently unemployed or are working in a completely different field, and finally 6% are back being full time students. No support teacher answered the questionnaire.

3.2. Results

The first two questions were related to the learning experience of our former students. In relation to their opinion about the impact of learning the computer skills to produce didactic materials, most participants rated 4 (M=3.98, SD=.89), being 1 'a total loss of time' and 5 'very important'. Similar rate got the question about the difficulty they felt in the learning skill process (M=3.75, SD=.91), being 1 'even during classes I did not understand it' and 5 'surprisingly easy'. So it is fair to say the students liked and think that is an easy skill to learn.

To analyze the practitioner use of this skill, we isolate three variables: making materials, applying materials and relevance to the profession, namely:

- The majority, 65%, of the former students made games or materials to practitioner use. In relation to the frequency the mean is 2.23 (SD=1.73), being 1 'sporadically' and 5 'regularly'. The majority produces didactic materials (52.1%) and 45.8% also design games.
- The numbers are similar to applying games or self-produced didactic materials: 62.5% participants respond positively. In relation to the frequency the mean also is 2.23 (SD=1.86).
- When asked to grade the impact of learning this skill to their practitioner overall performance between 1 'irrelevant' to 5 'fundamental' the result was a 2.77 (SD=1.61).

The answers to those questions were mainly influenced by age and experience of the participants as seen in table 1.

Table 1. Significant Spearman's correlations (n=48).

	Age	Practitioner experience
Frequency of designing games and pedagogical activities in their practitioner life	.370 (.010)	.416 (.003)
Frequency of applying self-made games and pedagogical activities in their practitioner life	.388 (.006)	.452 (.001)
Impact of learning this skill to their practitioner overall performance	-	.292 (.044)

The pros and cons were asked with two open questions: 'What are the main pros/cons of using self-made pedagogical resources by the practitioners?' The answers were categorized by us as follows: So the benefits mentioned by the participants were: all agree that is a great way to save time in a long run; 89.6% the possibility to create individualized materials (to meet the users' needs); 64.6% the possibility to adapt the materials in an easy way; 31.3% mentioned the motivation factor (to allow the choice of desirable themes and topics according to each user); 25% like to master all aspects of the process (design, make and implement the game/material); 6.3% refers to the low cost; The main barriers identified were: 47.9% the time consuming of the process; 12.5% have low IT skills and without any desire to change it; 12.5% mention the boss's negative attitudes towards technology; 10.4% have lack of hardware in the institutions and 12.5% did not mention any kind of barriers. When asked if they were willing to collaborate in a peer net to share resources 83.3% said yes (even if only 75% presently are identified as full or part time practitioners').

4. Conclusion

"Computer and video games have much in common with the strategies used in special education" [8, p.87]. The same author also defends that teachers and other practitioners "now have the capacity to develop games using a low budget and a little self-teaching" [8, p. 96]. The opinions given by the former students confirmed this and our personal believes: they liked and consider important to have a tool that enables them to produce specific material to work with people who have some kind of activity limitations or participation restrictions.

The main surprise of these results was the negative attitudes towards the use of technological solutions from some bosses, which think it's a waste of time to prepare good materials and to use computers with people who cannot read or write.

The use of presentation software can be a powerful tool to practitioners that understand people needs but don't have resources, human and/or financial, to buy or develop didactic materials to meet their needs. The next step is to find new ways to allow professionals to collaborate with each other and achieving more resources to their daily practitioner.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-458

Promoting Assistive Technology Competence among Care Staff in Europe

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Abstract. Care workers have the potential to play a fundamental role in advancing Assistive Technology (AT) in Europe. The use (or non-use) of personal enabling technology heavily depends on the awareness of the care workers and on their professional preparation. Whilst this is especially the case in care homes, nursing homes and other larger institutions, it is equally applicable to the (much larger) group of people with disabilities who are cared for in their own homes. Nevertheless many professional standards in the care sector, and the training leading to them, lack any specific reference to the importance of AT for the participation and inclusion of people with disabilities and elderly, and how this is related to the spirit of the UN Convention on the Rights of Persons with Disabilities. In this paper we will report on how the European Care Certificate (ECC) has recently updated its standard and adopted articles on enabling equipment, thus paving the way for a better preparation of the workforce with benefits for the entire social care environment.

Keywords. AT Training, Professional development, European Care Certificate, UN Convention.

Introduction

The European Care Certificate (ECC), the first European basic care certificate, is the first small step towards ensuring the consistently high quality of social care services across the European Union [1]. A partnership involving 16 member states (with more joining over time) has created an agreed definition of what staff need to know as a minimum to work in the social care sector in any member country of the EU.

The vision for the future of social care in the EU is that anyone who is working in social care services in any EU state will be able to access the ECC exam, sharing the same values and knowledge base in their work, creating a common foundation in care services across all of the EU. Workers can use their ECC in any country as a demonstration of their knowledge of the basics in social care. Employers will then be confident that the worker shares the same value base and has the right basic knowledge. The ECC will improve employability and worker mobility across the EU in a sector where the majority of workers have no training or recognised qualification in care at all at entry level. It will provide millions of care workers across the EU with a way of having their knowledge recognised and independently assessed.

These definitions are called the 'Basic European Social Care Learning Outcomes' (known as the BESCLO for short) and they are the main content behind the ECC. The ECC is awarded to anyone who passes the ECC exam and so can demonstrate that they have a good knowledge of all the areas of the BESCLO.

The BESCLO was initially created (in a first project 2006-2008) [2] by looking at what induction level training was included in partner states (in some it was non-existent). This produced a list of possible essential items of knowledge. We then refining that by asking employers and workers what they felt was universally essential. The next challenge was to see if this body of knowledge could be reliably tested for in a single uniform exam across all the partner states. We found it could.

The second project (2009-2011) [3] built on the success of the first, rapidly expanded the user base to 16 countries and developed an online version of the exam. The feedback from trainers, employers and workers was that the BESCLO was highly relevant to their work and that the questions in the exam did in fact test for this knowledge. Data on more than 3,600 candidates is now held in a central database and the exam pass rate is around 60%.

In the final project (2012-2014) [4] we are expanding the use base even more, developing a training course to deliver the BESCLO and a 'train the trainer course' to help new trainers use this new course. In the lead up to that project the Board of the ECC also agreed to revise the BESCLO to include specific reference to knowing about the importance of AT in care work and the contribution it could make. It was also agreed to include the UN Convention of the Rights of Persons with Disabilities (UNCPRD). This paper focuses on how this was achieved.

1. Size Matters

In the early days it quickly became clear that, although it was possible to construct the BESCLO, the major difficulty was in keeping it small enough to be manageable and to keep the focus on the social model of disability. In addition, there was always the issue of how well statements agreed in English (the working language of the project) would translate into other languages. The same language issue also meant that questions for the ECC exam had to carefully and very clearly formulated, so as to be capable of a true/false answer.

In addressing the later revision to the BESCLO to include AT, this issue was raised again. In making these changes it had to be kept in mind that the BESCLO:

- Is set at entry level – ie; at induction for a worker new to the sector.
- Needs to cover countries where AT in care was not (yet) widely used.
- Is a knowledge award, which also tries to examine understanding and attitudes.
- Already has a framework into which AT and the UNCPRD must be easily fitted.
- Can not afford to become significantly larger, without risking losing its universal applicability and ease of use for new workers.

The BESCLO consists of 8 main areas. These are:

1. The Values of Social Care
2. Promote Life Quality for the Individuals you Support
3. Working with Risk
4. Understand your Role as a Care Worker
5. Safety at Work
6. Communicating Positively
7. Recognise and Respond to Abuse and Neglect
8. Develop as a Worker

Each one of these is broken down into smaller areas referred to as Learning Outcomes. The Learning Outcome approach is now the basis for a major reformulation of all learning from secondary level up to high degrees in all EU states. It focuses not on *how* something is learned (eg by attending 25 hour long lessons on a Friday at 15.00 hrs) but rather on the *fact that you can demonstrate that is has been learned.* So, for example, in the BESCLO one learning outcome (1.5) in the area of the Values of Social Care is that the worker 'understands the limits of confidentiality.' The fact that this has been learned is demonstrated by the student being able to "outline why and when confidential information may sometimes need to be passed on, giving examples." Each of the 53 separate Learning Outcomes is accompanied by a corresponding definition of what proof of learning is needed. The BESCLO is a knowledge based set of learning outcomes, but this approach is equally applicable to competences and learning outcomes based on the demonstrable ability to do something (eg build a wall, bake a cake, use a particular software programme, drive a car to the required standard).

2. How we chose the BESCLO additions in AT

The original BESCLO standard had no reference at all to AT or to technology in care, notwithstanding the pervasiveness of technology in people's lives and living environment. Once the Board of the ECC had agreed that there was a clear need to update the BESCLO standard the question became: "What is the minimum essential knowledge every care worker in Europe should have about enabling technologies to better serve the needs of their clients and to support their quality of life?"

Answering this question is easier said than done and the final proposals would also need to be acceptable to the Board of the ECC. A small groups of experts was assembled and, starting from the outcomes of the *Keeping Pace with Assistive Technology* project [5] and the *Impact in Europe* project [6], a draft list of learning outcomes relating to AT was defined. These were classified in three areas:

- Enabling personal assistive technologies and their impact
- Alternative communication
- Technology to enhance safety of the care worker and the client

These learning outcomes were discussed in a focus groups with AT experts in Italy and following adjustments shared and discussed with a group of multiple stakeholders of the European Association of Service Providers to Persons with Disabilities. It was decided not to create another learning area within the BESCLO, but rather to include the new learning outcomes in the existing areas. This was consistent with the approach that understanding the potential contribution of AT to care work is not easily defined or capable of being limited to a few specific areas. Instead workers need to understand the full breadth of the concept of AT (eg not every piece of AT equipment has a microchip in it) and be alive to the possibilities which it might bring to a particular individual or a group.

The working group were conscious of the need to focus any additions to the BESCLO to have the maximum effect. They therefore suggested a mixture of additional words and/or Learning Outcomes, reinforced by additional text in the Guidance Notes. The final debate at Board level in the ECC underlined the wisdom of the 'less is more' approach adopted by the working group, with the vast majority of the proposal being accepted. Work is now underway to agree additional questions to the ECC exam, which, along with all the concomitant translations, will then need to be inserted into both the paper and online versions of the exam.

3. Additions to the Standard BESCLO agreed

For reasons of space we only report the areas and learning outcomes (LO) of the BESCLO affected by the additions. The additions are highlighted in **bold.** The full BESCLO is downloadable from the www.eccertificate.eu web site.

Area 1. The Values of Social Care

LO 1.1. Understand the need to promote the following values at all times: individuality, rights, choice, privacy, independence, **participation**, dignity, respect and partnership.

Explain why it is important to promote these values in everyday work, ***link these values to their own current policy & legal frameworks (eg the UN Convention on the Rights of People With Disabilities****) and give examples of ways this could* ***(and should)*** *be done.*

LO 1.2. Understand the need to promote equal opportunities for the individual(s) you are supporting.

Guidance note: the learning content should explain how enabling technology can facilitate equal opportunities. Eg people using computers and special hardware and software for learning, work, communication; powered wheelchairs and scooters to move around in the community.

LO 1.4. Understand the importance of confidentiality.

Guidance note: eg how 'new media' (such as Twitter, Facebook, mobile photo messaging etc) lower the barriers to communication, but increase the chances of confidentiality being broken. Eg a care worker publishing pictures of service users on their own Facebook page without consent.

Area 2. Promote Life Quality for the Individuals you support

LO 2.3. Understand the need to enable the individual(s) you support to control their own lives and make informed choices about the services they receive.

Explain why it is important to empower the individual(s) s/he supports to take control of their own lives ***and how this links back to the rights based approach of the United Nations Convention on the Rights of People With Disabilities & related documents.***

Guidance Note: eg the Council of Europe Disability Action Plan, European Disability Strategy 2010-20

LO 2.4. Be aware of the impact of assistive devices on the quality of life and participation of the individuals you support.

Explain the benefits of information and communication technologies and of environmental adaptations for the empowerment, inclusion and participation of persons you support and the consequences of inappropriate, malfunctioning or broken personal equipment, eg. mobility scooter, wheelchair, hearing aid, computer, etc.
Explain the rights of persons you support to access their enabling equipment.

Area 5. Safety at Work
LO 5.3. Know safe moving and positioning techniques in relation to people and/or objects.

Explain (not demonstrate) how to move and position people and/or objects safely, maintaining the dignity of the individual involved
Explain the advantages of using aids for moving people, such as lifts, hoists, motorised /adjustable beds, etc.

LO 5.14. Know the most common devices for the safety of the people you assist and provide examples of their use and benefits.

List the most commonly used safety devices and describe their benefits and areas of application.
Guidance note: the examples chosen by candidates may well reflect country-specific situations & practices (eg not many examples from independent living projects are possible)

Area 6. Communicating Positively
LO 6.4. Understand the basic forms of verbal/ non-verbal and alternative communication and how to use these in your work.

Describe how verbal, non-verbal ***and alternative*** *communication can be used to promote effective communication, including:*

- *what 'verbal communication' means, giving examples*
- *what 'non-verbal communication' means, giving examples*
- ***what 'alternative communication' means, giving examples (eg sign language, use of pictures and symbol systems, easyread documents etc)***
- ***the use of 'high' and 'low' tech devices to facilitate communication***
- *aspects of verbal and non-verbal communication that may differ between cultures*
- *how to use active listening effectively* ***and understand the need to allow some individuals more time to communicate at their own speed***

Area 7. Recognise and Respond to Abuse and Neglect
LO 7.1 Know what the following terms mean: Physical abuse, Sexual abuse, Emotional abuse, Financial abuse, Institutional abuse, Self neglect, Neglect by others.

Guidance note: learning should include issues related to the risks of abuse (eg psychological, sexual and financial) which can occur on the internet.

4. Conclusion

Following the update of the standard the new ECC training course and the exam question bank will be updated as well. It is expected that this process will take some more months to be completed and agreed. The ECC, as defined by the BESCLO, has now been formally accredited in the UK by Ofqual, the body which regulates UK qualifications and Awarding Bodies. It has been set at Level 2 in the Qualifications and Credit Framework, which equates to Level 3 on the European Qualification Framework. As a result of the strict usage of terms like 'Award', 'Certificate' and 'Diploma' which relate to the size of qualifications, the ECC in the UK will be known as 'The Award in European Care'. This follows other examples of accreditation in other countries such as Hungary, Romania and the Czech Republic.

Over the next few years there will be a careful monitoring of the new articles in the BESCLO. This will allow final evaluation with the target group, and, if necessary, their revision.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-467

Application of Cursor Movement Control Software to People with Physical Disabilities: Two Case Studies

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Abstract. The purpose of this study was to evaluate the effectiveness of cursor movement control (CMC) software and develop useful techniques for pointing device operation by people with physical disabilities. To accomplish this, experiments were conducted with the cooperation of users with spinal muscular atrophy (SMA). The results showed that, for a user who faced difficulty in operating a pointing device in specific directions, the CMC (separate control mode) application was effective because improvements in the usability could be achieved while making use of the user's ability. For a user whose operation was found to alter the direction and amount of cursor movement, the results suggested that an appropriate control mode would be to adjust the cursor movement by the same amount in all directions, which could reduce the physical burden on the user. In future work, we will make the CMC software available and will consider additional case studies.

Keywords. Pointing Device, Computer Accessibility, Spinal Muscular Atrophy, Progressive Disease.

Introduction

To enable people with physical disabilities to use a personal computer, it is essential to adapt input devices such as the keyboard, mouse, and switch to their physical abilities and the living environments in which they will be used [1], [2]. When voluntary movement of the upper extremity is possible but when it is not possible to input characters using a keyboard because of limited excursion or paralysis, in many cases, an input device adapted for the user and an onscreen keyboard are used. Various techniques have been developed to allow an individual to acquire the target on the screen. There are bubble cursors [3] or a method that combines an area cursor and sticky icons [4]. However, for these methods, it is necessary for users to have physical motor functions to move a cursor in the intended direction and distance to be able to approach the target. Consider the case of users suffering from functional motility disorders caused by the existence of limited excursion and muscle weakness in either

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the nerves or the muscles influencing the movement of the distal interphalangeal (DIP), proximal interphalangeal (PIP), and metacarpophalangeal (MP) joints because of joint stiffness or muscular atrophy such as amyotrophic lateral sclerosis (ALS) or muscular dystrophy (MD). When such a user performs operations using only an index finger on a trackball, it would be a problem to move the cursor to the extent and in the direction desired by the user. To deal with these problems, there are many adapted input devices and software, such as trackpads, joysticks [5] and the mouse driver [6], which can change the x and y coordinates every 90 degrees. However, to tailor them to individual user abilities and an operating environment, a more flexible technique that adapts to the users needs is needed so that the cursor can be set to any movement direction and amount without being dependent on the type of pointing device.

In order to adapt any cursor movement to a user's residual abilities, we developed cursor movement control (CMC) software to control the amount and direction of the cursor movement [7]. The CMC can be used with Windows XP and subsequent Microsoft software. The CMC, cursor movement can be considered to be a vector. By acquiring the coordinate values from Windows API messages that occur when the cursor is moved, the amount and the direction of cursor movement can be controlled by a specified algorithm in order to adapt to the residual abilities of people with physical disabilities. Furthermore, to allow people with physical disabilities to operate a pointing device with their fingers, CMC is implemented in three modes (separate control mode, bidirectional mode, and alternative mode), along with movement rate control. These are used to realize appropriate cursor movements in response to their muscular strength and range of motion and dexterity.

We aimed to evaluate the effectiveness of CMC and develop useful technology for pointing device operation by people with physical disabilities. To accomplish this, experiments were conducted with the cooperation of users with physical disabilities. We focused on the application of the separate control mode and movement rate control.

The separate control mode is a control mode that can transform cursor movement of the operator according to predefined set values. For each coordinate axis, the set values can be set for arbitrary direction (movement angle, θ_c) and speed (movement rate, a), such as those shown in Table 1. On the screen (Fig.1), when the cursor is moved from P (current coordinate values) to M by the operator, by inputting the appropriate set values into the set up window, the subsequent cursor movement is transformed into actual cursor movement C. Therefore applied set values alter the cursor movement according to the direction of vector PM (the range of θ_m), i.e. depending on the user's operation. However, when the cursor direction is outside the range of angles predefined by the applied set values, cursor movement is not unaffected. This mode is suggested for users with limited excursion due to joint contracture or muscular atrophy.

Table 1. Range of θ_m and applied set values.

coordinate axis	**Angle θ_c**	**rate a**	**Range of θ_m**
Upper (y)	θ_u	a_u	$45° \le \theta_m \le 135°$
Lower ($-y$)	θ_d	a_d	$-135° \le \theta_m \le -45°$
Left ($-x$)	θ_l	a_l	$135° < \theta_m < 225°$
Right (x)	θ_r	a_r	$-45° < \theta_m < 45°$

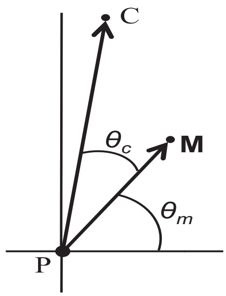

Fig. 1. Separate Control Mode.

1 Method

The participants (user1, user2) in the experiment were two persons with spinal muscular atrophy (SMA) (Figs.2 and 3). They are both teleworkers skilled in the use of PCs. User1 works as a Web designer, and user2 is a managing director. They typically use a PC with a trackball and an onscreen keyboard in supine position as follows. User1: He operates the trackball with an index finger and thumb while holding it by himself. However, he has to shift his hold on the trackball depending on the cursor movement direction because of the disturbance of excursion. Long-term operation also causes inflammation and pain in his hand joint. User2: He operates a trackball arranged in the desired position using not only his thumb but also compensatory movement of his upper extremity because of muscular atrophy. In his operation of the PC, the relationship between his upper extremity and the trackball position is important. Therefore, whenever this relationship position is slightly displaced, he has to call for assistance because he cannot operate it.

Fig. 2. User1.

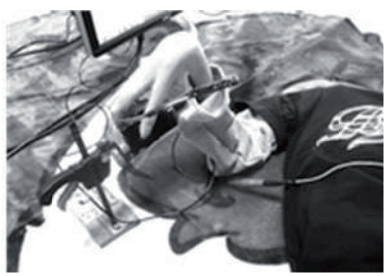

Fig. 3. User2.

The experiments consisted of cursor movement trials, where the locus of the moved cursor was recorded. The cursor movement trial had eight tasks involving vertical, horizontal and diagonal directions. Each task consisted of a pair of start and end targets (Fig.4). When a task appeared, users were asked to move the cursor from the start point to the end target with their own trackball. After each had clicked the end target, other tasks immediately appeared in random order. Users were asked to repeat the trial, consisting of eight tasks. The locus of the moved cursor was recorded on a chart that plotted the cursor movements when the pointing device was operated by a user in the up, down, left, and right directions. Users were asked to move the cursor to each direction goal as directly as possible.

The users each performed five trials, before and after implementing the CMC and when adjusting the set values. When evaluating the features of pointing devices, there were cases when participants were instructed to move the cursor and to select the targets as quickly as possible [8]. However, in our experiments users were asked to operate the pointing device at their usual operating speed as this study is primarily concerned with improving the usability of operation for the users.

The cursor movement trials and the recording of the locus of the moved cursor were conducted before and after the CMC application, in order to determine its effect (the current condition of the user refers to before applying the CMC). During a cursor movement trial, the movement times in every direction were recorded and added together to find the total movement time. A subjective evaluation from each user was also made in relation to the pointing device operation. The effect of CMC was considered by comparing these results. Some set values were enumerated by referring to the condition of each user and a control group. The control group comprised of participants without physical disabilities and was performed by recording the locus of the moved cursor using a trackball operated with a thumb. The set value of each user was adjusted individually after the set values were found through trials and tuning. In the experiment, CMC was applied to the direction adjustment for user1 and to the direction and amount of movement adjustment for user2.

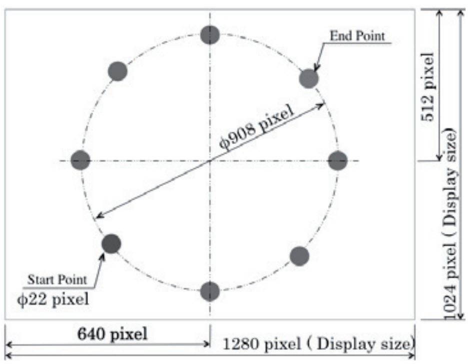

Fig. 4. Cursor Movement Trial.

2 Results and Discussion

Regarding the locus of the moved cursor (Figs.5-8), in a comparison of the charts made before and after the CMC application, differences in the physical abilities and operating environments could be seen. Figure 9 shows the comparison of total movement time of cursor movement trials. User1 had difficulty in specific directions (the horizontal direction, especially in the right hand direction). However, his efficiency in operating was significantly improved and the total movement time was much shorter than before applying the CMC (separate control mode). User2 had difficulty in the vertical direction, and his operation was found to alter the direction and amount of cursor movement, i.e., to be an alternating operation. His time was better only when the movement rate was set, even though attempts were made to set the direction and amount of movement to every possible value. The result of user2 (Fig.9) shows total time when only the movement rate was set. These results are for when all directions were the same rate and when each direction is different rate. There was not much difference compared to his current operation. His efficiency to operate also seemed to be improved because movement requiring zigzags was not necessary but his satisfaction decreased.

The user's subjective evaluations are listed in Table 2. In the case of users such as user1, the results suggest that the CMC (separate control mode) application would be effective because improvements in the usability could be expected while making use of the user's ability. In the case of users with alternating operation such as user2 or compensatory movement, the cursor moved when they altered the direction and the amount of their physical movement. Therefore, when only a specific direction of cursor movement is controlled by CMC, this situation hinders the pointing device operation and deprives the user of the feeling of the control operation. This case suggested that an appropriate control mode would be to adjust the cursor movement by the same amount in all directions, which could reduce the physical burden of users with alternating operation.

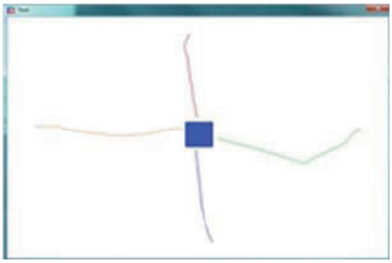

Fig. 5. Current Operation (User1).

Fig. 6. After the CMC Application (User1).

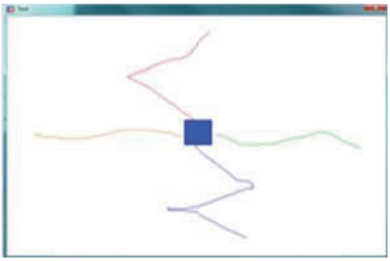

Fig. 7. Current Operation (User2).

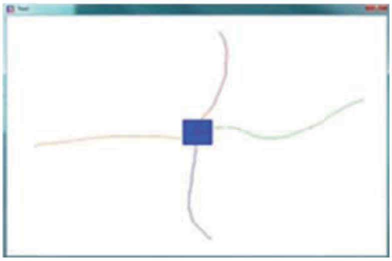

Fig. 8. After the CMC Application (User2).

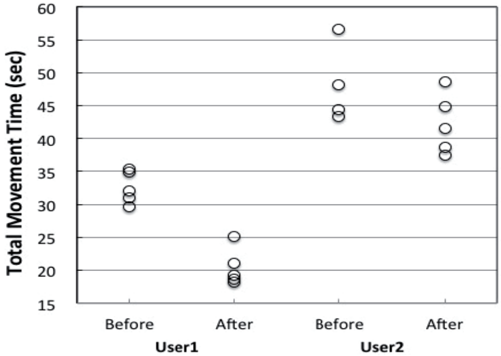

Fig. 9. Comparison of Total Movement Time.

Table 2. Subjective Evaluation of Users.

	Current Operation	After CMC Application
User1	・Difficult direction: rightward, downward ・Deviation in downward right hand directions	・Improved rightward movement and easy operation ・Reduction in amount of shifting in his hold on the trackball ・Reduction in amount of repeated finger movement
User2	・Difficult direction: downward ・Required time for downward operation ・Required to move upper extremity in zigzags, which were larger when he was tired	・Allowed less movement of upper extremity when the movement rate was increased in all directions ・Confused which direction the pointing device should be operated when the direction or amount of the movement rate was set individually

3 Conclusions

The application of CMC in pointing device operation not only improves its usability but will also contribute to supporting users with progressive diseases and in dealing with various operating postures. In future work, we will make the CMC and experiment environment available and will consider additional case studies for the effective application of CMC and the support methodology using cloud computing.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-473

Change in Eye Controlled Performance over Time with an Eye Tracker Controlled System, Used by Children with Severe Physical Disabilities

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Abstract. The aim of this study was to describe how speed and accuracy in eye controlled computer performance changed over time for children with severe physical disabilities that used eye tracker controlled system (ETCS) in daily activities as an effect of assistive technology (AT) intervention. Data was collected with diaries and with Compass software. The preliminary results from this study from the first four children indicate that two children improved significantly in eye controlled performance up to 19 months since start of ETCS usage in daily activities.

Keywords. Eye Tracker Control System, Children with Disabilities.

Introduction

Children with severe physical disabilities, often with cerebral palsy [1-2], constitute a small proportion of the total population of children with disabilities and these children have profound needs for assistance in communication, as well as in all other everyday activities [1,3], and are unable to operate a computer by body movements for alternative communication. An eye tracker controlled system (ETCS) as an AT is potentially available and safe enough to be used beyond laboratory settings [4] for people with severe physical disabilities. ETCS is of high relevance as it might be an effective intervention to enable independence and enhance participation in the close environment by providing the children with opportunities to communicate and perform

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activities via the computer. However, it remains unclear how people with disabilities use the ETCS as AT in real day-to-day contexts. In fact, research on usability of ETCS for people with disabilities in real life is to our knowledge non-existing [5].

The ETCS allows the user to interact with objects on the screen by moving their eyes. It is possible by an inbuilt camera in the screen that reads where on the screen the person is gazing with a precision of a few mm. The gaze replaces the computer mouse and keyboard as the input method [6, 7]. The provision of an AT does not mean that it is used or even can be used. If children do not have the opportunities to use the AT in everyday life, obviously they do not get experience needed to become competent AT users, especially true for children with severe disabilities and advanced AT [6, 8]. Therefore, the aim of this study was to describe how speed and accuracy in eye controlled computer performance changed over time for children with severe physical disabilities that used ETCS in daily activities as an effect of AT intervention.

1 Material and Methods

This was a longitudinal multiple case study with AB design. Ethical approval was obtained from the ethical committee in Uppsala, Sweden (2010/316).

1.1 Participants

Four boys (7-15 years) with severe physical disabilities (cerebral palsy) and living in Sweden, participated in the study. The children had level IV or V on both the Gross Motor Function Classification System [9] and on the Manual Ability Classification System [10]. The AT intervention consisted of provision of an ETCS (Tobii C12 or Tobii P10) for use in daily activities and support from a communication team. Three were beginners to ETCS and one child had had access for several years.

1.2 Instruments

Duration in minutes and number of occasions with ETCS usage each day during a two weeks period was documented in a diary. Compass [11] is a functional assessment software program with eight tests especially developed for evaluation purposes. The Aim test in Compass was used to measure the children's speed and accuracy with the ETCS to select small targets (12 targets/ test) that were presented at different locations of the screen one at a time. Selection was done by gazing at the target for longer than the pre-specified dwell time. The Aim test has high test-retest reliability [11], high construct validity [12] and a good internal consistency [11].

1.3 Procedure

Data from Compass and diary were collected for each child at baseline and at 5, 10 and at 19 months or more of usage of the ETCS in daily activities. Data at 19 months for child D will be collected in future. The Compass assessment situation was individualized to support each child to complete the test by the best of their ability. The test was administered three times if possible. Diaries were mailed to parents and teachers at each time point and they observed and filled in ETCS usage at school and at home respectively during a two weeks period. Loss of Compass data for child B and C derived from difficulties to find good calibrations at the particular time points, why these children were not motivated to select the 12 targets in a test due to the efforts required to complete the test.

1.4 Data Analyses

Percentage of days with ETCS usage was calculated for all time points by using both the home and school diaries. Friedman's analysis of variance and Wilcoxon signed rank test were used to determine differences in speed between assessments for each child. Effect size for each child was calculated by Cohen's δ. A true change of speed was considered to be a change of at least 2 SD of mean speed.

2 Results

Figure 1 show mean speed and figure 2 accuracy over time for all children (Compass). The mean difference in speed did not exceed 2 SD for none of the children. Diaries showed that child A and B started on no ETCS usage at baseline and ended with usage of 63 % (child A) and 100 % (child B) of the days at 19 months. These two were the only children that had significant increase in speed over time (p values <0,01 to 0,02) with effect sizes of 1,0 and 1,5. But both increase and decrease in mean speed over time for child A makes it impossible to evaluate if this was a real improvement for this child. Child C had 71 % ETCS usage both at baseline and at 19 months. The difference in mean speed over time was not significant (p>0.05), although the effect size was 0.7. Child D had no ETCS usage at baseline and 72 % ETCS usage at 10 months. Effect size was 0.5 for mean speed between baseline and 10 months, but there was no significant difference between the three time points (p>0,05).

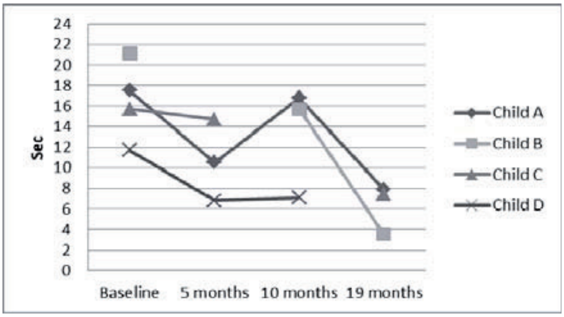

Fig. 1. Change in speed (mean) with ETCS (compass).

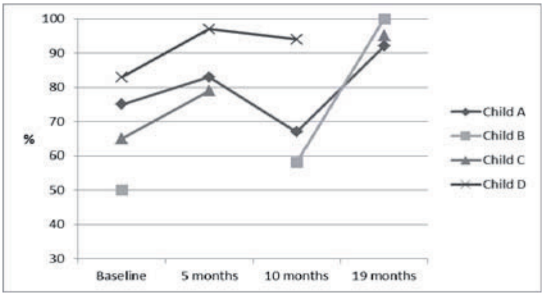

Fig. 2. Change in accuracy (%) with ETCS (compass).

3 Discussion

This study presents the first preliminary results from a larger study aiming at describing how speed and accuracy in eye controlled computer performance changed over time for children with severe physical disabilities that used ETCS in daily activities. So far, the results for the first four children indicate a significant improvement over time in speed for two of the three children that were beginners with ETCS at baseline. Although a limitation is that none of these children exceeded a change of 2 SD of mean speed. The accuracy increased for all indicating less missing targets and better ability in selecting targets over time. However, the interpretation of the results in this study needs to be taken with caution according to the limited number of included children. Unfortunately, we do not know if these children may have done some improvements over time even without daily usage because of development or growing older. This study shows that it may take up to 19 months to master a competence for children with severe physical disabilities related to accuracy and speed in using ETCS and this can be of interest for clinicians. This needs to be taken in consideration when doing assessments of performance with ETCS for children with disabilities that are inexperienced and unfamiliar with its usage in daily activities. This study contributes to the knowledge that the performance with an ETCS may improve over time as an effect of long-term usage of ETCS in daily activities together with support from a communication team for children with severe physical disabilities.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-478

A High-Throughput Auditory P300 Interface for Everyone

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Abstract. Brain Computer Interfaces (BCIs) might be the only communication resort for patients with Locked In Syndrome (LIS). Auditory-P300-based interfaces might provide an communication alternative to such patients. In this study we evaluate in an on-line setting the Emotiv's Epoc performance for capturing auditory P300s. Five healthy subjects (3 male, 2 female) participated in an on-line multi-class auditory oddball paradigm. The stimuli set consisted of six musical instruments sounds, different in pitch and stereo spatialization. Two different conditions of 300 ms and 175 ms Inter Stimuli Interval (ISI) were tested. In each condition, the training data consisted of 10 sub-trial recordings, each sub-trial consisting of 25 repetitions in the 175 ms condition and of 15 ms in the 300m s condition. At the beginning of each sub-trial a target sound was presented for the subjects to focus on. Each repetition consisted of a randomized sequence of 6 stimuli appearing once each. After training a spatial filter using xDawn unsupervised algorithm and a linear discriminant analysis (LDA) classifier on a window from 250 ms to 750 ms after the stimuli presentation, the average on-line performance was 97,5% in the 175 ms condition and 90% in the 300 ms condition, resulting in an average information transfer rate (ITR) of 5.39 bits/min -in the 175 ms condition-. The average ITR is found to be 8.88 bits/min when taking into account the minimum number of repetitions is to achieve 70% accuracy, while the best performance was 9.99 bits/min.

Keywords. Auditory P300, Emotiv, Brain-Computer Interface, EEG.

Introduction

Brain Computer Interfaces (BCIs) might be the only communication resort for people in Locked Syndrome State (LIS) usually caused by Amyotrophic Lateral Sclerosis (ALS) [13]. Total Locked In Syndrome patients cannot focus gaze on a screen and eyes roll back and forth involuntarily. In this case, an auditory-P300-based interface might be an alternative.

Although Emotiv Epoc is a low cost EEG device designed for gaming, Badcock et al in [1] conclude that "the gaming EEG system compares well with research EEG systems for reliable auditory Event Related Potentials detection, such as the P1, N1, P2, N2, and P3". In this study we aim to validate Emotiv Epoc in an on-line auditory oddball paradigm. Apart from its low cost, Emotiv is the current most user-friendly EEG device as no conductive gel is applied on the scalp of the user. These two factors make it a very

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promising device for building Brain Computer Interfaces and making them available for patients who cannot afford the cost of medical EEG equipment or prefer a more user friendly device.

1. State of the Art

The feasibility of an auditory stimuli P300 BCI was studied by N.J Hill et al [2] (2005) by running an auditory oddball paradigm, concluding that “it is possible for users to modulate EEG signals in a single trial by the conscious direction of attention, well enough to be useful in BCI”.

Andrea Kubler et al [4] (2006) proposed an auditory P300 Spelling system and evaluated it on 4 patients at the end-stage of a neurodegenerative disease . Each character in the system was placed in a 5x5 matrix. Each row and column was assigned with a number (1-5, 6-10). First the user had to select a row and then a column. The auditory stimulation was a male voice spelling the number of the corresponding column or row. The performance of the system was “generally low”, while it is proposed that “numbers can be replaced by more interesting stimuli such as musical tones varying in pitch and timbre and stimuli can be presented from different spatial positions”. In [5],the same system was tested on healthy subjects producing better results, but its performance was inferior to a similar visual P300 speller.

D. S. Klobassa et al [6] (2009) proposed a high-throughput auditory P300-based BCI, by replacing the male voice with environment sounds with different timbre. The Inter Stimuli Interval (ISI) was set to 500 ms, while the number of repetitions (stimuli presentations) in the on-line scenario varied depending on the performance of the classifier of each subject. The averaged Information Transfer Rate (ITR) over 5 subjects was 1.86 bits/min while in case of one subject the maximum bit rate reached 5.6 bits/min.

M. Schreuder et al. [7] (2010) introduced the Auditory Multi-Class Spatial ERP (AMUSE) oddball paradigm having 8 spatially distributed auditory cues. “Ten healthy subjects participated in an offline oddball task with the spatial location of the stimuli being a discriminating cue”. Between 5 subjects an average ITR of 17.39 bits/min was achieved when considering when considering only those numbers of averaging that resulted in a 70% selection score or higher (4.6 average number of repetitions). When canceling the spatial properties of the stimuli selection scores went down below 70%, indicating the significance of having spatially distributed stimuli in an auditory P300 speller. Based on the AMUSE paradigm M. Schreuder et al. [8] developed and evaluated an auditory speller on 21 subjects. Each stimuli consisted of a distinct base tone and a high frequency, band-pass filtered noise overlay. In an on-line scenario, and making use of a dynamic stopping method -of the repetitions required for the averaging-, a maximum writing speed of 1.41 char/min (7.55 bits/min), while the average writing speed over 21 subjects was 0.94 char/min (5.26 bits/min). Ivo Kthner et al. [9] proposed a portable auditory P300 brain-computer interface with directional cues, using headphones instead of speakers for triggering the stimuli. Average bit rates of up to 2.76 bits/min (best subject 7.43 bits/min) were achieved.

2. Methods

The commercial gaming Emotiv Epoc EEG device, placed slightly backwards was used for acquiring the EEG data. Emotiv is a wireless EEG device consisting of 16 wet saline electrodes -offering 14 EEG channels- and a wireless amplifier. The sample rate of the device is 128 Hz. The OpenViBE platform [10] was used for acquiring and processing the signal, while a VRPN to midi gateway was implemented and used along with LoopBe virtual midi port for triggering virtual instruments a virtual instrument host application. MBOX low latency sound card was used, offering 17 ms output latency. The LoopBe midi port used introduced an additional latency of 1 to 3 ms. Both data acquisition and on-line scenario were performed on a laptop with an i5 2.53 GHz processor with 4 GB of RAM, running windows 7 64-bit Operating System.

Five healthy subjects (3 male, 2 female) of average age 33 years old, participated in a multi-class auditory oddball paradigm. The stimuli set consisted of six natural musical instruments sounds (bell, cello, sticks, guitar, kalimba, balinese bell) different in pitch and stereo spatialization. Two different conditions of 300 ms and 175 ms Inter Stimuli Interval (ISI) were tested. In each condition, the training data consisted of 10 sub-trial recordings, each sub-trial consisting of 25 repetitions in the 175 ms condition and of 15 ms in the 300 ms condition. Each repetition consisted of a randomized sequence of one occurrence of each of the 6 stimuli. The subjects were comfortably sited in front of two speakers, instructed to avoid any muscular movement and stay calm with eyes closed. At the beginning of each sub-trial a target sound was presented and the subjects were instructed to tap on the desk every time a target stimuli appeared. A time interval of 5 seconds was introduced between sub-trials.

One fake training session was first performed, were the subjects were asked to tap on the desk every time a target sounded. Then the 300 ms condition training data were acquired, and after analysing them, the on-line scenario was performed. The on-line scenario was almost identical to the training one, with the difference, that after each sub-trial, the detected sound was played back to the user, followed by the next target sound. The same procedure was followed for the 175ms condition.

The signal was first bandpass filtered in the range of 1 to 12 Hz and down-sampled to 32 Hz. A spatial filter outputting three channels, was obtained by using the xDawn unsupervised algorithm proposed by Bertrand Rivet et al [11]. This resulted in matrix of 48 features (16 for each output of the xDawn filter) that were used to train an LDA classifier.

3. Results

The ITR value is computed using the formula:

$$ITR(bits/min) = S \cdot \left[log_2(N) + P \cdot log_2(P) + (1-P) \cdot log_2\left(\frac{1-P}{N-1}\right)\right]$$

Where, S represents the number of selections per minute, N represents the number of possible targets and P represents the probability that they are correctly classified.

In table 1 is summarized the the on-line performance of both 175ms ISI (25 repetitions) and 300ms (15 repetitions) conditions. Four out of five subjects achieved 10/10 on-line performance in the 175 ms condition, resulting in 5.9 bits/min ITR, while the remaining one achieved 9/10, resulting in 4.3 bits/min ITR.

Performing off-line analysis we can determine the minimum number of repetitions in order to achieve at least 70% accuracy, which is the minimum required to build a usable BCI [seventy]. As shown in table 2 the average ITR in that case is 8.88 bits/min for the 175ms condition. M. Schreuder et al. [7] for the same condition (70% minimum accuracy, 175ms ISI) reported an average of 17.39 bits/min, when using a much more expensive Brain Products 128- channel amplifier.

Table 1. *On-line performance.*

			Successfully detected targets (out of 10)		Information Transfer Rate (bits/min)	
User	Gender	Age	300 ms ISI, 15 rep.	175 ms ISI-25 rep.	300 ms ISI,15 rep.	175 ms ISI, 25 rep.
user1	male	29	10	10	5.74	5.9
user2	male	45	7	9	2.23	4.3
user3	male	37	7	10	2.23	5.9
user4	female	26	9	10	4.19	5.9
user5	female	27	9	10	4.19	5.9
Average		32.8	8.4	9.8	3.51	5.48

Table 2. *ITR after considering the minimum number of repetitions to achieve 70% accuracy.*

	175ms ISI		300ms ISI	
User	Number of Repetitions	ITR (bits/min)	Number of Repetitions	ITR (bits/min)
user1	8	9.99	4	8.39
user2	9	8.88	8	7.84
user3	9	8.88	13	2.58
user4	12	6.66	14	2.39
user5	8	9.99	11	3.05
Average	9.2	8.88	10	4.85

4. Conclusions and Future Work

In this study we indicate that a low cost, high-throughput P300 auditory BCI is feasible. The average achieved ITR is comparable, although inferior to the ITR reported by M. Schreuder et al.The ITR is found to be higher in the 175ms ISI condition, compared to the 300ms ISI condition, confirming Schreuder's results. The significance of this study is the low cost of the proposed auditory BCI. A gaming EEG device is used instead of the an expensive medical device, along with a pair of speakers. For the first time, an Auditory Multi-Class Spatial ERP oddball paradigm was proposed using natural musical instrument sounds with different timbre, pitch and stereo spatialization. The performance of the system when stimuli vary only in pitch and spatial distribution or timbre and spatial distribution should also be studied. Based on the results of this study we are motivated to build and evaluate usable low cost P300 based BCI, such as a P300 auditory speller.

Acknowledgements

This work is supported by the Spanish TIN project DRIMS (TIN2009-14274-C02-01).

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-483

Communication Oriented Brain Computer Interface in a Remote Monitoring System for Amyotrophic Lateral Sclerosis

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Abstract. Communication is a core aspect of the human life, since it makes us able to share concepts, information and needs. In patients afflicted by pathologies like Amyotrophic Lateral Sclerosis (ALS) an interruption of communication ability occurs: the patient must use Alternative and Augmentative Communication (AAC) aids to recover this capability. Due to the progress of the disease, the patient's abilities keep reducing, till complete paralysis. In that condition the only interface able to provide a communication channel is Brain Computer Interface (BCI). In the following we will present a P300-based BCI, integrated in a project implementing a remote monitoring system for ALS patients.

Keywords. Amyotrophic Lateral Sclerosis, ALS, Alternative and Augmentative Communication, AAC, Text-composing, Speech-synthesizer, BCI, EEG.

Introduction

One of the most significant aspects of the human affectivity is communication. Communicating means to be able to transfer a concept, an opinion, a need, etc. through any type of interaction, either verbal or non-verbal, like writing, gesturing or simply performing an atomic and simple action like turning on a switch. Patients afflicted by rare pathologies such as Amyotrophic Lateral Sclerosis (ALS), who suffer from a progressive and irreversible paralysis, need to be assisted in every single aspect of their life [1] and, in particular, they need special support for communication. A crucial step is when the pathology compromises the phonation and dysarthria occurs [2]: in these conditions, the main communication channel is irremediably interrupted. The situation gets worse as the disease proceeds: after phonation it compromises also writing and gesturing, finally even head and eye movements [1]. At the end the patient feels trapped in his/her body, without being able to communicate anything: discomfort, thirst, hunger nor even pain [2][3]. BCI can open a breach in such barrier and restore a communication channel.

1. Background

Ensuring communication along a degenerative and progressive paralysis disease is a challenge not often approached in the most effective way. Since the pathologies like ALS are very rare, devices and technologies directly targeted at those patients are quite uncommon. Most of times, during early stages, aids are not employed, but when the threshold of 125 words per minute (assessed with Speech Intelligibility Test [2]) is crossed physicians should start to suggest AAC (i.e. Alternative and Augmentative Communication) aids. Looking at the literature, it is clear that most of research projects are trying to exploit a “residual functionality”, providing the best functionality they can. Text-to-speech engines are widely employed, so verbal communication can be assimilated to text composition [4]. The first physical input mode can be of course a plain mechanical keyboard, even if this input method requires almost full arm control. When this functionality is compromised, the patient can use keyboards with a smaller set of buttons or can take advantage of even easier single-button interfaces. These can provide a monodimensional input or a simple binary answer. Sometimes residual muscular activity is not suitable for push or touch buttons. Anyway electromyographic (EMG) response power can be used as a monodimensional input value (or thresholded). This solution has been implemented by Naves et Al. [5]. Kherlopian et Al. developed a similar system, employing the Electrooculogram (EOG) [6]. They report a writing speed of 3-6 letters per minute, considering the achieved throughput of 200bits per minute as a “high rate of information transfer” in such a situation.

The last input interface, which can surely follow the patient even in case of full paralysis, is BCI [7]. The advantage is of course that the user is just asked to concentrate on the stimulation he/she is given or on a specific imagery task. Nijboer et Al. developed a P300-based BCI [8] using an EEG acquisition set and a computer, they were able to associate many oddball stimuli (6x6 matrix) to their event-related potential (ERP). They concern about the low communication rate (average 2.1 character/min with 65% of accuracy), but consider positive the stability of such technique through time. Dal Seno et Al. [9][10] have been working on a P300 based BCI which implemented a speller, improving its performance implementing a different classification solution and taking advantage of the error potentials. This method, which they report to have an accuracy of 68% while typing 4 character/min, is very similar to the one implemented in our system.

2. System Composition

The developed communication interface has been integrated in a wider system, which also managed remote acquisition of biological sensors, deployed to monitor the status of the patient. This project, known as “Progetto ON”, has been funded by Infosolution S.P.A.[11] under the Regione Lazio FILAS grant. The setup provided is composed of a client unit and a server unit. The client unit is composed of a light sensor, an EEG amplifier, an Android tablet and other sensors provided to monitor the patient. The experimental setup for the BCI client unit was composed of an Android tablet (ASUS TF101), and an EBNeuro BeLight EEG amplifier. A very simple light sensor, to provide the stimulation synchronization signal, was also developed. Its output is a simple voltage difference, which can be recorded directly through the EEG amplifier. The EEG amplifier commu-

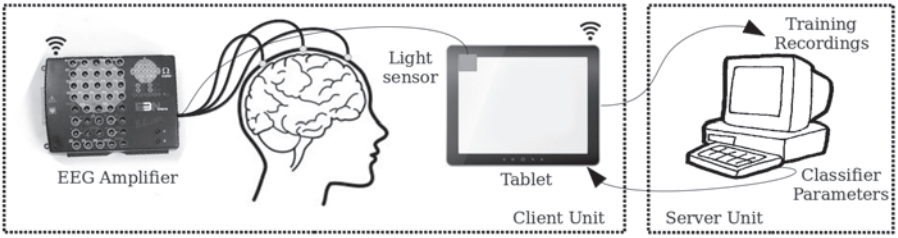

Figure 1. Architecture of the system. Other sensors and components not related to BCI are omitted.

nicates with the tablet through a wireless connection, receiving acquisition parameters setting as well as sending acquired data. The server unit is a remote PC, whose main purpose is to collect sensors information, store them and transmit them when required. Furthermore its computational power and storage are used to collect BCI training recordings and process them to obtain the BCI classifier tuning. The communication through the client and the server nodes has been implemented through the Dropbox API [12].

3. Methods

The working principle of the overall process is based on the recognition of a P300-wave, which can be induced by giving the user a specific stimulation [8][10]. This procedure is called "odd-ball" stimulation, since the patient has to be unexpectedly tickled with the target stimulus for a P300 wave to be generated. This, in our setup, has been achieved by randomizing the sequence of flashing letters: a 36 character keyboard (similar to qwerty, Figure 2) is shown to the user, and one out of 12 different groups of 6 letters is highlighted every 125ms. This leads to a stimulation frequency of 8Hz, which means that a complete serie of 10 repetitions (total 120 stimuli) takes 15s to complete, resulting in an output rate of almost 4 letters per minute. Whole this procedure is a single *sequence*, which, through the classifier processing, returns a single letter when composing. Due to delays between the application execution and the screen depiction it is not possible to record the stimulation instant directly by software. Furthermore since low level drivers for the screen were not available it was not possible to define a reliable time lapse for that delay. Thus the system takes advantage of a light sensor, which makes possible to record the precise instant in which the stimulus appears, directly through EEG acquisition.

The overall use process is composed by three phases: patient recording, classifier training and online use. In this application we omitted the implementation of the Error potential recognition (originally contained in Dal Seno's work [9][10]).

In the first phase the user is asked to copy-spell some words, for a total of 60 letters. The process is quite time-consuming, but necessary to customize the classifier on the user-specific P300-wave shape. The Android application has full control over the EEG amplifier thanks to the developed driver. The acquisition frequency is set to 512Hz, with two digital notch filters at the frequencies of 50Hz and 100Hz, to delete the power supply noise. The recorded EEG channels (Fz, Cz, Pz, all referenced at the mastoid, and the video synch signal) were organized in files complying with the standard EDF format. The whole stimulation procedure (all the *sequences*, one for each letter) is saved in a comma-separated-values text file. The information here recorded are the code representing the set of letter flashed (and whether it contains the target letter) for each stimulus.

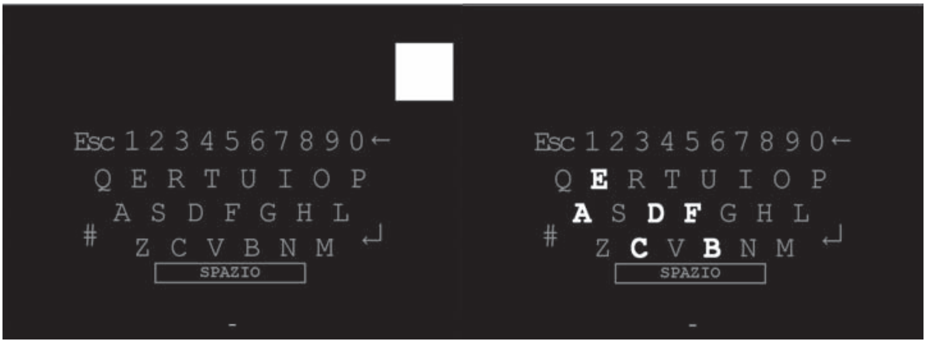

Figure 2. The tablet application keyboard, with no active stimulation on the left, one group of highlighted letters on the right. The white square (top-right corner) in the left image is the synchronization spot, over which the light sensor is placed: the stimulation is triggered on the falling edge of the brightness signal.

In order to move to the next phase those data are transmitted to the server unit. The processing here performed starts dealing with the data structure. The whole-session recording is pass-band filtered (form 0.5Hz to 50Hz) and split (accordingly to the synchronization signal) in epochs lasting 1s: 200ms prestimulus, 800ms response. Then, considering the information coming from the attached stimulation detail, epochs are classified in target and not-target ones. Both target and not-target sets are split in two, 70% of the data is fed to training while the remaining 30% is used for testing. A Genetic Algorithm (GA) [9] extracts the most suitable wave-shape to employ in a Logistic classifier during the online run. To that aim few different basic wave-shapes templates are represented as genes on the individual chromosome, each occurrence characterized by specific amplitude and delay. The fitness function chosen is related to the result of the classification on the training data: the better the classification on the training data the higher the fitness. The GA runs 100 individuals over 12 generations [9], the resulting ones are evaluated on the testing set: the best one represents the wave-shape to be employed in the online classifier, its data are made immediately available to the client application.

As soon as the information from the training is made available, the user is enabled to use the speech composer. This part of the application, which deals with online use, applies a real-time signal processing to the EEG data. Signals are again notch-filtered, but also split in epochs immediately. On each epoch a Logistic classifier is run in the background, identical to the one used to test fitness into the GA, tuned with the wave-shape coming from the training procedure. Epoch scores are grouped by stimulus, and cumulated as soon as they are available. This avoids any significant delay between the last stimulus of the sequence and the output: at the end of the stimulation sequence the letter which verifies the highest score is just appended to the spelled sentence.

4. Testing and Results

The system has been implemented and tested in two copies: a client-server setup in Milan and another in Rome. Both systems were tested on healthy subjects, in a first step both clients relied only on the server in Milan, later one client on each server.

Table 1. Results from the tests performed by Dal Seno [9].

Subject	S1	S2	S3	S4	S5	S6	S7
Training Result	88%	90%	58%	65%	43%	70%	39%

Table 2. Results from the tests carried on healthy subjects (H) and ALS patients (A). Dashes fill spaces where tests have not been completed yet.

Subject	H1	H2	H3	A1	A2	A3	A4	A5	A6	A7
Training	89%	85%	92%	36%	18%	40%	50%	14%	67%	33%
Spelling	72%	66%	77%	-	-	-	-	-	-	-

First experiments have been carried by Dal Seno [9] and are reported in Table 1. An additional experimentation involved three healthy male subjects aged between 25 and 28. The protocol defined comprises training of the system for the specific subject (as explained in section 3) and the spelling of a set of sentences. The subject were asked to copy-spell 9 Italian words for a total of 60 letters, 52 used for training and 18 for testing. Results of parameter testing on the specific dataset, reported in Table 2 are comparable to [10]. The further testing for spelling on 62 letters reported concordant results.

An experimentation on ALS patient is currently in progress. Up to now 7 patient (6 males and 1 female), aged between 47 and 76, have undergone the first part of the test, which is still the same procedure performed for the healthy subjects. The analysis of testing data showed unexpectedly low performances (Table 2). Looking at the Event-Related Potentials (ERPs), in Figure 3, it is clear that all the subjects had a P300 response to the stimulus. It was verified that almost all the patients missed some target stimuli along the sequence, due to double/triple subsequent stimuli or eye-blinking. Furthermore experiments have been performed at patients' home, a familiar and relaxing environment, but many times lacking of silence and comfort to guarantee user concentration. These factors can generate false negatives, i.e. epochs related to target stimuli in which a P300 is not present, affecting negatively the classification.

5. Future Work

It emerged, especially from ALS patient experiments, that the current stimulation sequence can be improved under many aspects. Surely it should be modified in order to avoid double or triple stimuli. Furthermore user attention could be tickled with color

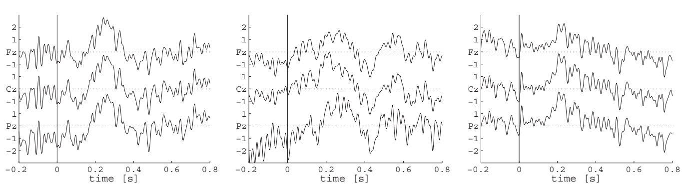

Figure 3. Difference between target end non target ERPs, for the subjects H3, A2 A3 and A5 (from left to right). EEG channels are (from top to bottom) Fz, Cz and Pz, while the vertical line represents the instant of the stimulus. As it appears clear the P300 response to target stimuli, even if variable from subject to subject, is still consistent even with low classifier performance (as in H2 and H5).

changes and different stimulation patterns, in order also to attenuate fatigue. EOG interface is ready to be implemented and integrated, in order to detect and take into account eye-blinking during stimulation.

6. Conclusions

In this paper we presented the implementation of a Communication Oriented BCI for ALS patients. The P300-BCI technology avoids a difficult user training since it relies on a natural brain behavior, making the solution almost ready-to-use. The experimental results, even if stigmatizing the need of complete concentration by the user, are aligned with those retrievable in the literature. The possibility to include such interface in a patient monitoring setup at home gives the patient a communication channel even when full paralysis occurs, through a familiar and common use object as a tablet.

Acknowledgements

We want to acknowledge Infosolution S.P.A. for the collaboration that led to this project, Doc. A.Paddeu and the Mariano Comense “Felice Villa” Hospital staff for their contribution in relations with ALS patients.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-489

Cognitive Impairments Simulation in a Holistic GUI Accessibility Assessment Framework

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Abstract. In this paper, we present a novel methodology to assess the accessibility and usability of Graphical User Interfaces (GUIs) using virtual user models to describe the users' cognitive capacities and applying these models in simulated interaction with virtual prototypes of ICT products' UIs. We have implemented two tools, to facilitate GUI accessibility assessment: VerSEd-GUI, which supports the creation of custom GUI interaction scenario sequences in an implementation-agnostic manner and VerSim-GUI, for the simulated reproduction of these interactions by virtual users with cognitive impairments. Using these tools, we create a holistic methodology to assess the cognitive accessibility of GUIs

Keywords. GUI Simulation, Cognition Simulation, Accessibility Assessment, Evaluation, User Experience, Virtual User Model.

Introduction

Access for all to ICT applications is fast becoming a prerequisite for the inclusion of groups of impaired users to an ever increasing number of services and tools, necessary for information, education, communication, entertainment and social participation. To this end, the assessment of ICT products' GUI accessibility is a task that extends the usability assessment of the GUI, by testing the interaction, given specific user impairments. Under the Veritas EU project, we have defined a virtual user model (VUM) [1] that encodes a set of parameters describing a user's motor, vision, hearing and cognitive capacities [2], the application of which in GUI accessibility assessment using simulation of cognitive functions in GUI interaction tasks is the focus of this paper.

Related Work

Various approaches have been proposed in the literature towards modeling of human cognition. Newell developed the Soar architecture [5], a production-rule based system, according to which any task is carried out by a search in a problem space using a chunking mechanism, according to which, whenever the system cannot determine a single operator for achieving a task and thus cannot move to a new state, an impasse occurs. An impasse models a situation where a user does not have sufficient knowledge to carry out a task. At this stage Soar explores all possible operators and selects the one that brings it nearest to the goal. It then learns a rule that can solve a similar situation in the future.

However, there are certain aspects of human cognition, such as perception, recognition, and motor action that can better be explained by a connectionist approach than a symbolic one [7]. The ACT-R system [3] was developed as a hybrid model, with both symbolic and sub-symbolic levels of processing. ACT-R divides the long-term memory into declarative and procedural memory. Declarative memory is used to store facts in the form of 'chunks' and the procedural memory stores production rules. The system works to achieve a goal by firing appropriate productions from the production memory and retrieving relevant facts from the declarative memory.

The CORE system (Constraint-based Optimizing Reasoning Engine) [4] models cognition as a set of constraints and an objective function. Constraints are specified in terms of the relationship between events in the environment, tasks and psychological processes. Unlike the other systems, it does not execute a task hierarchy; rather prediction is obtained by solving a constraint satisfaction problem.

The GOMS (Goals, Operators, Method and Selection) family of models was inspired by the GPS system [6] developed by Newell. It assumes that people interact with a computer to achieve a goal by selecting a method, which consists of a sequence of basic operations. The GOMS model enables a designer to simulate the sequence of actions of a user while undertaking a task by decomposing it into goals and sub-goals.

Methodology

In our approach, the ACT-R framework has been used to describe the cognitive processes in several ICT-related tasks. Using the parameters defined in the Veritas VUM for cognitive impairments and psychological or behavioral contexts, we have created a mapping between these parameters and the corresponding ACT-R modules affected, which in turn provide completion times for each cognitive task supported by both ACT-R and Veritas [9]. The basic cognitive functions are composed by reaction time, attention (which is subdivided in selective, divided and sustained), memory (subdivided in semantic, episodic, procedural and working) and perception (subdivided in visual, auditory and haptic). The higher-level group is composed by decision making, orientation, speech and language. CogTool[11] is a UI prototyping tooled using a human performance model to automatically evaluate how efficiently a skilled user can do a task on a design that has been introduced in 2004, also using the ACT-R system to simulate cognitive task performance. The main difference between CogTool and our approach is that in the holistic nature of the Veritas Accessibility Assessment, cognitive tasks are only one part in the total tasks involved in interacting with a UI. Our approach considers vision, hearing, motor and cognitive tasks to be interconnected in the execution of tasks and more importantly takes into consideration the limitations introduced by both cognitive impairments as well as external cognitive loads introduced due to environmental factors (e.g. stress, fatigue etc.) as part of the VUM, whereas CogTool only considers a generic user model without provision for such impairments.

Based on the aforementioned mapping between the Veritas supported VUMs of cognitive impairments and corresponding ACT-R parameters, the Veritas GUI Accessibility Assessment framework with regard to cognitive simulation is presented in **Fig. 1**. In summary, the Veritas approach extends the methodology defined in [8] in order to provide a real-time holistic simulation framework for HCI accessibility assessment [10]. It revolves around the definition of a GUI interaction area (e.g. an application window), recording of an optimal interaction session, the definition and annotation of each interaction component (position, size and description) and mapping of the recorded interaction events to a generic simulation model describing the tasks to be performed. This generates a simulation scenario that can then be simulated with several VUMs applying accordingly the VUM parameters to the generation of motion paths, error rates and task completion times of the interaction tasks. This approach is implementation-agnostic, meaning that it can be applied to any GUI-based application, wireframe or mock-up of one, regardless of platform, Operating System, GUI sub-system, or input/output device.

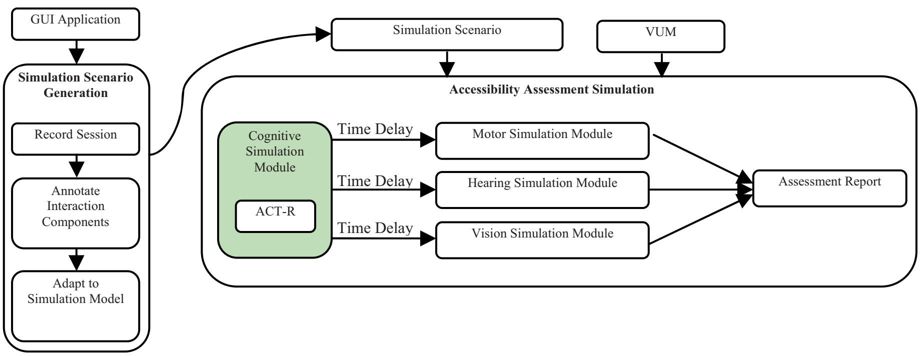

Fig. 1. The Veritas GUI Accessibility Assessment Framework.

As depicted in **Fig. 1**, cognitive simulation in the context of the Veritas GUI Simulation framework involves the generation of delays between the execution of motor, hearing or vision tasks (mouse motion, keyboard entry etc.) based on the VUM parameters.

Experimental Results

For interaction tasks with ICT applications, we have identified two main cognitive tasks, Locate and Read, the corresponding ACT-R Models of which were implemented in Lisp. The ACT-R model is activated before the simulation of the other modalities, to generate the time delays between each task. Motor tasks are, in turn simulated in real-time taking into account the delays generated by ACT-R, while vision and hearing parameters of the VUM are applied to filter the corresponding video and audio outputs.

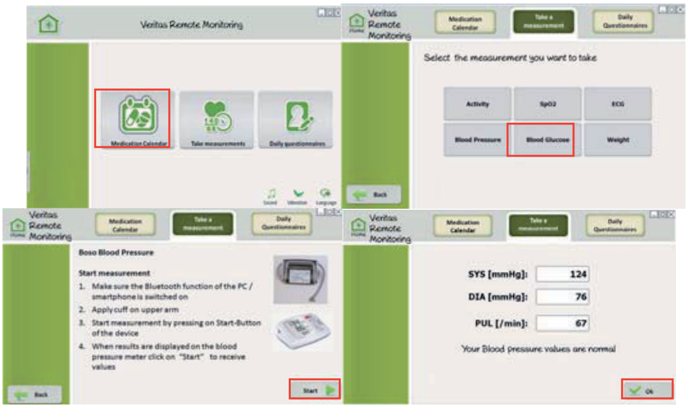

Fig. 2. Sample GUI used in the Use Case (4 GUI screens corresponding to 4 tasks – Interaction area for each task marked with red).

Fig. 2 presents a sample GUI application tested with VerSim-GUI, using three different VUMs representing: a user with no cognitive impairments, an elderly user with cognitive aging and a user with mental fatigue from sleep deprivation. These VUMs were tested under several use case scenarios involving applications in the Infotainment, Workplace, Smart Home and Healthcare domains, in desktop as well as mobile interfaces through the use of emulators. For brevity's sake, we present here only one of the use cases in the Healthcare ICT domain, in which 4 tasks were simulated. The times calculated by ACT-R and applied as delays before the execution of simulated motor tasks by VerSim-GUI are presented in **Table 1**. **Fig. 3.** shows a screenshot of a simulation session and the resulting cognitive task completion time vs. total completion time report.

Table 1. Cognitive task completion times for tasks in a Healthcare ICT application simulation.

Task	No Impairment	Cognitive Aging	Sleep Deprivation
Click on 'Take Measurements'	1.105sec	1.183sec	1.44sec
Click on 'Blood Pressure'	1.105sec	1.183sec	1.44sec
Click on 'Start'	0.82sec	0.874sec	1.05sec
Click on 'OK'	0.82sec	0.874sec	1.05sec

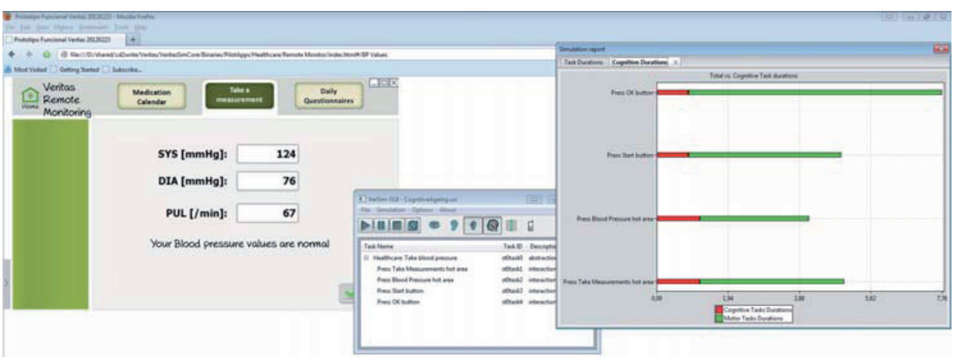

Fig. 3. Simulation report for a virtual user with **Cognitive Aging** impairment.

Conclusions and Future Work

We have developed a holistic approach in the accessibility assessment of GUI-based ICT applications using simulation of Virtual User Models describing cognitive parameters as an integral part of the interaction process. Pilot studies involving actual users with impairments are being conducted on all application domains covered by Veritas by 5 different research partners throughout 4 countries and will conclude in upcoming months. Furthermore, pilots with UI designers are also being conducted to evaluate the system's performance and acceptance by its potential target users and will conclude in upcoming months. Following the completion of the pilots, a quantitative and qualitative analysis will be performed both on the real users' performance in executing the tasks defined in the pilots, as well as the designers' evaluation of the system. The results of this analysis will be correlated to the results extracted from performing the same tasks with VUMs representing users with similar impairment as those of the actual users that participate in the pilots. The two results will be compared and an evaluation of our approach and validation of the Veritas VUMs and Accessibility Simulation system will be performed. This will be the topic of a dedicated paper to be produced in September 2013.

Acknowledgements

This work is supported by EU (project VERITAS FP7-247765).

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-494

Inertial Human Interface Device for Smartphone and Tablet Dedicated to People with Motor Disability

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Abstract. A novel interface to enable people with severe upper limbs impairment use a smartphone and a tablet is presented in this paper. Since smartphone and tablet market is constantly increasing and is overcoming respectively the one of cellular phones and the one of notebooks, the availability of novel human device interfaces (HIDs) for the disabled person is mandatory. Few solutions for Android and IOS-based devices are available on the market but not all the disabled users can take advantages of these products since these HIDs can mainly be used with upper limbs. Even though other types of HID technologies for disabled users are available, such as camera-based and inertial guidance systems, these can nowadays be used only with personal computer operating systems and they are not available for operating systems dedicated to portable devices. Therefore the technology transfer to Android and IOS is an eligible and novel result. To this aim a device featuring inertial-based pointer guidance and connectivity for standard sensor switches, is presented in this paper. It allows a person with disability to upper limbs to use a smartphone and a tablet by means of head tilt. A prototype of the device has been developed and tested, allowing some preliminary tests. A second test campaign with final users is soon expected and a second version of the prototype will be released according to the user's feedbacks.

Keywords. Disability, Inertial, Human Interface Device, Tablet, Smartphone, Human Computer Interaction.

Background

Smartphones and tablets are becoming more and more common among people, and they are rapidly substituting traditional mobile phones and personal computers. The market of these devices is constantly increasing so that the sale of smartphones has recently exceeded the one of mobile phones and it is estimated that the sale of tablets is doing the same with personal computers and notebooks during 2013 [1].

One of the main reasons is that people often need just mobile connectivity, entertainment and web browsing so they prefer using a single, small and lightweight device, such as a smartphone or a tablet, instead of having a cellular phone and a heavy and power-hungry personal computer or notebook. Furthermore the great availability of useful applications, such as notes, weather forecast, instant messaging, timetables, online shops and many more, makes smartphones and tablets very helpful also in everyday life. Just few years ago, with the first iPhone release, smartphones were

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considered luxury items, but now they are available at a low price, so their market has reached also people with a lower budget. Now you can find an Android device starting from few tens of euros.

Although the cost of a smartphone or a tablet is accessible to many people, their real accessibility is not guaranteed to everyone. In fact many people with disability to upper limbs find very difficult to use a resistive or capacitive touchscreen and a tactile switch as human-machine interfaces. From our experience we know that many people use a touchscreen with their nose or with a pen in their mouth, but you can easily imagine that these are not comfortable solutions. To let people with disabilities efficiently interact with smartphones and tablets different and specifically designed human interface devices (HIDs) must be used.

State of the Art

It is well-known that, unfortunately, any product is primarily designed for the mass market, then may be eventually adapted for users with disabilities. Operating systems for smartphones and tablets, such as Android, IOS, Symbian, Windows Phone, feature by default some accessibility options that are very useful for visually impaired people and blind people, such as the magnifier and the talkback functionality. Even for people with motor skill impairments there is a sort of help by means of voice controlled applications, such as Google Search for Android, or the accessibility options for the iPad, but these solutions are useful just for a few basic functionalities so a smartphone or a tablet cannot be entirely used with these helps. Also the apps are not conceived to be used by disabled users in fact most of them do not have any option to become more accessible. The fact is that smartphones and tablets can be used as their best only by employing the touchscreen and the default switches or, as less efficient alternative, using a traditional HID, such as a mouse and a keyboard. But it is well-known that the above-mentioned HIDs are not usable by many people with severe motor disability to upper limbs.

As alternative few companies have recently presented new HIDs dedicated to people with motor skill impairments. These solutions are both hardware and software (or mixed of the two), and let some disabled users interact efficiently with portable devices and use some basic functions in an easier way. Some examples are the application Click-to-Phone by Unique Perspectives [2] in conjunction with Housemate external box [3], Pretorian Receive Micro for Android [4] with Optimax joystick [5], J-Pad for iPad [6], Simply Works for iPad [7], APPlicator [8] and few others. These devices can either connect with Android or IOS-based devices and can be used with one or more switches, i.e. the commercial sensor switches dedicated to people with disabilities, in fact they feature 3.5 mm mono jack inputs. However the only device that let the user move the pointer on the screen employs a joystick.

Unfortunately not all the disabled people can efficiently use a joystick as pointer guidance system, but some of them are able to proficiently use other types of human-machine interface with a different body district than the hands or the upper limbs. For example users that can move the head and/or the torso can proficiently employ camera-based and inertial mouse emulators. These types of HIDs are available for personal computer operating systems like Windows, Linux and MacOS. Some examples are Camera Mouse, eViacam, SmartNav, Tracker Pro, Enpathia, Zono Mouse and others. Unfortunately none of them has been ported to Android and IOS so they cannot be used as HIDs for the purpose. Other widespread commercial products exploiting inertial sensors [9, 10] have been taken as key studies to understand if they were applicable as assistive technology devices. They both use wireless pointer guidance control but they have multiple and complex functionalities, since they are designed for non-disabled users, so they cannot be proficiently employed as HIDs for users with disabilities.

Several works in literature proposed solutions for human-machine interaction exploiting inertial sensors: for example the Chronos Flying Mouse [11] is a good example of wireless HID using accelerometers to implement a mouse and a joystick but it can be only configured and used with a PC; another good example is the one proposed by Huang et al. from Cornell University [12], it has a very effective implementation for the pointer control but can be only used with PCs and it has a PS/2-USB connector while different and wireless connectivity (e.g. Bluetooth) is needed.

A previous work [13] demonstrated how head-mounted interfaces can be used as pointer guidance systems for PCs and similar devices. However the work in [13] goes back to 1994 and refers to PCs only.

Other works [14-18] dealt with inertial sensors (particularly accelerometers) and human-machine interface but they all are dedicated to other applications than disability or can be used only with PC operating systems therefore inertial pointer guidance system for portable devices currently results a novel application.

We explored also the possibility to use AsTeRICS [19] framework, and in particular its 3D Accelerometer Sensor, to develop an inertial HID but it needs to be connected to the AsTeRICS platform, that is quite big-sized and power-hungry compared to a smartphone and a tablet, so it would not be suitable enough to be used everywhere and in battery operated mode.

The device proposed in this paper is a small and lightweight wireless inertial pointer guidance system for Android and IOS-based devices. It is like a proportional head tilt mouse but its functionalities let the user interact completely with Android and IOS devices in fact it generates HID reports that simulate controls implemented by those operating systems.

Development

The first prototype is based on iNEMO development board by STMicroelectronics [20] and Roving Networks RN-42 HID Bluetooth module [21]. The iNEMO board features a low-power STM32F103 microcontroller and several sensors such as a three-axis accelerometer, a gyroscope, a thermometer and more. The RN-42 module ensures wireless connectivity with a variety of hosts such as Android and IOS-based devices; it is very small and lightweight, embeds its own antenna and can be software configurable on-the-fly.

Other components are a battery pack (4 AAA Ni-MH batteries) and a low drop-out voltage regulator to keep the voltage at the required 3.3 V.

The firmware loaded into the microcontroller periodically reads inertial data from the accelerometer (embedded in the iNEMO board) and sends HID reports to the module according to these. Furthermore the jack switches condition is sampled, at a lower frequency. Inertial data are linked to the relative pointer shift, not to its absolute position on the screen. In fact the tilt of the accelerometer is interpreted as the direction where the user wants to move the pointer. For instance if you wear the device on your head, and you want to move the pointer to the right you simply tilt your head to the right and the pointer starts moving that way, if you want the pointer go down you simply tilt your head forward and so on. The velocity of the pointer movement can be configured in two ways: it can be proportional to the tilt or either have a fixed, pre-determined value. Unfortunately at this stage of development this value can only be configured via firmware, not on-the-fly.

A custom low-pass filter eliminates unintentional shaking and a threshold algorithm ensures an easy achievement and maintenance of the rest position, e.g. if your head is doing a little swing near to the rest position no pointer movement is performed. Unfortunately also the value of the threshold can be configured only by loading a different firmware in the microcontroller.

In order to be adapted to any posture the software let the user choose a given position as the rest one by pressing the two switches at the same time at the beginning. So you can firstly wear the device, secondly find your best position, the more comfortable one, then make some try to move your head in any direction and finally press the buttons to fix the rest position. This fact is very useful also because the position of the device can be different according to the usage, it may be horizontally, vertically or inclined so the person who looks at it must rest in a different position.

Device buttons are implemented by means of two 3.5 mm mono inputs, one is used for the click, the equivalent of touching the screen; the other is used for back (in Android) or home button (in IOS), according to the operating system of the device. The prototype is small and lightweight enough to be worn on anybody district, even though at this stage it is specifically designed to be put on the head by a special cap.

Results

A first release of the prototype has been fully designed and tested by the development team and by two disabled volunteers. In Fig. 10a you can see the developed device: on the bottom-right the iNEMO development board; on the top-right (blinded) the RN-42 module; on the left the Ni-MH battery pack. Jack inputs are provided by an external daughter card (see Fig. 10b) connected at the iNEMO board by means of the internal 10 pins expansion slot (visible in Fig 10a).

This prototype has been correctly connected both with Android and IOS-based devices, (not at the same time) allowing both pointer guidance and click action. Battery pack ensures several hours of continuous operation, even though a final release will probably use a smaller and lighter Lithium battery.

The first preliminary test campaign was carried out by the development team, using a Samsung Galaxy S smartphone and a Samsung Galaxy Note 10.1 tablet at a distance of 1 m approximately. Test-users were sit on a chair in a comfortable position, wearing the device on the head. The position of the devices was almost vertical. In Fig. 2 a moment from the very first test campaign is shown.

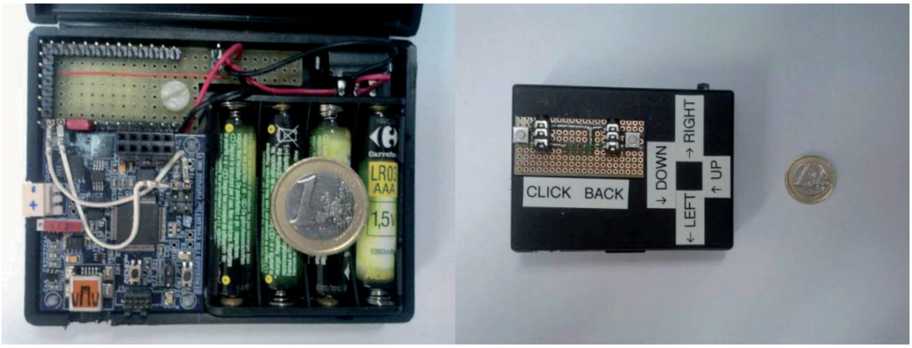

Fig. 1. a) A picture of the internal of first prototype b) the external box.

The device was conceived to be worn on the head and on a foot, but only the first scenario gave good results while the second has been abandoned because of poor usability and lack of comfort for the users.

We also involved two disabled persons in the development and test of the prototype, but at this stage we were able only to do some quick try with them, therefore a complete test campaign with disabled volunteers is soon expected.

However the above-mentioned tests gave encouraging results so a second prototype, featuring on-the-fly configuration tool, will be soon released.

Fig. 2. a) A moment of the very first tests.

Conclusions

A novel human-machine interface for Android and IOS-based devices has been fully developed and tested. This HID is based on inertial pointer guidance and can be used in conjunction with commercial sensor switches. The developed device enables smartphone and tablet use by means of tilting a body district, in particular the head or the torso, allowing for higher accessibility to those people with severe motor limitations to upper limbs.

First release features Bluetooth wireless connectivity and jack inputs for any commercial sensor switch, plus some data processing policy allowing an easy rest position. Several laboratory tests have been carried out by developers and showed promising results. More tests with disabled volunteers are soon expected allowing a full review of the functionalities. An easy configuration tool for PC is under development and a second, smaller, release is soon expected. Further enhancements will be considered according to the user's feedbacks.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-500

Validation of Fitts's Law Adapted for Upper Limb Motor Impairment on Software Keyboards

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Abstract. The aim of this paper is to make a validation of the Vella's model based on Fitts's law on several virtual keyboard layouts to prove its validity. Firstly, we have obtained this model through an experiment in three populations (able-bodied, suffering myopathy and tetraplegia). The Vella's model takes into account the motor behaviour variability inside of a population. We have observed a more important variation for the motor impairment than for the able-bodied. In second time, we have compared to the keyboard performance with the different models based on Fitts's law. Then we have evaluated the Vella's model on suffering myopathy subject. This one has used two virtual keyboards: Annie and AZERTY. Theoretical results have been compared with experimental results. The Vella's model is more efficient for suffering myopathy participants than for able-bodied participants . These results show that there are still strong needs to adapt the Fitts's law to accurately model the user's behavior.

Keywords. Motor Impairment, Fitts's Law, Soft Keyboards, Assessment.

Introduction

Participants with upper limb motor impairments have problems for pointing task on WIMP (Windows, Icons, Menus and Pointing device) interfaces. Indeed, the icons, the menus and the buttons are too small targets. Consequently, the access to these WIMP components can require many sub movements of the pointing device cursor to access it.

In human computer interaction it is important to understand and to model the interaction behavior of users. Several models have been proposed:

- From the prediction of time selecting an item from a set of choices under the Hick-Hyman' law [2], [3];
- From the performance of the movement performed by a user Fitts' law [1]. This law says that the target is more distant and smaller it is, the more it is difficult to achieve. This difficulty names index of difficulty (ID), the interval is range 1 (no difficult) to 7 (very difficult). The ID depends on the size and distance. The result of the model is the movement time (MT) in second;
- The Soukoreff and Mackenzie' model [4] is to estimate the time of entry on a virtual keyboard taking account of Fitts' law and the probability that the character is selected (in this paper we have adapted the probability to the French language);

- The models derived from Fitts' law [7] adapted to different populations (currently quadriplegic, myopathies and valid) that we call "Vella's model." This takes into account the variability within populations. This model lies not only in the predictions provided, but mainly in its characterization of text-entry tasks using keyboards.

The aim of this paper is to make a validation of the Vella's model based on Fitts's law on several virtual keyboard layouts to prove its validity.

1 Vella's Model

We carried out experimentation through the MPH platform (www.irit.fr/MPH). The MPH is implemented in JavaScript. This program implements a Fitts' point-select task (Fitts 1D [1] and Fitts 2D). The task consists in pointing on targets with different size (8, 16, 24, 32 and 40) at different distance (80, 160, 240 and 480). The subject proceeded to move the cursor to the highlighted bar with his/her usual pointing device.

We logged the duration and the distance between clicking two targets, the coordinates of the pointing click. This experiment was carried out on three population's types: 14 valid participants, 4 participants with spinal cord injury (uppers limbs disability) and 9 participants with muscular dystrophies. Thanks to this experimentation, a specific Fitts' model was obtained. But this model used the linear regression, the inconvenience is the Fitt's model for motor disable there are a lot of variability. Another way to model and reduce the variability is to achieve an "integral control for each population." To do this, we first plot (see Fig. 1) the linear regression lines of Fitts' law for each participant (about 1-5).

Then, we used the maximum linear straight (left side of the model of the subject 2, D1, right part of the model of the subject 1, D2, and right on the linear minimum 5: D3). Then we determined the intersection "b" of the lines D1 and D2. Finally, we calculated the total area by adding the two integrals: the integral one with the limits "a" and "b" and the integral two with the limits "b" and "c".

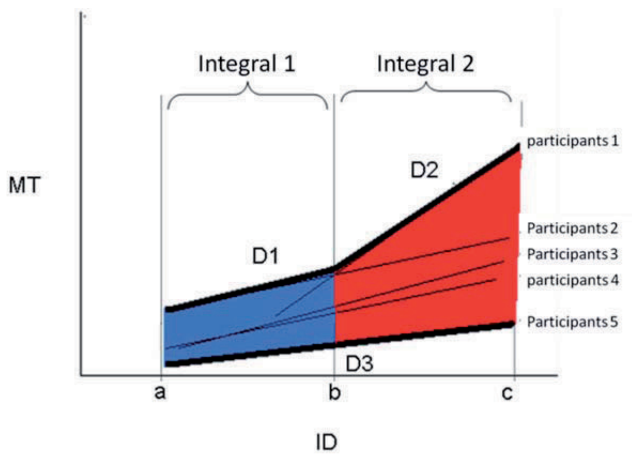


Fig. 1. Explanation of the modeling integral control.

This method allows taking into account the variability inside of a population. The Fig. 2 illustrates the three models. The Figure 2.b and Figure 2.c show that the index difficulty (ID) is in the range (2-8). The movement time (MT) has the largest variation for the tetraplegic participants. In particular, MT is twice more important for ID > 5.

Now we validated this model on the virtual keyboard and two myopathy participants.

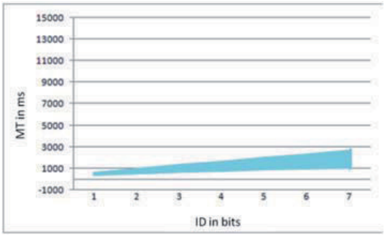


Fig. 2a. Vella's model for able-bodied**.**

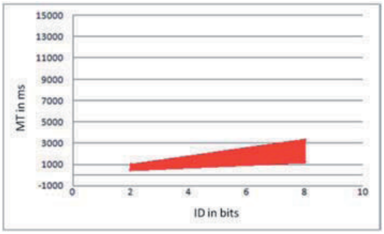


Fig. 2b. Vella's model for suffering myopathy participants**.**

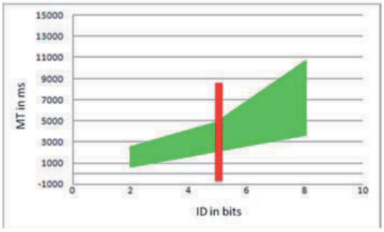
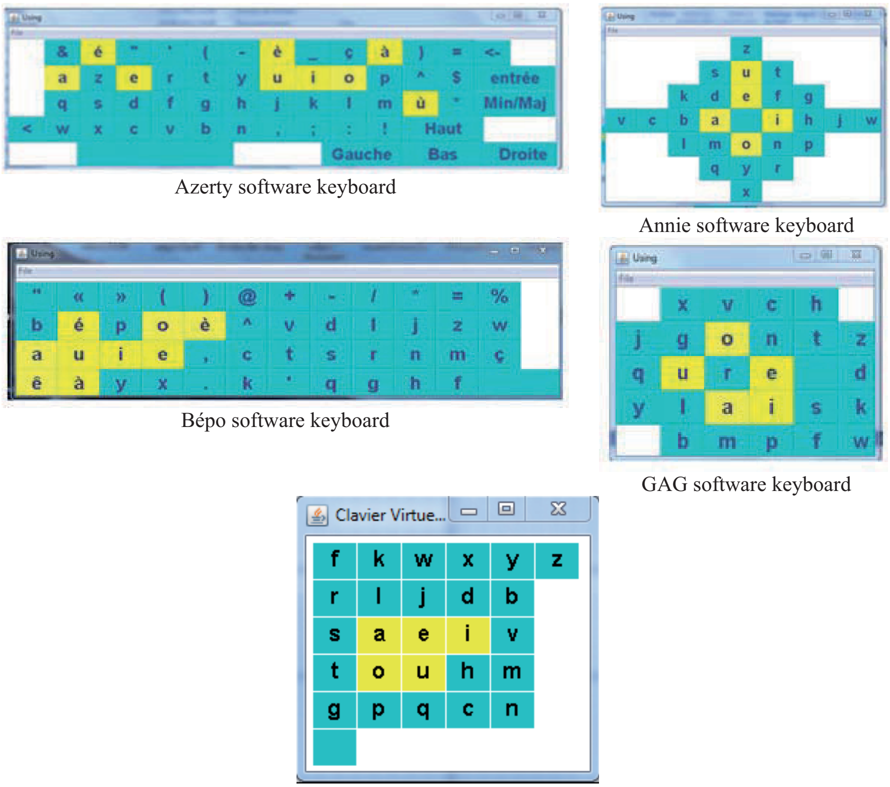


Fig. 2c. Vella's model for tetraplegic participants**.**

2 Virtual Keyboards

AZERTY, Bépo, Annie, GAG and Celine software keyboards (see Fig. 3) were set for the evaluation. These are four different keyboard layouts for French which we have seemed interesting to compare. The AZERTY one will serve as a reference. The Bépo layout [9] is based on placing letters most used on keys used most accessible, dividing by two the finger movement (or pointing device cursor)on this layout keyboard compared to the AZERTY layout. The Annie keyboard [6] was designed by a person suffering myopathy. The used principle was to place at the center the most frequently used characters in trying to place them in alphabetical order. Annie designer has explained this layout: her aim was to reduce as soon as possible the cursor moving of the pointing device. The GAG keyboard [10] was designed with a genetic algorithm taking into account the frequency table of bigrams for the French language. Celine keyboard was designed by a person suffering myopathy. The used principle was to place at the bottom the most frequently used characters. Celine designer has explained this layout: her aim was to reduce as soon as possible the movement of cursor to the top of the pointing device.



Azerty software keyboard

Annie software keyboard

Bépo software keyboard

GAG software keyboard

Celine software keyboard

Fig. 3. Software keyboards.

Firstly we have assessed these four keyboards by Fitts's law [1], the Soukoreff's model [4] and the Vella's model. The text used was the no accentuated panagram: "portez ce vieux whisky au juge blond qui fume". The key size is 31 pixels width and 26 pixels height, except the SPACE for the AZERTY keyboard.

3 Results and Discussion

The results in Fig. 4 show a large difference between the word per minute rate computed by the Vella's model and the ones of Fitts's and Soukoreff's models.

The GAG keyboard is the most efficient whatever the predictive evaluation model used. It is followed by the Annie keyboard excepted for the suffering myopathy population. Then, there is the Celine keyboard excepted for the suffering myopathy population. The Bépo keyboard is not efficient for tetraplegic participants. Fitt's law and Soukoreff's models give similar assessment independently of four keyboards. This difference can be justified: i) these models don't consider the behavior variability inside a population; 2) The Vella's model has defined its empirical parameters of Fitts's law for each population.

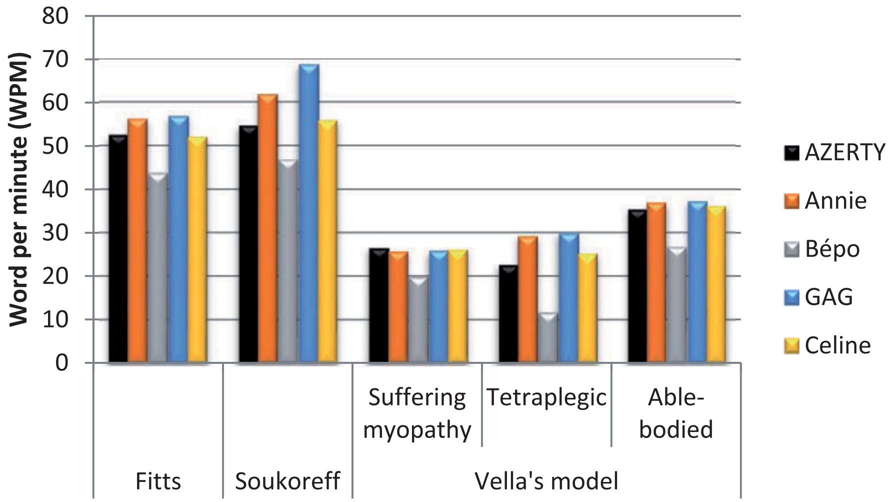


Fig. 4. Predictive evaluation of four keyboards in WPM.

These results raise the validity of the Vella's model. To test this hypothesis, we have invited two suffering myopathy participants to enter a text of 1367 characters. The first participant has used the AZERTY keyboard, then the Annie virtual keyboard. The second participant has used the AZERTY keyboard, then the Celine virtual keyboard. These participants have a high experience in the use of virtual keyboard: they use daily Windows keyboard and were the designer of Annie keyboard and Celine keyboard. For the first participant the WPM was respectively 11.25 for AZERTY and 11.6 for Annie. For the second participant the WPM was respectively 23.82 for AZERTY and 21.94 for Celine.

The table 1 gives the difference in WPM between the WPM given by the different models and the WPM computed during the text input. There is a big difference between predictive and experimental for Fitts's and Soukoreff's model. The Vella's model is more efficient for suffering myopathy participants than for able-bodied participants. These results show that there are still strong needs to adapt the Fitts's law to accurately model the user's behavior.

Table 1. Comparison between predictive and effective results in WPM (Word Per Minute).

		Experiment WPM	Theorical WPM Soukoreff's model	Theorical WPM Vella's model			Fitts' law	Soukoreff's model
				Myopathy	Tetraplegic	Able-bodied		
AZERTY	Participant 1	11,25 (+/- 0,38)	52,3	26,57	22,69	35,5	52,62	54,7
	Participant 2	23,52 (+/- 0,19)						
Céline	Participant 2	21,94 (+/- 0,24)	54,8	26,15	25,21	36,19	52,12	55,91
Annie	Participant 1	11,6 (+/- 0,01)	57,2	25,88	29,39	37,14	56,33	61,95

4 Conclusions and Future Work

In this work, we have achieved a model taking account to the motor disabled variability. This model named "Vella's model". We have validated it on two suffering myopathy participants. We have showed a big difference between predictive and experimental for Fitts's and Soukoreff's model. The Vella's model is more efficient for suffering myopathy participants than for able-bodied participants. We have showed our methodology for validated of Vella's model but we have need of others participants for enhance our model. We want also mature the Vella's model taking account to the degree of motor.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-506

ePhone – a Technical Aid System to Ease Accessibility to Android Smartphones for Motor Skill Impaired Users

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Abstract. Mobile devices are indubitably the main tools for communications, and they offer a wide range of opportunities to the users. Especially for people with disabilities these devices produce benefits in social inclusion and security. Unfortunately, the accessibility of the current devices is compromised by small form factors, touchscreen input methods, complex user interfaces. A complete aid system is presented in this paper, to allow people with motor skill impairments to take advantage of mobile devices. It enables to control the main functionalities of a smartphone through different kinds of switch sensors for the exploitation of residual abilities. Compared with similar solutions, it reduces the efforts required to the user.

Keywords. Assistive technology, Mobile Accessibility, Motor skill Impairment.

Introduction

In recent years, mobile devices (i.e. smartphones, tablets) are becoming essential tools in everyday life for personal communications and social integration. Modern devices, in addition to the basic phone and SMS messaging functionalities, provide the access to many kinds of information anytime and everywhere (e.g. web pages, e-mails, maps, music, videos, etc.), exploiting Internet connection, Bluetooth and GPS functionalities.

In particular, for people with disabilities the mobile communication has the potential to enhance the autonomy and the opportunities to carry out a more independent life [1]. Despite the promotion of *"design for all"* strategies in making mobile phone and services [2],[3], the accessibility remains relatively unimplemented in mobile devices currently available. Major manufacturers, following the mass-market demand, are still producing richer and richer devices favoring the design instead of considering the accessibility aspects. Conversely, the specialized devices are often considered too expensive [4].

The complexness of the user interfaces (i.e. many and small on-screen controls, matrix placement of icons, soft color contrast, reduced text fonts), as well as the

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implemented input methods (i.e. multi-touchscreen, small on-device or on-screen keyboards) pose many accessibility and adoption problems to users with perceptual, motor and cognitive disabilities [4]. For these reasons, the difficulties increase in case of multi-impairments [5]. This influences social inclusion, self-esteem and personal safety.

The present work proposes ePhone; a novel hardware-software based aid system, with the aim of enabling people with motor skill impairments to access and use autonomously the main features of current Android smartphones. The system overcomes some issues presented by other currently available commercial solutions. Hereafter section 1 provides the state-of-the-art review. Section 2 describes in details the ePhone aid and section 3 shows the results. Finally, conclusions are drawn in section 4.

1. Current Approaches and Solutions for Mobile Devices Accessibility

Concerning motor skill impairments, some dedicated solutions are available to allow the access to the mobile devices functionalities, based only on software applications or using also additional hardware stuffs. Moreover, some native functions (i.e. voice recognition) may apply to this purpose. To the best of our knowledge, two main approaches exist to control the smartphone native or ad-hoc developed applications: i) vocal control and ii) scanning control and switch interfaces for the exploitation of specific user's abilities.

1.1. Vocal Control

Vocal control allows controlling directly the device with commands submitted by means of the user's voice. There are substantially speaker-dependent (SD) and speaker-independent (SI) systems. SD systems require a training phase to learn the user's pronunciation, while in SI systems no training is required. SD outperforms SI systems. Voice controlled systems generally need a good pronunciation, and this capability is often compromised in motor impairments caused by neurological diseases. Vocal control also suffers from voice alteration [6] due to emphasis, emotion, temporary illness, etc.. Additionally, as studied in the Minnesota street test [7], native voice recognition on smartphones dramatically suffers from environmental noise. Voice recognition failures may turn into a tiring and frustrating experience. In general, vocal control turns out to be not completely suitable to allow smartphone access to motor skill impaired users.

1.2. Scanning Control

In scanning controlled devices, the control is based on the recursive highlighting of one item at a time within a set, in order to allow the user to select the desired one when focused (e.g. buttons of an application, rows of an on-screen keyboard, etc.). Usually the scanning control relies on a hardware system connected to the mobile device by means of wired or wireless technologies that acts as interface for switch sensors specific for the exploitation of user's abilities. Various scanning strategies are available depending on user's abilities [8]. The simplest one requires a switch sensor to confirm the actual selection while the scanning procedure is time-based; manual scanning uses an additional sensor to change the focus to the next item; more complex strategies involve hybrid modes or for example four sensors in a sort of joystick emulation to move the focus.

Regarding the input modes, scanning systems can be controlled by means of stand-alone specific switch sensors, or can be integrated with power wheelchairs and controlled by means of the wheelchair-driving joystick, once properly configured. Systems independent from wheelchair allow for more flexibility, being suitable also in scenarios other than the wheelchair usage (e.g. lying in the bed, etc.). Concerning the graphical user interface, some scanning systems use the native interface of the mobile device implementing only a different input method, while other systems provide a dedicated interface to facilitate the access to the main functionalities (e.g. phone call, SMS messaging, etc.). The latter systems are more effective for the target users, because they present less complex and linear layouts with large fonts and high-contrast icons.

Table 1 shows the analysis results of some products. In our view, stand-alone systems with dedicated interfaces are the best solution for motor skill impaired people, but they still present some issues and performance limitations, especially in contact list browsing. This was the main reason for the study and development of the ePhone system.

Table 1. Characterization and performance evaluation of some scanning systems. Performance are evaluated in terms of actions required to make a call with the i-th contact of the alphabetically ordered list.

Scanning System	Input Mode	Graphical User Interface	# Actions in automatic scanning	# Actions in manual scanning
Tecla [9]	Stand-alone	Native	i+4	i+16
Click2Phone [10]	Stand-alone	Dedicated	6	i+2
iPortal [11]	Integrated	Native	---	i+17

2. The proposed Aid System

In light of the considerations on the state-of-the-art, the ePhone architecture shown in Figure 1 was defined. The system consists of two main parts, a hardware device named gateway and a software application. The gateway is able to manage commercial switch sensors for the exploitation of residual user's abilities. The gateway is also connectable to the Environmental Control Unit port (ECU) of power wheelchairs, to receive commands from the driving-joystick. The smartphone application allows managing telephony, contacts list and messaging features by means of scanning strategies and dedicated graphical user interfaces. The communication with the gateway uses a Bluetooth or USB connection.

During the entire project, specific requirements for the target users, substantially different from those dictated by the mass-market demand, were accurately considered in order to address the technology potential towards target users' specific needs. Moreover, during the development phase, some tests were carried out with the help of end users, in order to tune up the system implementation concerning in particular its usability.

The proposed aid system was realized as a prototype, and it is shown in Figure 2.

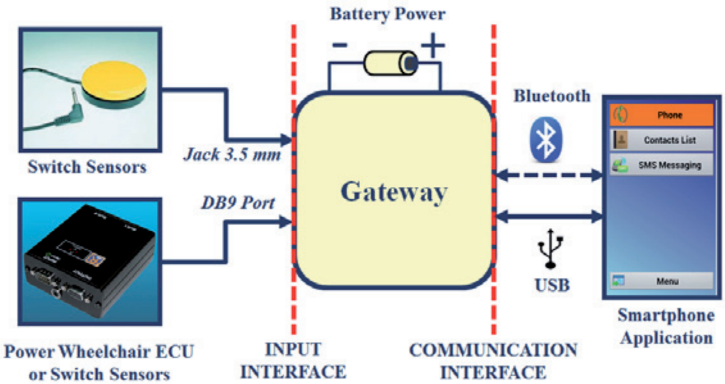

Figure 1. Schematic view of the ePhone system architecture.

Figure 2. The developed aid system in its final prototypical realization.

2.1. The Gateway

The gateway is a microcontroller-based device in charge of detecting the state of the switch sensors actuated by the user. Indeed the switching events are translated into proper information that are sent to the smartphone. These information are interpreted by an ad-hoc layer of the software application and then translated into specific commands within the application (e.g. move the focus to the next menu item, select the focused one, etc.).

This stand-alone device allows for the use of one or two single switch interfaces for the exploitation of specific user's abilities provided with standard 3.5 mm jack connectors (e.g. buddies, tongue-sensors, eye-blink detection sensors, etc.). It is equipped also with a DB9 connector supporting both a standard DB9 5-switch multiple interface and a 6-pushbutton custom keypad. Additionally, the DB9 port allows ePhone to be integrated with the power wheelchair, realizing a hybrid approach concerning the input mode.

The gateway was developed taking into account the requirements posed by the different scenarios in which the system should be used (e.g. mounted on a wheelchair, used by a person lying on the bed or sitting at a desk, etc.). These requirements are essentially compactness, portability, independence from the wall power.

The supply to the device is currently provided by 2 AA rechargeable batteries, as a compromise between lightness and battery life, which is about one day for typical use cases. The device is compatible also with non-rechargeable batteries, in order to improve its flexibility. A dedicated LED signals low battery state. The size of the current prototype is 180 mm x 120 mm x 40 mm, expected to be halved in the next version.

2.2. The Software Application

The ePhone software implements a *"portal"* where the user can easily locate and launch, or interact with, the desired functionalities offered by the application. Currently, these ones are telephony, contact list navigation and SMS messaging. For example, the user can make a call and answer or hang up incoming calls. The rationale is to provide ad-hoc layouts (e.g. placement and colours of buttons, background, etc.) and contents (e.g. button controls, text fields, etc.) to be used in replacement of the screens offered natively by the smartphone. This improves the accessibility to the mobile device by the target users. ePhone uses layouts with a linear placement of controls (e.g. buttons, text fields, etc.), large icons and fonts to clearly identify them, high color contrast, reduced number of nested screens. Moreover, an ad-hoc control strategy was implemented to reduce, with respect to the other analyzed solutions, the number of interactions required to control the application and in particular also to select a desired contact in the list. The results of the comparison are discussed in section 3. This strategy is based on the possibility to refine progressively the subset of the contacts shown on the screen by composing a search string letter by letter on user's input. At the j-th step only the letters that appear at the j-th index of the names that match the letters previously selected are available. Typically, a search string of one letter is enough to reduce highly the average user effort in selecting the desired contact, but the user can bypass this phase and scan normally the entire contact list.

The application was developed for the widely spread Android-based devices, both smartphones and tablets. It is compatible with Android version higher than 2.3 if the Bluetooth connection is used and version higher than 3.0 for USB connection.

The application is completely controllable via a reduced set of user's input commands generated according to the information received from the gateway by the smartphone. Each command is used to simulate a touchscreen interaction of the user with the controls in the actual screen or a direct activation of the physical buttons of the smartphone (i.e. Back control). Commands produce different effects depending on the current active screen and/or focused control, implementing a sort of context-aware mechanism. It is possible to select for the application a control strategy among i) 1 switch sensor and timed scanning, ii) 2 switch sensors and manual scanning, iii) 5 or 6 switch sensors and manual scanning with shortcuts for the navigation of the on-screen controls.

The application requires an initial configuration through the native smartphone interface. Configuration parameters allow choosing between Bluetooth and USB connection with the gateway, the use of headset or speakerphone for calling, the scanning strategy, etc..

3. Discussion and Results

In order to maximize the usability, the system was developed taking into account the critical review of the state-of-the-art and trying to overcome the limits found.

In comparison with analysed solutions, the ePhone gateway reaches a high degree of flexibility, as, differently from them, it can behave both as stand-alone module, receiving commands from different switch sensors, and as integrated solution if connected to the power wheelchair. The battery supply and the possibility of both wired and wireless communication with the mobile device make the system suitable to different scenarios (e.g. mounted on a wheelchair, for a user lying in the bed, etc.).

The software application redefines the graphical user interfaces for the supported functionalities. As provided also in other systems, this improves the readability and make easier to navigate the screens of the application.

In comparison with the analysed commercially available solution with better performance (i.e. Click2Phone), the control strategies implemented in the application lead to a significant reduction of user's effort and time required to manage smartphone functionalities. In particular, with one and two external switch sensors and scanning control, for typical use cases the navigation of the contacts list requires in average a significant lower number of user actions. As an example, see Figure 3, for a contacts list uniformly populated with 3 contacts for each letter, as an average among all letters ePhone allows to call the first contact of a given letter with a number of user's interactions in the order of 45% less than other systems. The application also provides a list of preferred contacts that the user can call in a quick way. This feature is not present in the other investigated solutions.

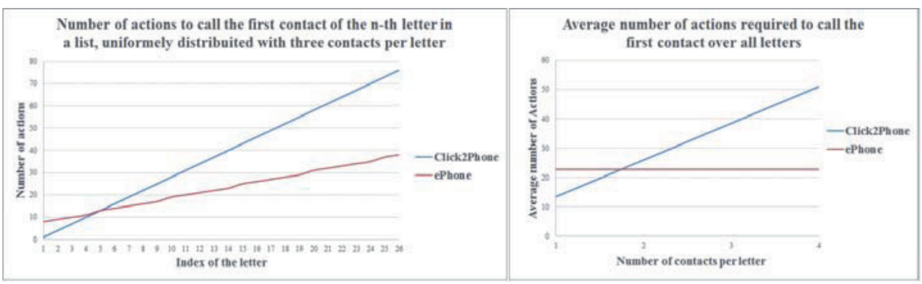

Figure 3. Performance comparison between ePhone and Click2Phone contact list navigation algorithm.

4. Conclusions

The implemented aid system goes in the direction of an enhanced accessibility and performance with respect to similar systems already available on the market, in terms of reducing user effort, complexity of application interfaces, and at the same time trying to maintain affordable costs. The final goal of the ePhone system is to help to overcome the accessibility limits posed by mobile devices, and to allow people with motor skill disabilities to take advantages of these devices for communication and social inclusion.

The first prototype of the system is currently used by a power wheelchair user with upper limbs disability. The feedbacks from the user are positive. A more complete collection of user's impressions and suggestions is expected in the near future, involving a sufficient number of end users.

Finally, future activities deal with the realization of an engineered version of the gateway, equipped with rechargeable Li-Poly batteries, reduced size, and expansion of the functionalities of the application (e.g. e-mail, multimedia, social network, etc.).

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-513

Improvement of the Mouthpiece Type Remote Controller for the Integrated Tongue Operation Assistive System "I-to-AS"

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Abstract. To control assistive devices to be used by seriously disabled people, we have focused on tongue motion. We have tried to develop an Integrated Tongue Operation Assist System ("I-to-AS") to control a PWC and a PC as an AAC device. In this study we developed a stick type mouthpiece remote controller as a new type of the remote controller. This controller has a 4-directional tact switch and a push switch. To investigate the operativeness of the "I-to-AS" with the stick type mouthpiece remote controller, eight able-bodied candidates drove a PWC on the same course. Each candidate operated the PWC using the stick type mouthpiece remote controller by "Tongue" and by "Fingers". The average driving times were compared and the difference between using the tongue and fingers was about 25% which was considered acceptable. These suggest that the "I-to-AS" with the stick type mouthpiece remote controller would be effective and it has the potential to be used by seriously disabled people.

Keywords. Assistive Technology, Rehabilitation Engineering, Tongue Motion, Cervical Cord Injury, ALS.

1. Introduction

Some seriously disabled people use an electric Powered Wheelchair (PWC) for their mobility, and some other disabled people use Augmentative and Alternative Communication (AAC) devices to aid communication. People with serious cervical cord injury, muscular dystrophy or Amyotrophic Lateral Sclerosis (ALS) can only move their eyes, mouth and tongue voluntarily, but can't use their hands and fingers to operate even PWCs or AAC devices.

To control those kinds of assistive devices, chin, voice, head, and eye motion control systems are applied [1) – 6)]. But each system has its own advantages and disadvantages. On the other hand, the tongue can move quickly and accurately, and most seriously disabled people can move their tongue voluntarily. These factors indicate that the tongue has sufficient potential to operate some control devices. A few authors have tried to develop devices operated by tongue motion for seriously disabled people [7) – 9)]. So we have focused on tongue motion, and have developed a mouthpiece type remote controller operated by the user's tongue. In recent years, we have tried to develop an Integrated Tongue Operation Assist System (I-to-AS) to control a PWC and a personal computer (PC) as an AAC device [10) – 13)].

In this study, we developed a stick type mouthpiece remote controller with a 4-directional tact switch and a push switch as a new type remote controller. The system configuration of "I-to-AS" and the mechanism of the stick type mouthpiece remote controller are described in this paper. Then we evaluated the effectiveness of this system by driving a PWC using the new remote controller.

2. Specification and Mechanism of the "I-to-AS"

2.1 The System Configuration of the "I-to-AS"

The "I-to-AS" has two operating devices. These are the mouthpiece type remote controller and the tongue operated mini joystick (tongue joystick) as input devices. The mouthpiece type remote controller is inserted into the user's mouth and fixed on the upper jaw. The tongue joystick is held in the user's lips. Both of them are operated by the user's tongue.

The "I-to-AS" also has two operating targets of a PWC and a PC's mouse as an AAC device (see Figure 1). The user can drive the PWC by depressing switch buttons on the mouthpiece type remote controller, or by tilting the tip of tongue joystick. When using the "I-to-AS" as an AAC device, the PC's mouse cursor will be moved by in the same way, so the user can input any letter or sentences on the PC's screen (we call this the "Tongue Mouse System").

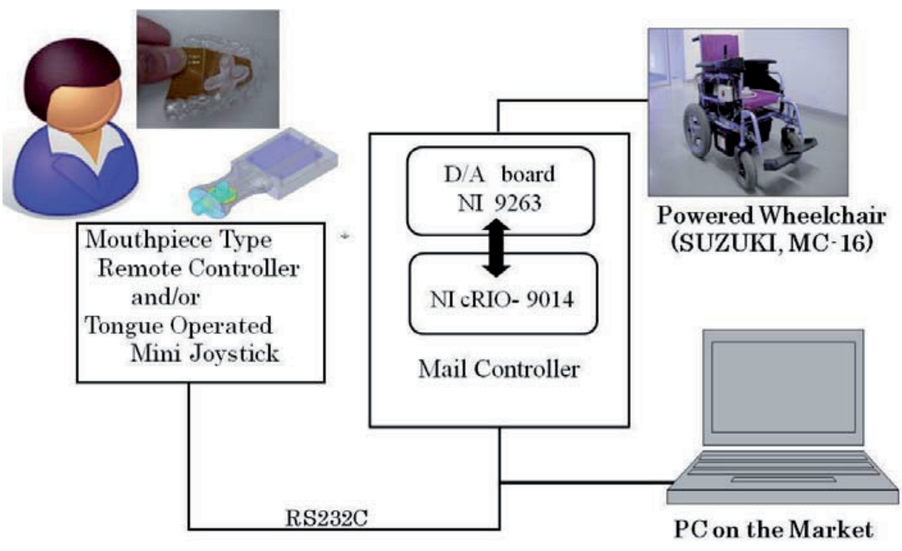

Figure 1. Schematic diagram of the "I-to-AS".

2.2 Mechanism of the Stick Type Mouthpiece Remote Controller

When operating the existing mouthpiece type remote controller (button type remote controller), the user needs to keep depressing switch buttons if they want to continue moving the PWC or the PC's mouse cursor. This leads some users to get tired from using it for long time. To improve operativeness and to increase the number of users, we thought that another operation style controller was needed.

We developed a stick type mouthpiece remote controller (see Figure 2). The basic mechanism is same as the existing controller; passive RFID (Radio Frequency Identification) transponders are used for the main system. This means that this remote controller can work without a battery. The stick type remote controller has a 4-directional tact switch instead of 4 push button switches to determine the directions of movement. Only while the user tilts the tip of the 4-directional tact switch, the operation targets move in the same direction as the tilting direction. This remote controller also has a push switch. This button switch will be used as an alternative "Enter key" for a PC or some other enhanced features.

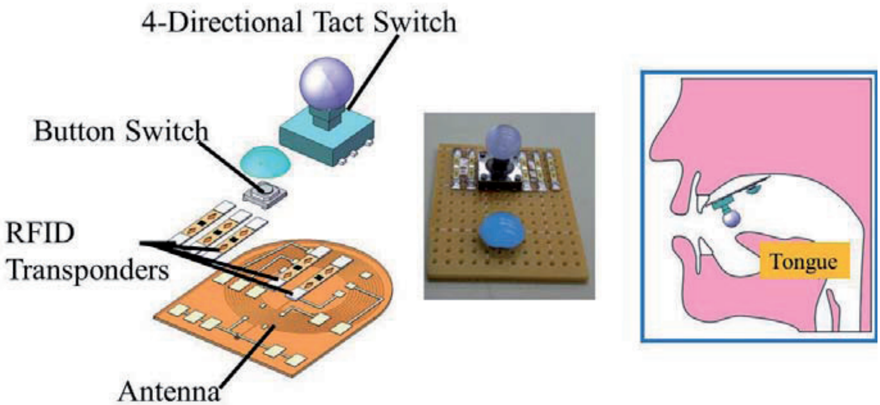

Figure 2. Schematic diagram of the Stick type mouthpiece remote controller.

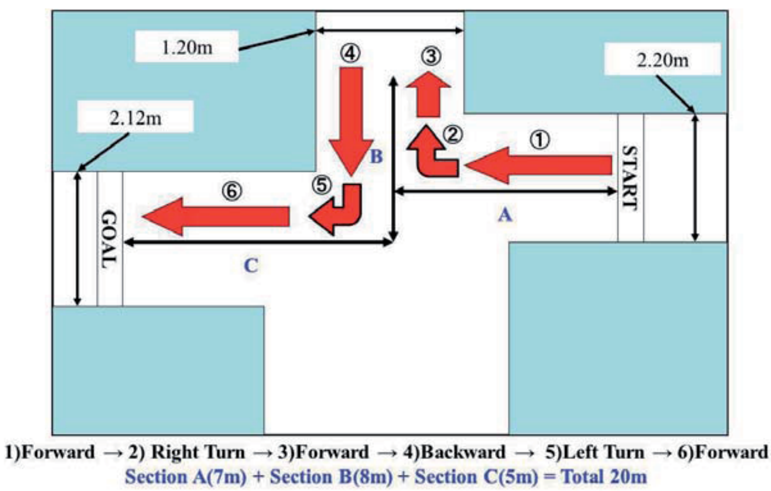

Figure 3. Illustration of the driving course.

3. Investigation of the Effectiveness of the “I-to-AS”

To investigate the effectiveness of the “I-to-AS” with the stick type mouthpiece remote controller, the driving course was set as in Figure 3. A simple driving course was set, but it contained the major driving operations of “Move Forward”, “Turn Right”, “Turn Left” and “Move Backward”.

Eight able-bodied candidates drove a PWC available on the market by using the stick type mouthpiece remote controller. The time taken to drive the course using the stick-type controller with the “Tongue” and with a “Finger” was measured. For comparison, the time taken using the “button-type controller” with the “Tongue” was also measured. In addition, the time taken using a “Normal Joystick” was measured too. Each candidate drove the course 5 times and the average times and Standard Deviation (1S.D.) [s] were calculated.

The speed of the PWC was 1.1[m/s] using the normal joystick, but for the candidates’ safety, the speed for the mouthpiece type remote controller was set at 0.8[m/s].

4. Results and Discussions

The average driving times are shown in Table 1.The average driving time of the “Normal Joystick” was 29.1[s] which was the fastest. The average time of the “Stick type remote controller” that was operated by “Fingers” was 42.0[s] and by “Tongue” was 52.4[s]. The average time operated by “Tongue” was 10.4[s] longer than the time by “Fingers”, and it was about 25% longer.

The average driving time of the “Button type remote controller” was 84.7[s]. When we compared the average time of the “Stick type with Tongue” with the “Button type”, the time for the “Stick type” was much shorter. The time of the “Stick type” was about 50% shorter than the time of the “Button type”.

As you know, fingers can move quickly and accurately. The difference between the average driving times operated by “Stick type remote controller” by “Finger” and by “Tongue” was about 25%. We thought that the difference was small, so we concluded that the driving time was acceptable and the effectiveness of the stick type mouthpiece remote controller was recognized. These suggest that the “I-to-AS” with the stick type mouthpiece remote controller would be effective and it has the potential to be used by seriously disabled people.

Table 1. Average Driving Time by Tongue and by Finger.

Operating Apprication	Driving Speed [m/s]	Operating Method	Driving time (mean±S.D.[s])
Normal Joystick	1.1	Finger	29.1±1.3
Button Type Remote Controller	0.8	Tongue	84.7±24.0
Stick Type Remote Controller	0.8	Finger	42.0±5.5
	0.8	Tongue	52.4±10.7

For future work, we need to investigate the effectiveness for seriously disabled candidates. Each disabled person has a different functional disturbance. So we need to investigate how this “I-to-AS” system would be effective for disabled people with different kinds of functional disturbance.

5. Conclusion

We have tried to develop an Integrated Tongue Operation Assist System (“I-to-AS”) for seriously disabled people to control a PWC and a PC as an AAC device. In this study we developed a stick type mouthpiece remote controller as a new type of remote controller.

To investigate the effectiveness of the “I-to-AS” with the stick type mouthpiece remote controller, eight able-bodied candidates drove a PWC on the same course. Every candidate operated the PWC using the stick type mouthpiece remote controller by “Tongue” and by “Fingers”. The average driving times were compared. The difference between them was about 25% and we thought that this was a small difference. These results suggest that the “I-to-AS” with the stick type mouthpiece remote controller would be effective and it has the potential to be used by seriously disabled people.

Acknowledgements

This study was supported by following projects.
The Ministry of Education, Culture, Sports, Science and Technology (18700480 and 21500524).
Japan Science and Technology Agency (05-021).
Uchida Energy Foundation (2009-40, 2011-39)
NIIT grant for joint research (NIIT-18-01, 20-01, 22-03 and 23-02).

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Knowledge/Technology Transfer

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-521

User Experience and Feedback of an Assistive Technology Construction Set

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Abstract. The open-source AsTeRICS system brings rapid prototyping together with Assistive Technologies (AT) and therefore revolutionizes the development process of AT systems. In several publications the technical baseline of the hardware and software components and the possibilities of the AsTeRICS system have been presented and discussed. Over the last 6 months prototype 2.0 has been tested by users in Austria, Poland and Spain and two setups for long-term users were installed to get quantitative measures about the systems quality. In the user trials different scenarios were tested like mouse-replacement, gaming and environmental control. 75 % of the users stated that they liked the models that were adapted and tailored to their individual needs and that these AT systems work better for them than any system they are using at the moment.

Keywords. AsTeRICS, Assistive Technology, Construction Set, Long term user tests.

Introduction

A vast number of people with disabilities are supported by Assistive Technologies (AT), but often AT solutions do not fit the specific requirements of a user out of the box, which makes costly adaptations necessary. AsTeRICS (Assistive Technology Rapid Integration & Construction Set) aims to change this situation by employing free and open rapid prototyping technologies in AT. The technical baseline of the hardware and software components and the possibilities of the AsTeRICS system have been presented and discussed in several publications [1][2][3][4][5][6][7][8]. In short, the system consists of the AsTeRICS Runtime Environment (ARE) running on a computing platform. Within the ARE, models consisting of building blocks (OSGi [9] plugins) are executed and provide the desired AT-functions to create flexible solutions for each individual user. The platform can be connected to sensors and actuators which allow the system to interact with its environment (see **Figure 1**). The set of building blocks is configured by a visual modeling software application which allows creating systems which are adaptable and perfectly tailored to each user's individual needs, by simply connecting the building blocks. Building blocks include sensors (such as switch inputs, but also vision systems, brain computer interfaces and many more), data processing elements (mathematical digital signal processing (DSP) and flow control) and actuators (such as mouse/keyboard replacement, KNX [10], environmental control devices and mobile phone access). **Figure 2** shows a model of a headtracker to control the mouse created with the model utilities provided by the AsTeRICS framework. The model uses one module to track the movement of the user's nose (block FacetrackerLK) and directly maps it to the x and y position of the mouse pointer (block

Mouse). The additional two average components (block Averager) smooth the mouse movements by calculating the mean of the last 15 x and y positions of the nose.

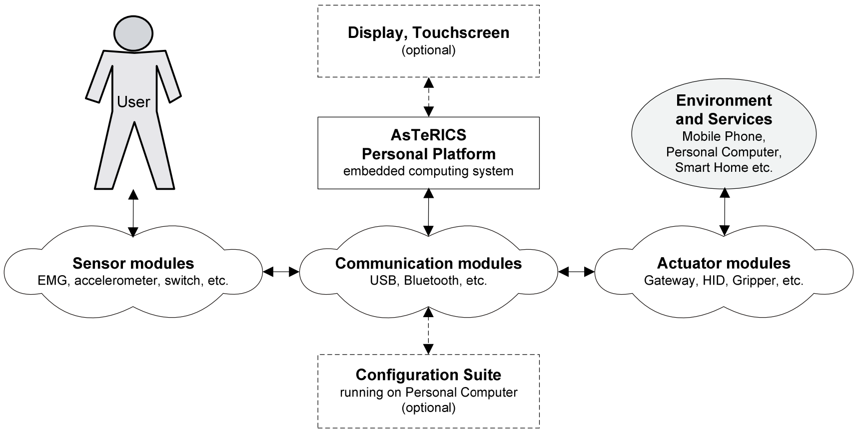

Figure 1. Schematic concept of AsTeRICS.

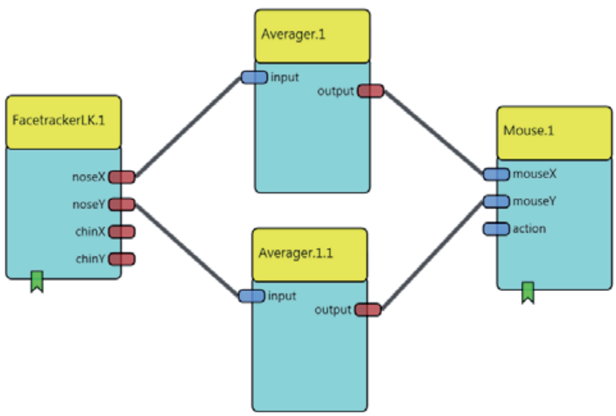

Figure 2. AsTeRICS model of a headtracker.

After the development process the model can be transferred from the development tool into the AsTeRICS runtime environment (ARE) where it is executed.

Virtual prototyping via visual modeling is known in many fields of research and application. However, it is a new strategy for prototyping Assistive Technologies. Visual modeling of signal processing configurations allows building virtually any type of signal processing chain without knowledge of a particular programming language. A model is created and adjusted by connecting graphical design elements and editing their properties. This flexibility is only limited by the available processing elements and the supported input- and output modalities. Especially in the area of scientific computing, visual design has become very successful (e.g. via the use of Matlab/Simulink [11] and LabView [12]), and reduces the time needed for prototyping and time-to-market tremendously.

1 User Tests and Methodology

User evaluations were conducted simultaneously in Austria, Poland and Spain. The methodology of evaluation facilitated the exchange of knowledge among the partners. The main idea was to make the necessary adaptations for individual users in each country, as well as modifications or creation of new models in order to share with the rest of the partners. In this way, the evaluation procedure benefited from some variety of models and use cases, thus providing a wider overview of the possibilities of AsTeRICS as a flexible system that can be adapted to any kind of motor disability. The total sample for the AsTeRICS final prototype evaluations was composed of 11 primary users, suffering from multiple sclerosis, amyotrophic lateral sclerosis, spinal cord injury or cerebral palsy.

The results show that AsTeRICS, as a flexible system, provides the developer with a high degree of adaptability, making it possible to tailor solutions for each user's unique needs. In the evaluations AsTeRICS models for different scenarios were created and adapted to the needs of every specific user during the 5 week test period. The models were grouped in three scenarios: mouse replacement, environment control and gaming scenarios like flying a remote controlled helicopter or playing a racing game on the Playstation 3 [13].

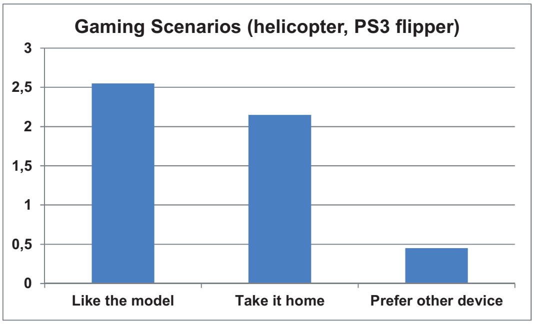

Figure 3. Results of the gaming scenarios.

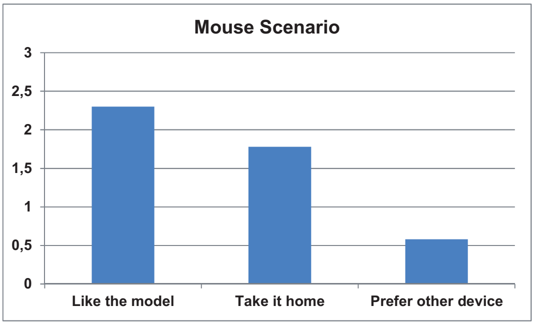

Figure 4. Results of the mouse replacement scenarios.

For every scenario an easy task was created and every week the participants had to fulfill it and the time was measured. More than 90 % of the participants showed improvements in their performances regarding the given tasks over the trial period. After the tests the users also filled a questionnaire with a scale between 0 and 3 where 0 is absolutely no and 3 means absolutely yes. **Figure 3** and **Figure 4** show the results for the gaming and mouse replacement scenario. The user feedback was very positive and for every user a mouse replacement and a gaming model could be created within the 5 weeks which the users could interact with.

The third question was if the user prefers another device over the solution created with AsTeRICS. The result shows that with AsTeRICS it is possible to build AT for all kinds of scenarios which are better than the ones the users had before.

In conclusion, according to users' feedback, the AsTeRICS final prototype is usable, accessible and well acceptable and has a high potential of improving peoples autonomy and quality of life.

2 Long Term User Tests

Beside the user tests at the end of the project, two long term user tests of the gradually developing AsTeRICS prototype have been performed during the entire second half of the project's runtime. These two users helped finding problems and bugs of the AsTeRICS system by using it for their daily activities and therapies to improve their skills.

2.1 Fritz

Fritz is a 46 year old man, who suffers from the consequences of a cerebral haemorrhage. For several years, he was locked in, but after changing his medication, he was able to control his eye blinks and one toe again. His main activity during the day is watching TV but he can't control it by himself. Therefore a special remote control for his TV was created with the AsTeRICS system using an On-Screen keyboard, see **Figure 5**.

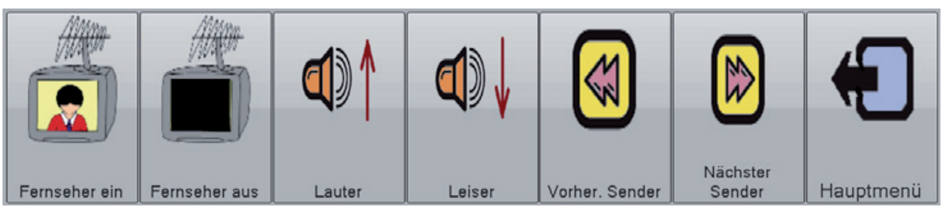

Figure 5. On-Screen keyboard to control a television.

Within the test setting, a matrix of symbols with automatic scanning was used to choose the TV control commands. At the beginning of the long term trial, a switch, triggered by the toe was used to make selections. This way of interaction was not very reliable, as Fritz needs a lot of energy and concentration to move his toe and it was not possible for him to do more than 2-3 successive control inputs within a few minutes. In the next step, the switch was substituted by a webcam and the FacetrackerCLM plugin of AsTeRICS which allows the detection of eye blinks via a standard webcam. This method worked well and the detection rate was about 98 % whenever the camera was perfectly aligned in front of his face. The alignment was the main disadvantage of this solution because it was a time consuming and difficult task for his care persons. When the camera was not aligned correctly, the recognition rate dropped down to about 10%

which made the system unusable. As the physical and psychical condition of Fritz became much better during the trial period, the system was adapted again to select the corresponding command by pressing a switch mounted next to his head.
As next steps and further therapy goals, Fritz is supposed to use a symbolic communication table and as an overall goal he wants to be able to use an on-screen keyboard to write emails to his daughter.

2.2 Richard

Richard is a 37 year old man who suffers from a craniocerebral injury. His accident was about a year ago. He is undergoing several therapies and his condition changes quite often. On days with a good physical condition he is able to make controlled movements with two fingers. In a first test setting, he used two buttons under his two controllable fingers to trigger ‘yes’ and ‘no’ commands to answer questions of his caretakers and relatives.

In the next step, a simple communication table was developed, see **Figure 6**. With this table, Richard is able to communicate his wishes and needs, like the need to be relocated in his bed but also the wish to watch TV or to listen to music. Beside the possibility to communicate with his environment, the AsTeRICS system is used to train his finger coordination.

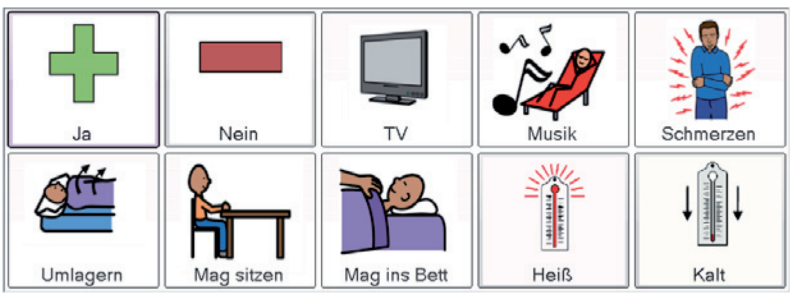

Figure 6. Communication table controlled by two buttons.

Depending on his daily condition, the yes/no model or the communication table model is used. Richard uses the system every day for at least an hour. In the near future the used model will be extended with an environment control to allow the control of the television via a universal infrared remote control.

3 Conclusions

AsTeRICS was conceptualized as a flexible, extendable, adaptable and affordable construction set for AT devices. Due to this customizable nature, AsTeRICS aims to offer specific solutions to a broad range of users with impaired motor abilities. Different participants have been involved since the beginning of the project according to the user centred design methodology. So the system has been adapted to the user requirements and needs in several ways. This flexibility, as one of the system’s most important advantages, is also a challenge while evaluating the system due to the high number of combinations of devices and the open adaptation and customization features.

Instead of having a singular system to be tested there exist a virtually endless set of interfaces for supporting users in their daily activities related to technology.

For developers AsTeRICS represents a new sort of development tool in the AT area. It allows fast prototyping of various AT systems and sensor technologies to find the system that fits the users' requirements most without the need to buy different commercial products.

The results of the user test show that AsTeRICS seems to be usable, accessible and rather acceptable and can already compete with existing commercial AT systems. Especially the two long term users show the strength of the system. At the beginning the system was installed on their personal computers and a basic model was built to test if it suits their needs. If it didn't or if the users' physical conditions became better, additional sensors or actuators were plugged into the computer running the ARE and the model was adapted to support the new functionalities.

Acknowledgements

The AsTeRICS project was partially funded by the European Commission under the Seventh (FP7 - 2007-2013) Framework Programme for Research and Technological Development, Grant Agreement number 247730.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
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doi:10.3233/978-1-61499-304-9-527

Tools for Technical, Business and Consumer Analyses: Expanding Need to Knowledge Model

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Abstract. The Need to Knowledge Model is a static representation of the dynamic processes underlying the generation of technological innovations, involving three methodologies of scientific research, engineering development and industrial production. It is a framework through which government agencies and university faculty can plan, implement, manage and evaluation progress. Ensuring rigor and relevance requires much technical, marketing and consumer analyses, much of which falls outside the training and experience of academics and entrepreneurs. The paper describes the addition of nearly eighty analytic tools, chosen to represent the type of analyses required to optimize the probability of successfully reaching the marketplace and generating beneficial socio-economic impacts.

Keywords. Innovation, technology transfer, analytic tools, marketing, consumer.

Introduction

The Need to Knowledge (NtK) Model was created to be a static representation of a dynamic process encompassing all elements of the technology innovation process from problem validation to solution delivery [1]. Government programs funding technological R&D with the intent to generate beneficial socio-economic impacts, need to know the requirements and constraints of three related methodologies (scientific research, engineering development, industrial production), which generate new knowledge in three different states (conceptual discoveries, prototype inventions, commercial innovations), which is exchanged between stakeholders through three processes (knowledge translation, technology transfer, commercial transaction). The NtK Model's stages, gates and steps are each substantiated with evidence drawn from a scoping review of academic and practitioner literature.

The R&D programs represented in the NtK Model must address a number of challenges in the new product development (NPD) process, such as linking actors from multiple sectors, communicating across cultural barriers and integrating multiple methodologies. Participants must work to mitigate potential barriers to the successful introduction of products in the marketplace. The complexity increases when the envisioned product must address the requirements of people at various ages and representing a range of functional abilities.

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This paper describes a recent effort to identify a representative set of tools which are called for to conduct critical technical, market and customer analyses within the NtK Model. Adding this array of tools was necessary because the project participants trained in one of the core methodologies (i.e., scientific research, engineering development, industrial production) are not typically familiar with the tools in the others. Having the tools imbedded in the model signals the various participants about actions and analyses they need to consider and accommodate in their resource, staffing and implementation plans.

Companies vary widely regarding their level of interest in and commitment to the needs of persons with disabilities. However, the desire to broaden the customer base or increase the market share is understandably a high priority in the competitive marketplace. Applying analytic tools that support these elements of a business case, increase the likelihood of uptake and use by corporation partners in the new product development process.

1 Methodology

A review of the evidence-based underlying the NtK Model's stages, gates and steps, revealed dozens of requirements for the application of a valid tool/instrument to conduct some type of technical, market or customer analysis. The project team classified the tools for these required analyses into five categories of required competencies. That is, if a product has complex electronics, there are several analytic tools which require the expertise of an electronic engineer to ensure its technical functionality.

The four competency categories are:

- ***Electrical/electronic engineering tools***: measurement systems, design and testing systems and mass manufacturing tools.
- ***Material science tools***: required to make the choice for a particular manufacturing material or to examine the characteristics of a potential material.
- ***Mechanical engineering tools***: encompasses the generation and application of heat and mechanical power and the design, production, and use of machines and tools.
- ***Business tools***: such as quantifying customer requirements, benchmarking, marketing tools, business feasibility, process improvement and return on investment.

Descriptive categories were then established to create a template for comprehensive descriptions of each tool. The categories were standardized across the four competency groups of tools to ensure that they would have a common format for ease of display and use. The categories and their content are described in great detail elsewhere [2].

Given our focus on the field of assistive technology devices and services, we wanted to delve deeper into the analytic tools to assess the extent to which each tool contained criteria representing the criteria of Inclusive/Universal Design (I/UD). Literature demonstrates that inclusive design criteria are widely applicable across various stages and steps in the NPD process, as part of a design criteria reference set to represent and maintain a priority for end users needs at key decision gates [3]. Our prior experience in technology transfer and product commercialization proves that maximizing market share for any one product is a critical requirement to ensuring optimal return on the costs of production, distribution, promotion and support. Therefore, we added a fifth category to our appraisal of the tools listed under the initial four:

- ***Inclusive/Universal Design tools***: to ensure that the widest possible audience will be considered in the design process, regardless of age, size, ability or disability.

The tools classified as I/UD were then assigned to their own competency group for two reasons. First, they were specifically developed to foster I/UD in new product development. Second, many of these tools span more than one of the other competency groups. For example, the Anthropometry tool and Design Exclusion Calculator tool offers insights to mechanical engineers for design parameters, while also used by marketing personnel to consider additional target market segments. Categorizing them under the other competency groups, could have masked the tool's broader applicability and its explicit relevance to usability issues.

2 Results

The NtK Model is now populated with tools for use where specific technical, market or customer analysis is required. The project compiled a total of seventy-nine (79) tools appropriate for the required analyses. Subsequent appraisal found that more than half (45) were relevant to I/UD in that they contributed to identifying and setting priorities for the functional requirements and personal preferences of the target consumer audiences. All of the tools are now imbedded in the NtK Model via hotlinks. The details underlying the tools can be viewed within the plain text version of the NtK Model, by clicking on any of the red toolbox icons shown at the end of stages, steps or gates: *http://kt4tt.buffalo.edu/knowledgebase/model.php*.

3 Conclusions

Sponsored projects intending to generate products with socio-economic benefits, need to consider the proper analyses required within the research, development and production phases of activity. Academic investigators may not before familiar with – and therefore not properly plan for – the analyses required by the corporate engineers and marketers who will advance their outputs to the marketplace. In addition to ensuring proper rigor across all three phases and methods, introducing I/UD constructs can expand the market for products by designing for the broadest possible customer base. Expanding the NtK Model enhances the operational framework through which these twin goals can be addressed and achieved.

Acknowledgements

James Condron, Jennifer Flagg & Michelle Lockett led the study design, implementation and analysis. This work was jointly supported with funding from the National Institute on Disability and Rehabilitation Research of the U.S. Department of Education (H133A080050). Dr. Eugene Coyle provided Post-Doctoral guidance to Dr. Condron at the Dublin Institutes of Technology, Dublin, Ireland.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-531

Towards a Framework for User Involvement in Research and Development of Emerging Assistive Technologies

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Abstract. Many research and development projects in the field of assistive technology involve the participation of people with disabilities as potential end users. Within the context of a recent brain-computer interface (BCI) project, the AT team of AIAS Bologna has tried to identify the core components of a framework that would endow end users with an enhanced role in the design of innovative solutions based on emergent technologies. The components identified are described in this paper.

Keywords. Research and Development, Brain-computer Interfaces, User Centred Design, Living Lab, UN Convention.

Introduction

Carrying out research into the benefits of emerging technologies for people with disabilities represents an important way of advancing the utilization of assistive technologies (AT). In many cases, such research activities will involve the development of applications and prototypes that require testing by potential end users. This paper focuses on user involvement in research and development (R&D) projects. Our objective is to contribute to the current discussion about how people with disabilities can play an enhanced role in the design and development of innovative solutions based on emerging technologies [1].

1 Background

This paper is based on the experience of the AIAS Bologna onlus Ausilioteca team as a partner in the TOBI[1] (Tools for Brain-Computer Interaction) project which was funded by the European Commission between 2009 and 2013 under the 7th Framework Program[2]. Ausilioteca is a nonprofit multidisciplinary AT service that supports people with disabilities in identifying appropriate AT solutions.

The TOBI project developed applications in the field of AT and neuro-motor rehabilitation based on non-invasive Brain-Computer Interaction (BCI) [2].

[1]For more information please visit: http://www.tobi-project.org/
[2]This paper reflects the views only of the authors. The European Commission cannot be held responsible for any use which may be made of the information provided.

A BCI monitors the user's brain activity and translates intentions into commands without requiring muscular activity or involving peripheral nerves [2].

The project saw the involvement of a large number of potential end users (106 persons with severe motor disabilities). They took part in the development, testing and validation of the prototypes, a process that involved a total of 925 BCI sessions. Nine potential end users took part in the process in Bologna, for a total of 51 test sessions plus two group meetings.

BCIs were new both to the AT team and to the end users, who were recruited through direct contacts established in the course of service provision. All of them had made use of our services and had gone through a full assessment of their assistive technology needs. All of them lived at home with their families.

At the beginning of TOBI, no framework was available that could provide guidelines for involving potential users in the development of BCI based AT solutions. As a result, since the Ausilioteca team and its partners and stakeholders within the TOBI Consortium were committed to make potential end user involvement as significant as possible in the design process. To fulfill this task we consulted pre-existing models for bringing technology out of the lab to the end-users home and developed a respective framework.

2 Framework Development

The framework integrates a number of different components that together determine the strategies and the tools adopted (see Figure 1).

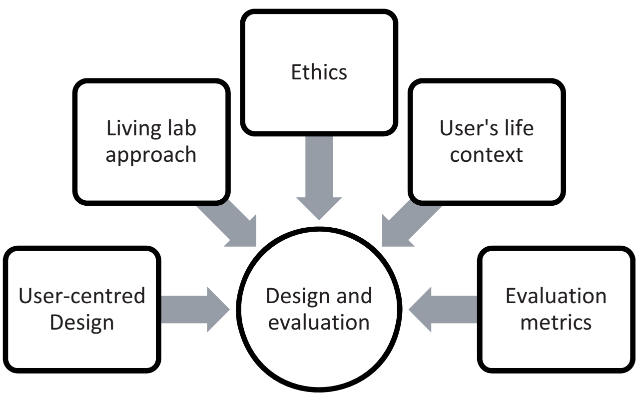

Fig. 1. Emerging AT and AT professionals: framework for implementing design and evaluation activities.

In the paragraphs below, we will provide a description of the main underlying assumptions upon which this operative framework is based.

2.1 User Centred Design (UCD) Approach

UCD refers to a methodology that makes user involvement (his/her needs, requirements and feedback) the principle driver in the design process. As such this approach is democratic and compliant with the spirit of the UN Convention on the Rights of People with Disabilities which considers the involvement of people with disabilities in all publicly funded programs that concern them to be a human right. Given its emphasis on user involvement, UCD also offers a guarantee that solutions do effectively meet the needs of the potential users. Moreover, UCD is fully compatible with the knowledge translation and technology transfer models according to which researchers and developers collaborate with end users, industry and other stakeholders in order to proceed from problem identification to solution validation [3]. There are various models for UCD [4], among which the ISO standard 9241-210 [5] is prominent. This standard for human-centred design processes insists that optimal design solutions depend, among other things, on early and active user involvement and repeated verification. At a practical level the latter principle means:

(1) understanding and specifying the context of use;
(2) establishing user requirements;
(3) producing design solutions to meet user requirements;
(4) and evaluating solutions with respect to requirements.

In the context of the TOBI project this meant taking into consideration existing AT solutions for people with severe motor disabilities and their context of use, the definition of user requirements and the refinement of design solutions through a process of repeated evaluation involving activities with end users [6].

2.2 Living Lab Context

A Living Lab (LL) is an user-driven open innovation ecosystem which enables users to take an active part in the research, development and innovation process.

The LL approach aims to:

(1) bring the users early into the creative process in order to benefit from their views;
(2) bridge the innovation gap between technological development and the uptake of new products and services by involving all the relevant players in the value network;
(3) allow for early assessment of the implications of new solutions [7].

As such there is an overlap with UCD. What distinguishes a Living Lab approach is its emphasis on a real-life environment, a space where researchers, users and other stakeholders (physically) meet and discuss the research objectives, the intermediate and final outcomes and the next steps. Living Labs thus tend to be semi-permanent and able to address different issues. As a matter of fact, the objectives of the AIAS Ausilioteca Living Lab go beyond the limits of the TOBI project and involve knowledge sharing between AT professionals and persons with disabilities and development of a broader kind, as well as the training of end users to refine their views on AT and to improve their evaluation skills of existing and new solutions. The Living Lab co-exists and interacts with the service delivery activities of the organization, providing space and time for more in depth analysis of the relationship between evolving needs, personal factors and technology.

2.2.1 Definition of End Users and Professional Users' Roles and Relationships

Not all AT users are people with disabilities. The independent experts who help individuals with disabilities to make appropriate choices when it comes to the selection and deployment (installation, personalization, training) of an AT can in fact be considered professional users of AT. Their role is important since lack of success might lead to frustration and to public or private resources being wasted. Professional users, or AT professionals, should have a good knowledge of the total range of existing technologies, as well as competence in matching personal and environmental factors with the available solutions. In research projects these domain experts can perform a variety of roles: they may be researchers themselves or liaise with the end user or represent them when their involvement is unfeasible [8]. The TOBI project sees AT experts and end users as collaborators in a team, integrating each other's viewpoints [9].

2.3 Testing in Real Life Environments

To complete the framework it is important to be aware of context related factors. In the course of the TOBI project BCIs were tested outside of the research lab in real life environments. These have included: rehabilitation clinics, AT centres, but also people's homes. Factors such as the physical space available, the presence of carers, the time available for setting up the systems, the availability of high speed Internet, etc. are important factors that have to be taken in consideration once outside the protected environment of the research lab.

2.4 Ethics

Besides the more obvious ethical risks related to the privacy and autonomy of end users, including those concerning their full consent or exposure to media attention, ethical questions may arise as a result of the emotional involvement of researchers and end users, an ever present possibility where people work intensively together for a certain period of time. Murphy [10] and Kristeva [11] have both emphasized that where disability is concerned such relationships are never neutral. Research projects should invest time and resources in identifying the ethical risks deriving from these relationships and in considering how they may best be addressed [12].

2.5 The Definition of User Centred Evaluation Metrics

The above mentioned ISO 9241-210 standard identifies verification of the "*extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use*" as being crucial to the design process.

The TOBI project consortium has accordingly opted for evaluation metrics that privilege the whole user experience while providing valuable information on the effectiveness, efficiency of use and satisfaction with the new assistive technologies [13].

Following the definition provided by the ISO 9241-210, "usability" in the context of BCI-based AT devices incorporates three different components: effectiveness, efficiency, and user satisfaction. These components have been operationalized and fully described in [10] and in [13] in relation to BCI. In Table 1 we provide a summary of the metrics identified for each usability component utilized in evaluating BCI applications.

Table 1.

Usability components	Definition	Operationalized measures	Evaluation metrics
Effectiveness	Performance of task: accuracy, completeness	• Accuracy	• Percentages of correct responses
Efficiency	Relationship between user's investment and results	• Objective measure (information transfer) • Subjective measure (users' workload)	• Information transfer rate (ITR) • NASA Task Load Index (TLX) [14]
User satisfaction	user's perceived comfort; acceptance	• Satisfaction with general aspects of the device • Satisfaction with specific BCI aspects • Overall user satisfaction	• Adapted QUEST 2.0 [13, 15] • Adapted QUEST 2.0 [13, 15] • Visual analogue scale (VAS)

In addition, in order to assess user attitudes towards the use of BCI-based AT devices, the ATDPA [16] scale was employed.

3 Evaluation

This framework was adopted in practice during the realization of the TOBI project which thus provided a context for an initial evaluation of its feasibility and effectiveness.

At the end of the Project, the end users who were most involved in the testing of the BCI prototypes (n=5) were invited to respond to a set of open questions via email or in face to face interviews. The questions sought to investigate further their perceptions of novelty with regard to BCI technology and its applications, their views on what BCI based AT solutions could mean for themselves, and their perceptions of their own role in the project.

Those end-users considered BCI applications too immature for providing a realistic alternative to other AT solutions. Nevertheless, all the respondents were optimistic about the possibility that BCIs could represent an additional way of controlling an interface. Overall, they seemed aware of the potential of BCI technologies, but they could not translate this awareness into concrete ideas for applications, even though they had considerable experience of different ATs and despite having a level of disability that might be expected to encourage them to think in terms of a BCI based solution.

All of the respondents expressed satisfaction regarding their level of involvement in the project. All expressed their willingness to participate in further BCI related projects.

Overall, the involvement of the users from an early stage impacted positively on the usability of the prototypes. The Living Lab approach has laid the foundations for future collaboration between end users and the AT team, which will be further developed through specific user training activities within the framework of the ATLEC project and through the use of social media tools. Testing outside the lab in the home environment reduces the gap between the researchers and users and their primary care circle and clearly represents the road that studies in AT design should take. The evaluation metrics we utilized have proven to be appropriate.

4 Conclusions and Next Steps

The TOBI project provided the AT team of AIAS Bologna onlus (with the support of its partners) with an opportunity to develop a framework for the involvement of people with severe disabilities in the development and evaluation of emerging technologies. More research and experience is needed to assess to what extent these core components could form part of a wider model of user involvement in R&D projects.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-537

There Is Nothing More Practical than a Good Theory: Designing an Ambient Event Detector based on a Technological Impact Assessment Model (TIAMo)

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Abstract. In this paper we report the results of two multi-cultural user requirement surveys which have been conducted within the European AAL-JP-project *fearless* prior to technical specification of an ambient event detector for solitarily living elderly. Needs and expectations of older adults (N=259), relatives and trusted persons (N=215) as well as healthcare professionals (N=22) from Austria, Germany, Spain (Catalonia), and Italy were surveyed. Subsequently, a set of system requirements was derived from the empirical data. These requirements were integrated into a *Technological Impact Assessment Model* (TIAMo) which describes the interplay of technical performance, psychological well-being and business indicators related to the projected ambient event detector. In the forthcoming stages of the user-centered design process the TIAMo will serve as a "balanced scorecard" for project evaluation.

Keywords. AAL, User Requirements, Fall Detection, Fire Detection, Inactivity Monitoring, Technological Impact Assessment.

Introduction

The European AAL-JP-project *fearless* (*f*ear *e*limination *a*s *r*esolution for *l*oosing *e*lderly's *s*ubstantial *s*orrows) is dedicated to fall and fire detection as well as inactivity monitoring in the homes of solitarily living elderly. An autonomously operating ambient event detector is being developed in a user-centered design process. Open source software and off-the-shelf depth-sensors are integrated into a single sensor unit [1, 2]. This hardware allows for a straightforward installation of the *fearless*-system into an existent home ensuring interoperability, upgradeability and affordability.

We would like to thank the European Union and the national funding organizations of the EU member states involved in this project for supporting our work under grant AAL 2010-3-020. Thank is also due to our partners in Austria, Italy and Spain (Catalonia) for their contribution to the studies presented in this paper.

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1 Primary User Requirement Survey

Our first survey targeted the needs and expectations of potential primary users (older adults aged 60+) as well as their closest relatives and trusted persons: (a) What are the most prevalent fears of elderly people? (b) Where do the most severe falls occur? (c) Which functions should an ambient event detector provide in order to meet needs in terms of fear resolution? (d) How much are users willing to spend on an ambient event detector and the services related to it?

Methods. Qualitative and quantitative research methods were applied to capture needs and expectations of prospective primary users as well as their relatives and trusted persons. All participants either filled in a questionnaire (58%) or participated in a standardized interview (21% face-to-face interviews; 21% phone interviews). Primary users answered questions about resources and deficits of their private home, previous falls and fears related to a broad variety of critical incidents (e.g. falls, fire, housebreaking, etc.). Besides, they were asked to specify preferred functions and an appropriate pricing for an ambient event detector. Relatives and trusted persons answered these questions from a third-person perspective.

The questionnaire—which also served as an interview guide—contained open questions as well as rating scales and items featuring a multiple choice format. For the analysis of verbal data produced by open questions the method of Qualitative Content Analysis (QCA) was used [3]. It allows for a strictly rule-based categorization of content. Content categories were extracted from the verbal material itself.

Sample. 259 older adults from Austria, Germany, Spain (Catalonia), and Italy responded to this survey. These participants were aged between 59 and 101 years (M=73.6; SD=8.3; Mdn=73.0). In terms of gender (154 females) the sample reflects the demographical gender ratio of this age group (59% females). Solitarily living (n=111) as well as non-solitarily living elderly (n=144) from urban (n=118) and rural areas (n=139) were included. In parallel 215 relatives and trusted persons of potential primary users were surveyed [4].

In Austria 180 questionnaires were distributed to people from Vienna (urban area) and Burgenland (rural area). The return rate was 31%. In Spain (Catalonia) our partners arranged for 100 face-to-face interviews with primary users and relatives from Barcelona and the surrounding rural areas. In Germany 300 questionnaires were distributed to students of the University of Bamberg who passed them on to their parents, grandparents and great-grand parents throughout Germany. In addition, 15 family members of co-workers were surveyed and 5 participants from Lower Franconia responded to an advert in a local newspaper. The return rate for Germany was 57%. In Italy our local partners arranged for 100 telephone interviews with primary users and relatives from Padua as well as from rural areas south of Padua. For Italy the rate of participation was 56%. In Austria, Italy and Spain (Catalonia) participants were contacted at public meeting places and community counseling centers.

Results. Two events were perceived as most threatening by primary users and relatives alike: suffering a stroke and falling with no help available. In the home of elderly users five hot spots for severe falls could be identified: garden, living-room, stairs, bathroom, and transition areas. Apart from these cross-cultural commonalities, elderly people from Italy and Spain (Catalonia) were particularly worried about housebreaking, whereas solitarily living elderly from Austria and Germany frequently reported fear of social isolation. Table 1 shows the preferred functions across the four different cultures involved in this survey. Two basic functions for an ambient event detector could be identified: fall and fire detection. In this respect a considerable number of users from Austria, Spain (Catalonia) and Italy were agreed. In addition primary and secondary users from Spain (Catalonia) and Italy would also appreciate an integrated burglar alarm.[2] In terms of pricing participants stated that the hardware should be less than 200€ and monthly expenses for services should not exceed 50€ [4].

2 Expert Requirement Survey

With our second user requirement survey we sought for answers to the following questions: Which functions should a new ambient event detector provide in order to meet the expectations of healthcare professionals? Which aspects of a new telecare system are critical for success?

Methods. Again qualitative and quantitative research methods were combined in order to capture needs and expectations of healthcare professionals from Austria, Germany, Spain (Catalonia), and Italy. Participants either filled in a questionnaire (n=16) or took part in a face-to-face interview (n=6). They answered questions about their previous experience with current telecare devices (e.g. panic button) and their expectations towards innovative telecare technology. Furthermore, they were asked to specify preferred functions and an appropriate pricing for an ambient event detector.

The expert questionnaire and the corresponding interview guide contained open questions as well as rating scales and items with a multiple choice format. For the analysis of verbal data QCA was used [3]. Again content categories were not generated on a theoretical basis but extracted from the verbal material itself. Due to a small sample size inferential statistics could not be applied. Thus, quantitative analysis was confined to descriptive statistics.

Sample. A total of 22 experts from Austria (n=3), Spain (Catalonia) (n=2), Italy (n=10), and Germany (n=7) responded to this survey. Nonetheless our expert sample reflects a broad variety of different organizations and professions from the field of healthcare: members of research organizations, SMEs and large healthcare providers were included. The participants were employed either by profit (n=8) or non-profit (n=14) organizations [5].

Experts from Austria, Italy and Spain (Catalonia) were recruited within the research and end-user organizations involved in the *fearless*-project. In Germany healthcare providers were either contacted at the 5th German AAL-Congress in Berlin or via e-mail.

Results. Across the four national healthcare systems and individual areas of expertise four functions were favored by healthcare professionals: fall and fire detection, inactivity monitoring, and gas detection. Besides, five critical aspects for an innovative ambient event detector could be identified: (a) privacy and data protection, (b) usability, (c) accreditation, (d) interoperability, and (e) affordability. Due to a severe shortage of trained care personnel in their countries, experts from Austria and Germany

[2]Apparent cross-cultural differences in terms of preferred functions (s. Table 1) should be interpreted very carefully since these findings are confounded with different methods of data collection: In Spain (Catalonia) and Italy participants were interviewed, whereas in Austria and Germany most participants filled in the corresponding questionnaire.

also emphasized (f) low staff intensity in terms of installation, maintenance and handling of the projected ambient event detector [5].

Table 1. Preferred functions for an ambient event detector from different user perspectives.

	Austria		Spain (Catalonia)		Germany		Italy		
	Elderly	Relatives	Elderly	Relatives	Elderly	Relatives	Elderly	Relatives	**Healthcare professionals**
Fall detection	X	X	X	X	(x)	(x)	X	XX	XX
Fire detection	X		XX	X	X	(x)		X	X
Burglar alarm			XX	X	(x)		X	X	
Gas detection			X	X			X	X	X
Inactivity monitoring			X	X	(x)	(x)			X
Flooding			X	X					
Monitoring of daily routines			X	X					
Light triggered by motion	X				(x)				

(x) = functions appreciated by at least 30% (only applied to German samples)
X = functions appreciated by at least 50%
XX = functions appreciated by at least 70%

3 Technological Impact Assessment Model (TIAMo)

Based on the results of the two user requirement surveys the *Technological Impact Assessment Model* (TIAMo) was designed by psychologists from the University of Bamberg. The basic assumption of our model is that system requirements can be arranged hierarchically similar to the elements of a prefabricate house (s. Figure 1). For instance: A telecare system that does not meet the expectations of telecare providers will not be available for primary users in the first place. Thus, we suggest that the perspective of telecare providers forms the basis of the TIAMo:

- **Privacy and Data Protection.** The *fearless*-system has to be compliant with national and European data protection laws. Besides privacy and data protection, usability is probably the most basic prerequisite for market access.
- **Usability.** The ambient event detector has to be reliable and easy to handle. It has to display relevant information comprehensibly (e.g. current status of a client). These aspects are closely related to staff intensity: Only if the *fearless*-system functions reliably it may relieve rescue staff. Only if it is easy to operate it will not require intensive training.

- **Low Staff Intensity.** Especially for Austria and Germany a great shortage of qualified care personnel was reported. Also for the sake of labor costs operating the *fearless*-system must not be more labor intensive than established telecare systems (e.g. panic button).
- **Interoperability.** Hard and software of the event detector should be compatible with the given IT-environment of telecare providers.
- **Accreditation.** In order to allow for reimbursement—and thus for a better affordability—the *fearless*-system should be certified as an assistive device.

According to our survey results potential primary users and telecare providers share four basic requirements:

- **Affordability.** The ambient event detector and the services related to it must be affordable for elderly with limited financial resources. According to our survey data the hardware should be less than 200€ and monthly expenses for services related to it should not exceed 50€.
- **Fall and Fire Detection.** The results of our user requirement surveys indicate a need for reliable fall and fire detection among primary users and experts.
- **Social Networks.** In order to reduce fears effectively, we have to be considerate of social needs. Design and image of the ambient event detector must not allude to age-related deficits (e.g. frailty). Otherwise the event detector is likely to intensify social withdrawal: Elderly might limit social activities in their home to avoid stigmatization—if they accept it in the first place. What are the implications for the *fearless*-system? For instance, the ambient event detector should blend into the furnishing of the home or mimic other widely-used devices (e.g. smoke detector).
- **Adaptability.** Besides fall and fire detection a considerable number of potential primary users and experts from Spain (Catalonia) and Italy also favor an integrated burglar alarm function. Diversity among potential users calls for adaptability: The *fearless*-system should be adaptable to individual needs by allowing for upgrades (e.g. a burglar alarm) and a straightforward integration into existing private homes.

An intact social network, reliable fall and fire detection, and adaptability are the pillars which support the three pivotal factors for outcome assessment:

- **Internal Control Beliefs.** Maintenance of an internal control belief is essential for well-being and fear resolution. [6] Elderly with an internal housing-related control belief are convinced that they can exert control over their home environment. By introducing a novel technology to their private home this belief must not be undermined. Hence, the *fearless*-system should provide a user interface which makes relevant information visible or audible (e.g. status of the system) and allows for active control.
- **Falls Efficacy.** Fear of falling is defined as “a lasting concern about falling that can lead an individual to avoid activities that he/she remains capable of performing” [7]. By contrast, *falls efficacy* refers to an “older person’s confidence in performing a series of everyday tasks without falling” [8].
- **Mobility.** Ideally the mere presence of the *fearless*-system will disinhibit physical activity among primary users by increasing their falls efficacy. Here the virtuous circle closes as mobility is a prerequisite for social participation and hence for the maintenance of social networks.

4 Conclusions

The TIAMo maps requirements of primary end-users and healthcare providers by describing the interplay of these stakeholder perspectives. It specifies the interrelations between aspects of psychological well-being (e.g. control beliefs), measures of technical performance (e.g. false alarm rate) and business indicators (e.g. labor costs). Thus, the TIAMo will provide a common understanding of different user perspectives among our multi-disciplinary project partners and serve as a "balanced scorecard" [9] in the course of pilot implementation and project evaluation.

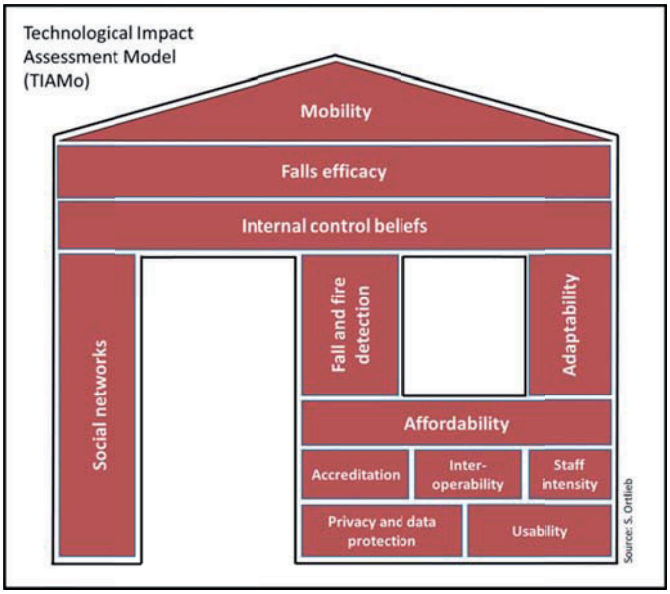

Fig. 1. Technological Impact Assessment Model (TIAMo).

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Socioeconomic Aspects/Outcomes

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-545

Facilitators and Barriers to Participation Survey for People with Mobility Limitations: Italian Localisation of the FABS/M Instrument

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Abstract. This article deals with the Italian localisation of the FABS/M [1] questionnaire, a new instrument measuring the effectiveness of mobility assistive technology devices. The FABS/M was developed in the United States within the framework of the ICF model. The questionnaire was translated into Italian and the resulting text was submitted to a panel of 6 experts including physiotherapists and biomedical engineers. After revision the questionnaire was field-tested by administering it to a cohort of 22 users of three types of assistive devices. The resulting questionnaire proved to be understandable and usable in the Italian context. The instrument showed to be suitable to assess environmental facilitators and barriers, helping to understand which items obstacle participation of individuals with lower limb mobility impairments and limitations in each one's real life situations. Information about obstacles and facilitators to participation can be used to improve measures and regulations concerning buildings, public places, transportation and personal attitude toward individuals with disability. While these improvements are made, adaptations of the assistive technologies service delivery system can be carried out to compensate for the gap.

Keywords. Assistive Technologies, Outcome Assessment, Mobility

Introduction

Today, several internationally-validated outcome instruments are available in Italian language to assess the appropriateness of individual assistive technologies (AT) interventions. They look at the compliance of AT products with the objectives for which they were chosen, especially in relation to their usefulness or meaningfulness for the user's quality of life. Among such instruments, the QUEST (Quebec User Evaluation of Satisfaction with Assistive Technologies) [2], the PIADS (Psycho-social Impacts of Assistive Devices Scale) [3], the IPPA (Individual Prioritised Problem Assessment) [4], and the MTP (Matching Person and Technology) [5] have been translated and localised in Italian language, and are currently being used in rehabilitation practice.

Most other instruments that are popular in clinical rehabilitation show significant limitations when used to attempt detection of the outcome of AT interventions: their

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focus is chiefly on body functions or performance in activities [6] rather than on the AT potential to enhance the person's possibilities to participate in everyday life and society [7]. Indeed, central to the ICF definition of disability [8] is the relationship between the individual and the contextual factors, whether personal or environmental, whether physical or social or aptitude-related. It is the interaction between the person's health conditions and contextual factors that produces disability. Thus also the environmental factors' impact on the participation of a person who uses AT should be assessed. For this purpose, various instruments have been developed in the latest years [9]; among these, the FABS/M (Facilitators And Barriers Survey of environmental influences on participation among people with lower limb Mobility impairments and limitations) [1] was chosen to be translated and validated in Italy.

1 The FABS/M Instrument

The FABS/M Instrument is composed of 61 main questions. The maximum number of answers generated by the FABS/M is 133. They are clustered round six domains of the environment that can influence participation. Each item is scored in relation to how often and how far it influences the user's participation.

In Domain 1 – concerning the primary mobility devices used in the community – respondents are asked to score how often these devices are used (by means of a four-levels scale: always, often, some, never) and how far they influence participation (again by means of a four-levels scale: helps a lot, helps some, limits some, limits a lot).

In Domains 2 and 3 – concerning features commonly found in the home or in the community (referring to either the built or the natural environment) – respondents are asked whether the feature influences participation or not. In case it does, respondents should score how much and how often (by means of a four-values scale, like in domain 1). In case it doesn't, respondents should clarify whether the feature actually exists but doesn't influence participation, or it doesn't exist, thus the question is not applicable.

In Domain 4 – concerning access to usual destinations in the community – the extent to which with each destination influences participation is scored by means of a five-level scale (helps a lot, helps some, has no effect, limits some, limits a lot).

In Domain 5 – concerning community facilities such as restrooms and transportation – the degree of accessibility of each facility is scored by means of a five-levels scale (very accessible, somewhat accessible, not accessible, don't know, not applicable).

In Domain 6 – concerning the community support network (medical doctors, therapists, paid personal assistants, special equipment repairs personnel, store clerks, strangers, peers, friends, family) – respondents are asked to score the influence of each of them (five-levels scale: helps a lot, helps some, has no effect, limits some, limits a lot) and how often are encountered (six-levels scale: more than twice a week, once or twice a month, once or twice a week, once or twice a year, rarely, never).

As the FABS/M scale was judged potentially useful in the context of Italian service delivery practice, it was decided to try it out in a typical setting of public service delivery, so as to achieve a validated Italian version and get a clear picture of the information it can provide.

2 Method

The FABS/M questionnaire was translated into Italian and an initial language validation was carried out by a panel of 6 rehabilitation professionals and researchers within a major Rehabilitation Centre (IRCCS S.Maria Nascente, Fondazione Don Gnocchi, Milano, Italy). The professionals rated FABS/M as being potentially useful to gather information about effectiveness of AT interventions in their actual context of use. They found the questionnaire slightly extensive but complete, and appreciated the fact that it is also suitable for individuals that don't carry out a very active life, in that not all questions need to be answered.

Then it was administered to a sample of two AT users with lower limb mobility impairments and limitations, selected within the customers of some AT manufacturers who were interested in getting feedback about their products. Each respondent was asked to express her/his opinion on difficulties encountered in filling-in the questionnaire, on problems related to the interpretation of items, on the instrument in the whole. Based on this first feedback, the Italian translation was reviewed to re-word those questions that showed interpretation difficulties. The revision included: a lexical modification of the questions regarding how often a contextual factor is encountered; the Italian expressions for "participate in community activities", "participating in your community" and "participation in community activities" – that have different shades of meaning in Italian and in English – were revised to make them more understandable; in Domain 6 (Community Support Network) the generic term "doctor" was substituted by "your reference medical specialist", as respondents showed doubtful about which of the numerous doctors they meet was concerned. A significant amount of work was made on the questionnaire layout/graphics to make it easier browsing the questions.

A second round of questionnaires administration was made to a larger group of twenty AT users with lower limb mobility impairments and limitations. Each respondent was duly informed on the objectives of the study; a qualified professional handed out the questionnaire, waited until it had been filled-in and provided any explanation required; in case of respondents who had difficulties to write, she filled it through interview. Also in this round, each respondent was asked to express her/his opinion on difficulties encountered in filling-in the questionnaire, on problems related to the interpretation of items, on the instrument in the whole; no significant difficulties were highlighted at this stage (except some suggestions for minor graphical improvements). The processing of results was then carried out.

The complete cohort of AT users, to which the FABS/M was submitted, was composed of 12 men and 10 women, whose age ranged from 19 to 76, with 43 as mean value; their clinical conditions ranged from paraplegia (59%), to quadriplegia (32%), lower limb amputation (5%), and ankle fracture (5%). 45% of them use a power wheelchair, 45% use a manual wheelchair, 9% use a walking cane; 48% live in a city, 29% in small towns in flat country, 24% in small towns in hill country.

3 Results

The full Italian version of the FABS/M questionnaire is freely available in the Internet on the Italian SIVA Portal on Assistive Technologies (www.portale.siva.it) [10]. Table 1 summarises the Italian wording of the questionnaire domains, items and response options.

Table 1 - Italian Version of FABS/M: Domains, items and response options.

Dominio 1: Ausilio primario per la mobilità
Selezioni l'ausilio per la mobilità che usa più spesso quando partecipa ad attività di vita sociale.
¤ Carrozzina manuale ¤ Bastone ¤ Carrozzina elettrica ¤ Stampelle ¤ Scooter ¤ Deambulatore
¤ Altro……..
¤ Non uso ausili per la mobilità (Non è necessario compilare il questionario)
Ausilio ________ Marca ________________ Anno di acquisto _______
Quanto spesso usa questo ausilio mentre partecipa ad attività di vita sociale?
¤ Sempre ¤ Spesso ¤ Qualche volta ¤ Mai
Come influenza la sua partecipazione ad attività di vita sociale?
¤ Aiuta molto ¤ Aiuta in parte ¤ Limita in parte ¤ Limita molto
Dominio 2: Caratteristiche della casa
Nell'edificio in cui vive i seguenti fattori influenzano la sua partecipazione ad attività?
Caratteristica _________ (Scale, tappeti, porte, pavimenti, rampe, temperatura interna, corrimano)
¤ Sì ¤ Quanto? ¤ Aiuta molto ¤ Aiuta in parte ¤ Limita in parte ¤ Limita molto
Quanto spesso? ¤ 1 o più volte al giorno ¤ 1 o più volte la settimana ¤ 1 o più volte al mese ¤ meno di una volta al mese
¤ No ¤ ____ Non influenzano la partecipazione ¤ N/A ¤ Non presenti in casa (Passi alla prossima domanda)
Dominio 3: Edifici pubblici e caratteristiche naturali
Edifici, caratteristiche costruttive: ghiaia, superfici pavimentate, scivoli, rampe, porte automatiche, ascensori, montascale e altri dispositivi dedicati
Fattori ambientali: clima estivo, clima invernale, pioggia, terreno in piano, folla e rumore
All'aperto i seguenti fattori influenzano la sua partecipazione ad attività?
¤ Sì ¤ Quanto? ¤ Aiuta molto ¤ Aiuta in parte ¤ Limita in parte ¤ Limita molto
Quanto spesso? ¤ 1 o più volte al giorno ¤ 1 o più volte la settimana ¤ 1 o più volte al mese ¤ meno di una volta la mese
¤ No ¤ ____ Non influenzano la partecipazione ¤ N/A ¤ Non presenti (Passi alla prossima domanda)
Dominio 4: Accesso a luoghi pubblici
Quanto l'accessibilità di ______ (il luogo) influenza la sua partecipazione ad attività quotidiane?
¤ Aiuta molto ¤ Aiuta in parte ¤ Non è influente ¤ Limita in parte ¤ Limita molto
L'accesso a _______ è limitato da:? ¤ Nessuna limitazione ¤ Struttura ¤ Parcheggio
Dominio 5: Accessibilità dei servizi sul territorio
Accessibilità dei servizi igienici
Quanto sono accessibili le toilettes a ______ (ristorante, hotel, biblioteca, aeroporto, centro commerciale, teatro, fast food, palazzetto dello sport)
¤ Molto accessibili ¤ Abbastanza accessibili ¤ Non accessibili ¤ Non so ¤ Non applicabile
Accessibilità dei mezzi di trasporto
Quanto è accessibile viaggiare con (macchina, taxi, pulmino per disabili, autobus, treno, aereo)
¤ Non accessibile ¤ Abbastanza accessibile ¤ Molto accessibile ¤ Non so ¤ Non applicabile
Dominio 6: Rete di supporto (medico di riferimento, terapista, assistente personale a pagamento, tecnico degli ausili, commessi dei negozi, estranei, vicini di casa, amici, familiari)
Quanto spesso incontra____________?
¤ Più di 2 volte alla settimana ¤ 1/2 volte alla settimana ¤ 1/2 volte al mese ¤ 1/2 volte all'anno ¤ raramente
¤ Mai (Passi alla prossima domanda)
Quanto le attenzioni che riceve influenzano la sua partecipazione ad attività quotidiane?
¤ Aiuta molto ¤ Aiuta in parte ¤ Non è influente ¤ Limita in parte ¤ Limita molto
Quanto l'atteggiamento del medico influenza il suo utilizzo dei servizi sanitari di cura?
¤ Aiuta molto ¤ Aiuta in parte ¤ Non è influente ¤ Limita in parte ¤ Limita molto

The FABS/M questionnaire was considered by the rehabilitation professionals and researchers understandable and clear. Overall, it has been judged an useful and informative tool to detect the impact of the user's environment on the success of a mobility assistive device; when used in combination with other outcome measures, it helps understand the actual impact of the AT intervention on the person's life.

The questionnaire took from a minimum of 15 to a maximum of 40 minutes to be filled-in, with a mean value of 26 minutes. The questionnaire was well perceived by respondents; they had no problem in understanding it and were nicely impressed by the interest the survey shows in their everyday life quality. Critical remarks included some difficulty to express the frequency with which climatic factors can limit or help participation, and some difficulty to answer questions regarding the accessibility characteristics of community destinations, as there is great variability in their characteristics which makes it difficult to answer with just one value.

In the Italian context, the FABS/M turned out to be very useful in that it captures a set of user's perceptions that are seldom detected in rehabilitation practice. Until now such perception was known to the AT prescriber just by intuition or could be inferred from observation, while the FABS/M helps bring it to light quickly and easily.

The analysis of the responses provided by the complete cohort of 22 AT users involved in the study, highlights some recurrent items that are most often stated as barriers to participation. Items rated as limiting participation "some" or "a lot" by at least the 50% of the respondents include: gravel, paved surfaces, winter weather, rain, crowds, public buses. Items rated by 100% of respondents as having "no effect" or helping participation "some" or "a lot" are handrails, automatic doors, escalators or specialized lifting equipment, airports, malls, cars, therapists, paid personal attendants, special equipment repairs personnel, store clerks, friends, family.

Figure 1 compares the answers provided by manual and powered wheelchair users. It can be appreciated, for instance, that there are recurring differences in the items judged as facilitators rather than barriers. A reason could be found in the bigger size of powered wheelchairs, and conversely in the difficulty for manual wheelchairs to negotiate slopes or rough terrain.

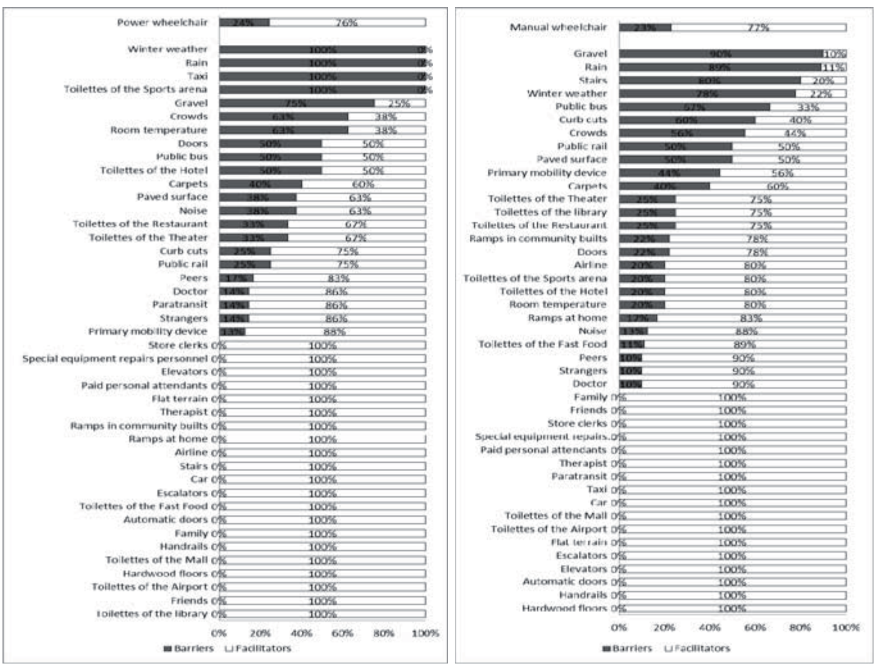

Figure 1. Comparative overview of answers provided by manual and powered wheelchair users to the questions of domains 1,2,3,5,6 regarding how far the items influence participation. The black side of each histogram bar indicated the percentage of respondents considering the item as a barrier, while the white side indicated the percentage of those considering it a facilitator.

4 Conclusions

Four main conclusions can be inferred from this Study:

- the questionnaire is easily understandable and is well perceived by both professionals and AT users; filling-in takes about 25 minutes, either in self administration or interview mode;
- the study indicates that the FABS/M survey is actually able to detect environmental factors that limit participation in daily activities of AT users with lower limb mobility impairments;
- information collected on the obstacles that hinder participation in a given community can be used to identify possible measures and stimulate policy makers to have them implemented;
- based on this information, rehabilitation services and AT providers may revise the AT intervention to better enable the user to cope with the existing barriers, while waiting for them to be removed.

Acknowledgements

This work was partially funded by Osservatorio Biomedicale Veneto, within the framework of the "Dialogo nel Medicale" Project. Special thanks go to all the respondents to the Questionnaire for their collaboration, and to the following persons who collaborated in the expert panel and in recruiting the respondents: A Caracciolo, M Romano, M Saruggia from Fondazione Don Carlo Gnocchi; A Oggioni from Unità Spinale Ospedale Niguarda Milano; A Gaiani from TONUS s.a.s..

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-551

Item Development for the Psychosocial Impact of Assistive Devices Scale for Continence (C-PIADS)

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Abstract. Urinary incontinence (UI) poses problems for millions of people of varying ages worldwide. Continence symptoms can be ameliorated with pelvic floor rehabilitation, drugs, or operational intervention. In addition there is a great variety of assistive technology devices (ATDs) used to aid continence management. Because continence difficulties (CD) can profoundly affect an individual's participation in society and, thereby, their health-related quality of life, it is important to have valid, responsive and sensitive measure of the impact of these devices on psychosocial experiences. One such tool, a 26-item self-report questionnaire the Psychosocial Impact of Assistive Devices Scale (PIADS) has been shown to reliably predict the adoption and use of ATDs. Our study was to investigate if and how this instrument could be modified to be sensitive to the use of continence management devices. The study used interpretive methods in which qualitative information from semi-structured interviews was combined with the findings from cognitive interviews for questionnaire pre-testing to inform the development of a new questionnaire. A total of 40 participants from Canada and UK were recruited. All interviewees self-reported CD – bladder and/or bowel - and use of ATDs to manage continence symptoms. Semi-structured interviews, lasting between 10 and 30 minutes, were conducted with all participants. The objective was to provide opportunities for interviewees to spontaneously (i.e. without reference to PIADS) identify important concerns and issues that should be considered for developing a version of the PIADS for continence technologies. Twenty-nine participants were also asked to complete the paper version of the PIADS questionnaire while considering their currently used continence device or product. They were asked to comment on the suitability and appropriateness of PIADS for assessing quality of life outcomes resulting from UI intervention and how well the questionnaire captured the impact of continence management products and devices. Finally, they were encouraged to suggest supplemental items, (i.e. issues not represented in the PIADS) perceived to impact upon quality of life outcomes following UI intervention. Results of the in-depth semi-structured questionnaires so far, reflect the findings from similar studies carried out on Foley catheter users with frequent references to the inconvenience, embarrassment and resignation to their condition. Generally, participants appeared to be able to complete the PIADS without difficulty and indicated that the tool reflected their primary psychosocial concerns with continence devices. Some indications for additional items, such as those related to stigma, are emerging. A version for continence, the C-PIADS, will require some modifications to the PIADS, and is likely to contain the addition of some new items. Following our full analysis a draft C-PIADS will be produced and this will be tested and validated as part of a European ERA-net grant in 2014.

Keywords. Continence Management Devices, Psychosocial Impact, Patient rRported Outcome Measure.

Introduction

Urinary incontinence (UI) poses problems for millions of people of varying ages worldwide. Continence difficulties (CD) are generally defined by the presenting symptoms of urgency to void (urge), leakage when coughing, laughing or with exercise (stress), both urge and stress (mixed) and voiding difficulties. Causes vary and include functional difficulties (e.g. impaired mobility), neurological disease, birth defects and spinal injury, or can be iatrogenic.

Treatment of the underlying condition and symptoms forms the basis of care. Continence symptoms can be ameliorated with pelvic floor rehabilitation, drugs, or surgical intervention. In addition, there is a great variety of assistive technology devices (ATDs) used to aid continence management. In the US and Canada, ATDs are defined as 'any item, piece of equipment, or product system, whether acquired commercially, modified, or customized, that is used to increase, maintain or improve functional capabilities of individuals with disabilities' (Assistive Technology Act, 1998). In the UK, the definition has been simplified to 'any product or service designed to enable independence for disabled and older people' (King's Fund, 2001).

The most commonly used ATD for the management of urinary continence is the absorbent pad. Other products include pessaries, vaginal inserts, penile clamps, male and female urinals and male external catheters. These may be single use or re-usable. Implantable devices such as artificial urinary sphincters and slings are used to provide structural support to the pelvic floor and thus reduce urine leakage. Urinary catheters are used primarily to empty the bladder when voiding is compromised, but are also used to manage urine leakage in some patients. Devices for electrical stimulation of the sacral or posterior tibial nerve may be employed to assist in the management of incontinence, and biofeedback devices that promote or stimulate pelvic floor contractions are used to help restore continence. Evidently, there are many devices to help manage continence in adults; however, the psychosocial impact on the user has not been well established, primarily due to the lack of a suitable validated instrument (Jutai *et al.,* 2011).

The purpose of this study was to develop a measure for the psychosocial impact of continence management technologies. The strategy chosen to develop the measure was to adapt the Psychosocial Impact of Assistive Devices Scale (PIADS). The new measure will be known as the C-PIADS (Continence-PIADS). The provision of such a tool will enable patient-centred evaluation of new and existing technologies and facilitate the establishment of a robust evidence base on which to establish treatment decisions for individuals with CD and for guidance at a population level.

Background

Clinical assessment of treatment outcomes has been shown to underestimate the degree of impact perceived by patients, and to focus on clinical issues which can be of lesser importance to patients than social or psychological issues (Fisher, 1999; Murawski & Miederhoff, 1998). Patient self-completed questionnaires or patient reported outcome measures (PROMs) provide a method for the standardised collection of data on symptom impact and treatment benefit from a patient perspective. In essence, this is an objective assessment of the patient's subjective experience of incontinence (Staskin *et al*., 2009).

UI can have an important impact on psychological and social functioning, and has been associated with elevated levels of stress and feelings of powerlessness as well as isolation and depression. UI also serves as a formidable barrier to engaging in activities of daily living.

We consider unrestricted and facilitated participation in human life to be essential in the technology user's definition of quality of life outcomes (Jutai & Day, 2002), and it is therefore important to have valid, responsive and sensitive measures of psychosocial experiences associated with CD because these experiences can profoundly affect an individual's participation in society and, thereby, their health-related quality of life. However, the numerous effects of CD on a person's psychological and social well-being, combined with frequent co-morbidities, make it challenging when measuring the impact of a particular ATD.

There are several well researched and fully validated instruments which are designed principally to assess the health-related quality of life impact of incontinence symptoms (Abrams *et al*, 2006). However, these have not been used consistently or extensively in device effectiveness research and their validity for evaluating the psychosocial impact of assistive devices is unknown. To achieve this in a standardised, objective and measurable fashion, specifically designed tools are required. One such tool, a 26-item self-report questionnaire called the Psychosocial Impact of Assistive Devices Scale (PIADS; Day & Jutai, 1996; Day *et al.*, 2002), originally developed for the English and French speaking populations of Canada, and is now available in many international linguistic and cultural translations. Scores on the PIADS are summarized in three quality of life subscales: Competence (reflecting perceived functional capability, independence and performance); Adaptability (reflecting inclination or motivation to participate socially and take risks); Self-esteem (reflecting self-confidence, self-esteem, and emotional well-being). The PIADS is an assessment tool that has been shown to reliably predict the adoption and use of ATDs (Jutai *et al*. 2000; Jutai *et al*., 2003; Saladin & Hansmann, 2008).

Method

The study used interpretive methods in which qualitative information from semi-structured interviews was combined with the findings from cognitive interviews for questionnaire pre-testing to inform the development of a new questionnaire. All participants provided written informed consent prior to enrolment in the study, which was approved by the Research Ethics Boards of the Bruyère Research Institute and the University of Ottawa in Canada, and the Southmead Research Ethics Committee in the UK. A purposive sampling strategy was employed in order to recruit individuals that could provide information rich interviews. All participants had consulted a health care professional about their continence concerns prior to participating in the study.

Semi-structured interviews, lasting between 10 and 30 minutes, were conducted with all participants. Questions included: *What technologies (i.e., devices and strategies) are used for continence management? What daily difficulties are* *encountered with continence management? What is the impact on daily life and significant other people? What are the most liked and disliked features of the technologies being used? What barriers are there to obtaining desired continence management solutions?* The objective was to provide opportunities for interviewees to spontaneously (i.e. *without* reference to PIADS) identify important concerns and issues that should be considered for developing a version of the PIADS for continence technologies. Face-to-face interviews were audio taped with permission from participants.

All participants at the Ottawa site and 20 of the 31 participants at the Bristol site were also asked to complete the PIADS in paper format, while considering their currently used primary continence device or product. They were asked to comment on the suitability and appropriateness of PIADS for assessing quality of life outcomes resulting from UI intervention and how well the questionnaire captured the impact of continence management products and devices. Finally, they were encouraged to suggest supplemental items, (i.e. issues not represented in the PIADS) perceived to impact upon quality of life outcomes following UI intervention. These additional comments were recorded by the researchers.

Recordings of the interview sessions were subjected to qualitative content analysis (Elo and Kyngas, 2008). Common themes and patterns that emerged in response to each of the scripted questions were identified. Participants' environments or past experiences were examined in relation to their behavior and attitudes. Quotations were identified that helped illuminate the central questions. The similarity of themes and patterns that emerged was compared with the findings of other studies on similar topics.

Findings

In Ottawa, 9 participants (M= 1; F= 8) were recruited, based on recommendation by physio- and occupational-therapists from Ottawa hospitals and community care access centres. The average age was 80 years (range: 63-86 years). In Bristol, 31 individuals, (M= 8; F= 23) were recruited from Southmead Hospital Urology Outpatient's Department and a community based continence clinic. The average age was 56 years (range: 17– 87years). All interviewees self-reported CD – bladder and/or bowel - and use of ATDs to manage continence symptoms. All the participants at the Ottawa site used absorbent pads to manage their CD; at the Bristol site, 24 participants used pads (3 were in addition to other continence devices), 6 used intermittent catheters (ISC), 2 used Foley (indwelling) catheters and 1 had an artificial sphincter.

Semi-structured Interviews

In general, participant narratives, as well as the subsequent themes and sub-themes arising from analyses corresponded well to the 26 items in the PIADS, and the 3 main PIADS dimensions of Competence, Adaptability and Self-esteem appeared to adequately cover the issues experienced by participants (Fig.1). Themes arising from the analysis of interviews reflected findings from similar studies carried out on Foley catheter users. A full analysis of interview findings are not detailed in this paper;

instead we focus on the applicability (or otherwise) of the PIADS as a measure of continence ATDs.

Some indication for additional items emerged; *relationships* - particularly intimate or sexual relationships, *convenience* – around storage, portability and disposal of devices, and *knowledge* – understanding of CD and performance of the device (Fig 1).

Embarrassment and concealment of UI from others, and a reluctance to acknowledge the condition to others in the participant's surrounding, were common topics. Examples of *self-stigma* (i.e., directing prejudicial attitudes inwards, resulting in shame and decrements in self-esteem and dignity), were expressed as *"...I feel dirty, it's horrible, that's the bad thing"* (female, aged 43 years). The fear of a stigmatizing event was ever present, primarily around leakage, odour and visibility of device; *"[I] often have to come home because of stains on my trousers [due to leaks]*" (male, aged 62). Another typically expressed the fear of smell as, *"...it's horrible, and then the smell and I know it's me. I know I get used to my smell and then you don't know if you are smelling*" (female, aged 43 years). Participants and their family members referred to the stigmatisation of CD as *"...they look at you as if you should have a big cross on your head and be like 'catheter user'...*" (participant's daughter).

Although many participants had few issues with the disposal of pads, for some the worst aspect was "*carrying one around all the time and getting rid of it*" (male, aged 69).

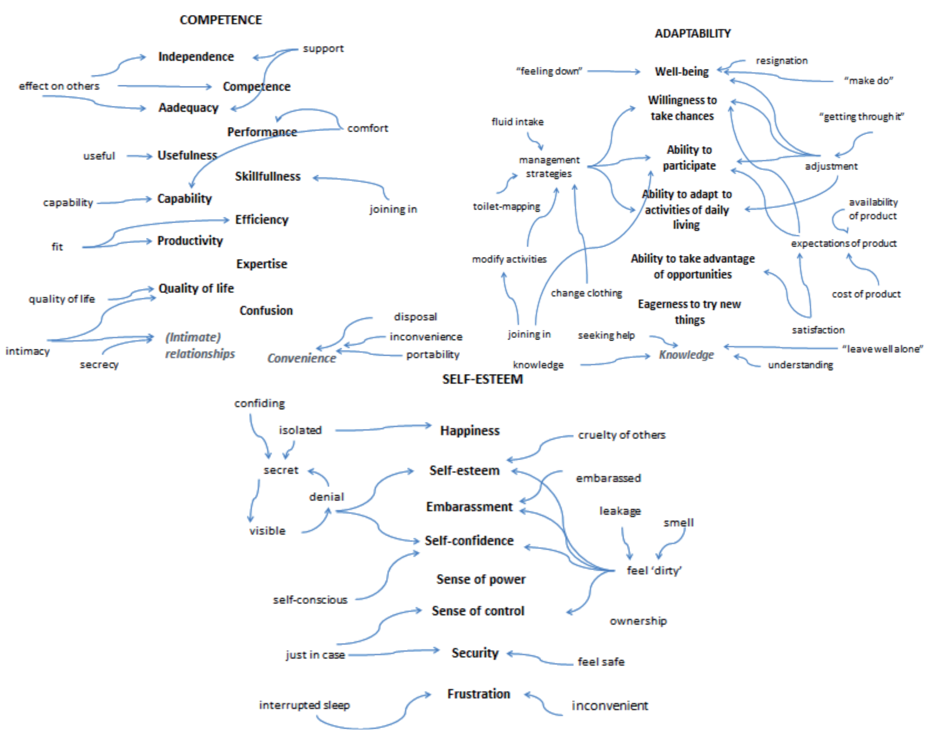

Fig. 1. Mapping of interview responses to PIADS.

Piads

Most participants appeared to be able to complete the PIADS without difficulty, although the design of the form caused problems for some participants. Even with the assistance of the PIADS glossary, the items *adequacy*, *productivity*, *expertise*, *performance*, *skillfulness* and *sense of power* were queried by more than 20% of the UK cohort. In the Canadian cohort, some participants said that they either did not understand the meaning of the items *competence, confusion, efficiency, embarrassment,* and *frustration,* or felt that more than one interpretation may apply depending on the circumstances. A few participants in both countries were confused by the reverse rating of the items *confusion*, *embarrassment* and *frustration* (i.e. positive ratings denote negative psychosocial impact).

Several items, *expertise*, *confusion*, *eagerness to try new things* and *sense of power* were not easily identifiable as issues relevant to continence from the interview data, and were predominantly attributed a zero score in the PIADS (Fig.2). Participants generally did not proffer suggestions for new PIADS items; exceptions were one participant who suggested that 'feeling down' or 'depression' should be included, while another thought that 'optimism' was a better reflection of his state than *well-being*.

None, or few, of the participants had difficulty in understanding or relating to items *usefulness*, *quality of life*, *well-being*, *ability to participate*, *ability to adapt to activities of daily living*, *ability to take advantage of opportunities*, *eagerness to try new things, self-esteem, sense of control* and *security* to their ATD.

Some potential new items, derived from interviews with the Canadian cohort were tested with the 20 participants in the UK cohort who had been asked to complete the PIADS. These included *self-consciousness, fear of being 'outed', social acceptance, secrecy, isolation, revealing to others, social participation* and *intimate relations*. The item *fear of being 'outed'* was not understood by UK participants in the context of their ATD. Items *social acceptance, secrecy* and *revealing to others* were queried by a few participants and several declined to answer '*intimate relations'* rather than ascribe a zero value.

The results of completing the PIADS indicate that ISC and pad wearers have higher competence, adaptability and self-esteem attributable to their ATD than indwelling catheter users (Fig 2).

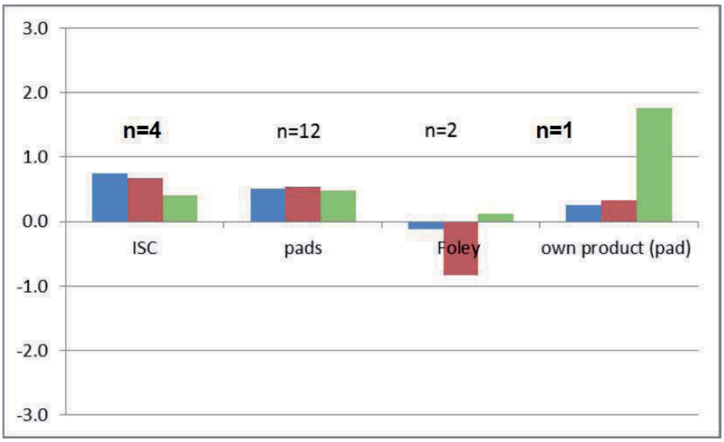

Fig. 2. PIADS scores for cohort of 20 UK participants.

Discussion

The results indicate that the PIADS instrument, with some modification, is potentially a useful and accurate instrument to assess the psychosocial impact of continence devices. The form design and selection of words or phrases need to be changed for a UK population and for continence device users generally.

The issue of stigma requires further investigation. Continence ATDs differ from many other ATDs in that they assist with an activity (toileting) that is usually carried out by adults in private. Furthermore, the negative connotations with waste, hygiene and contamination are unique. These factors, combined with the associations with sexual activity, separate CD from most other disabilities.

The putative new items derived from the Canadian study and those from the UK study require further testing to establish validity. The PIADS offers comprehensive coverage for expression of the majority of issues raised. For example, a number of references were made in the interviews to disturbed sleep and this could affect scores for items such as *frustration*, *performance*, *productivity* or *quality of life*. Issues relating to stigma (*secrecy, social acceptance*, etc.) and *relationships* may not be readily ascribed to existing items and thus may need to be included as new items in the C-PIADS. Whether *convenience* and *knowledge* are adequately represented within the PIADS requires further testing.

For some participants the use of their continence ATD was a temporary measure prior to a surgical solution. For others, it was considered permanent. This contextual use of the ATD appeared to be an important factor in the dimensions of Adaptability and Self-esteem, but it is not clear if this can be identified through the PIADS.

Although the study did not aim to compare different continence ATDs, the results from PIADS completed by the UK cohort fit well with patient feedback of their devices from other studies as well as their anecdotes.

Impact

The development of an instrument to measure the psychosocial impact of continence devices will provide a useful tool for technology developers, researchers and for clinical assessment. Continence has been described as a hidden condition, because (in many instances) the manifestations of CD are not immediately identifiable by others in social settings. The C-PIADS potentially offers users a way to speak out, and make their attitudes about devices known.

Conclusions and Planned Activities

The PIADS appears to fundamentally address many of the important psychosocial concerns of adults who have CD. A version for continence, the C-PIADS, will require some modifications and is likely to contain the addition of some new items. Following our analysis, a draft C-PIADS will be produced and this will be tested and validated as part of a European ERA-net grant.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-559

Electronic Mobility Aid Devices for Deafblind Persons: Outcome Assessment

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Abstract. Given the lack of studies using standardized and objective measures on the effect of electronic systems that helps obstacle detection or orientation, the purpose of this article is to present a single-subject's case study of 4 users aged between 50 and 70 years old followed in a deafblindness program in a rehabilitation center. The Canadian measure of occupational performancesuggests that the performance and the satisfaction are higher following the use of the Miniguide and the Breeze, two commercial electronic mobility aid devices, in four types of occupations (functional mobility, active leisure, community role, and socialization). The training was completed in 4 to 10 sessions (5 to 14 hours in total). The Québec User Evaluation of Satisfaction with Assistive Technologyreveals high satisfaction except for one participant regarding 4 of 8 items. Finally, a follow-up interview three months after training was done to evaluate the used features, the frequency of utilization, problems, safety and the impact on functional independence.

Keywords. Assistive technology, obstacle detection, orientation, hearing loss, low vision, blindness.

Introduction

Roentgen et al. [1] conducted a literature review that identified some 146 different products for people with visual impairments. However, only 21 of them were considered to be both available and be used as such, without further adaptation. The authors of this study were surprised to see how many of these products were no longer available on the market or have failed to penetrate the market. While these authors suggested further research to explain this situation, our research team suggests instead to focus on the effects of electronic mobility aid devices for persons who are deafblind (EMAD-DB), more specifically those available in the Québec province (Canada). Roentgen et al. published a second study, in 2009 [2], to identify studies that have documented effects and the effectiveness of an EMAD but only for persons with a visual impairment only. 13 studies were identified, but no one with experimentation in real life. The methodological quality of these studies were considered low, especially due to the lack of standardized and validated measurement instruments. Furthermore, no studies of the literrature could be identified with samples of persons with both types of disabilities (blind and deaf) and using an EMAD on real life.

1 Specific Objectives

The purpose of this study is to test a methodology for assessing the effects of EMAD-DB on the mobility of deafblind persons. Specific objectives are: 1) assess performance and satisfaction with independent mobility in various occupations; 2) assess satisfaction with the technical aid; 3) document the feasibility of training with various technical aids with clients aged 50 and older; and 4) document actual use of the technical aid three months after training (features used, intensity, frequency, problems encountered, etc.).

2 Methods

2.1 Research Design and Selection of the Participants

A feasibility study with a single-subject design was conducted (T1 = initial assessment and intervention; T2 = assessment after intervention; T3 = follow-up 3 months later). Recruitment was done among deafblind persons that currently receive or have received rehabilitation services from the deafblindness program at the rehabilitation center (Quebec City, Canada). The orientation and mobility (O&M) specialists targeted some of them who could benefit from more ease or independence because they want to try new tasks or want to go on known paths but without assistance (for detection or for orientation). If interested in participating, they met their O&M specialist to receive more detailed explanations and sign the consent form.

The inclusion criteria were: 1) to have already been trained to use a long cane, 2) not to have cognitive impairment or language impairment likely to seriously impede the safe and efficient use of the EMAD-DB, 3) being legally blind (visual acuity $\leq 6/60$ or visual field $\leq 20°$ in the better eye after correction); 4) to be able to travel independently indoor or outdoor. One of the technologies used is the Breeze. This one uses a speech synthesis system, other auditory criteria must be add: 5) to have sufficient abilities for speech recognition (open choice) in various listening conditions, for example in presence of competitive noise and 6) to have the possibility for coupling the aid with an optimal hearing device on at least one ear.

2.2 Technology and Intervention

The EMAD-DB was paid by the Québec Medicare equivalent. Because of this constraint, there were only two available technologies (Figure 1). The Breeze is a talking GPS designed for people who are blind or low vision (helpful for orientation). It verbally announces names of streets, intersections and landmarks in your commute. The Miniguide is presented as an accessory to the more traditional aids such as the cane (helpful for detection). It uses ultrasonic echo-location to detect objects and vibrates to indicate objects. These EMAD-DB are among the 13 studies identified by Roentgen et al. [2]. Steps included in the user's training were: 1) teaching of the Breeze or Miniguide features, 2) training on how to use the Breeze or Miniguide indoors or outdoors, 3) cognitive mapping of the chosen route using a tactile map, and 4) assisting the user to achieve the mobility target. Total intervention per person was under 3 months.

Figure 1. The Miniguide (left) and the Breeze (right) (from: GDP Research at http://www.gdp-research.com.au/ and HumanWare at http://www.humanware.com/en-canada/products/blindness/talking_gps).

2.3 Measurement Tools

The standardized questionnaire of the Canadian Measure of the Occupational Performance (CMOP) is used to detect changes in the users' perception about their own performance in an occupation over time [3]. The CMOP key areas are: personal care (including mobility), productivity and leisure. Performance and satisfaction given to occupations are listed on a 0 to 10 scale. The questionnaire on training specification is done following each training (date and duration of training, time spent teaching EMAD-DB features and nature of exercises indoors and outdoors). The standardized questionnaire "Québec User Evaluation of Satisfaction with Assistive Technology (QUEST)" calculates satisfaction scores on the technological aspects, services and overall scores [4] (12 items to assess on a scale of 1: not satisfied to 5: very satisfied). The audio-recorded semi-structured interview last about 45 minutes for the experience on EMAD-DB and security. Four questions were asked to the users: 1) real use of the EMAD-DB (features used, intensity and frequency), 2) problems/difficulties regarding the technology, 3) advantages and disadvantages perceived (safety and functional independence), and 4) opinion about maintaining this service in the future.

2.4 Data Collection and Data Analysis

T1: With a first O&M specialist, users complete the "participant profile" questionnaire. They choose significant paths within specific occupations that could be reached after the EMAD-DB training. With a second O&M specialist, they complete the CMOP. **T2**: The QUEST and CMOP questionnaires are completed in the week following the last intervention. **T3**: The second O&M specialist administers the QUEST and CMOP questionnaires and the semi-structured interview 3 months after T2. Descriptive analyses are presented for each variable, at each measurement periods (total, percentage, mean score on Likert scales). For the analysis of interviews content, a qualitative and inductive approach was used [5].

3 Results

Table 1 presents the participant's profile of three men and one woman aged from 50 to 70 years old and having the Usher syndrome with different levels of low vision and deafness. Training was different in term of duration (2h25 up to 9h) for each participant according to the number of occupations they targeted at the beginning of the study. For example, participant 4 received less training because he chose only one community life activity to realise with the Miniguide (also see note 4, Table 2).

Table 2 indicated that participants 1, 2 and 4 chose the Miniguide because they needed to detect objects on their route (the Miniguide vibrates to indicate objects). Only participant 3 chose the Breeze because she needed assistance for orientation and was able to hear with audio system. Occupational performance as well as satisfaction is higher for all participants in at least one targeted occupation after training and during the follow-up. For all participants, the larger impact was observed between T1 and T2, probably due to training. In comparison, the 3 months of utilization did not change much the scores for participants.

Satisfaction of the Miniguide and the Breeze was high (4 or 5 out of 5) for the 8 technical aspects measured for three participants. There was a constant across the participants for two of the aspects measured, with satisfaction generally increasing after the three months of real-life testing: *adjustment of the different functions* and *durability* of the device. Conversely, satisfaction generally decreased for two aspects but only for Miniguide users: *ease of use* and *comfort*.

The content analysis for interviews reveals highly variable comments. Each participant used the Miniguide features differently. Indoors, some preferred to set detection at 0.5 meters, others at 1 m. or 2 m. Outdoors, all three participants set the detection for the Miniguide at a longer range (usually double the range). The frequency of use also varied: daily, every other day, winter only or everyday indoors only. Usage pattern was personalized (see notes under table 2). Participants 1 and 2 reported that the Miniguide helps locating overhanging objects which are not detectable with the long cane. Regarding the ease of use, results are nuanced: only some features are easy to use, difficult to use the cane at the same time than the Miniguide. Reported benefits are important (presented at the congress). At least seven major problems have been identified and only one is common for two participants: it is difficult to use the Breeze or Miniguide with gloves during winter.

4 Discussion and Conclusions

The purpose of this study was to test a methodology for assessing the effects of EMAD-DB on the mobility of deafblind persons in real life. Globally we think that with this methodology, we have attained our objectives. In real life, three participants had used an aid for detection and one participant used an aid for orientation. The questionnaires could assess the performance and satisfaction toward the EMAD-DB and the independent tasks in real life. It might have been difficult for some participants to complete the CMOP at T1. Participants had to choose tasks where they will be trained to use the EMAD-DB. The training time was reasonable and participants did not have negative complaints about their experience. Results also show that older age (up to 70 years old) wasn't an obstacle to the use of the assistive technology, but the familiarity with technology might be. The clinical results of this study demonstrate that a high satisfaction score for QUEST which does not necessarily imply that the assistive technology is efficient in all circumstances. Participants are satisfied of some benefits provided by the Miniguide and the Breeze (highlighted in the QUEST, CMOP and interviews verbatim) but their satisfaction is more nuanced when considering the whole experience. These technologies brought its share of problems in many situations.

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Appendix

Table 1. Clinical profile and training sessions.

	Participant 1	**Participant 2**	**Participant 3**	**Participant 4**
Age (years)	69	70	55	50
Gender	male	male	male	female
Education level	grade 7	college	university	grade 9
Diagnosis	Usher syndrome	Usher syndrome	Usher syndrome	Usher syndrome
Visual acuity (VA)	almost total: 6/360 ≥ VA ≥ light perception	almost total: 6/360 ≥ VA ≥ light perception	profound: 6/120 ≥ VA > 6/360	severe: 6/120 ≥ VA > 6/360
Visual Field (VF)	almost total: 5° > VF ≥ 0°	almost total: 5° > VF ≥ 0°	profound: 10° > VF ≥ 5°	severe: 20° > VF ≥ 10°
Deafness degree	profound (bilaterally)	moderately severe to profound (bilaterally)	mild to profound (bilaterally)	moderate to severe (bilaterally)
Technology use in general Regularly Occasionally Rarely	✓ Work shed, computer	✓ computer for hobbies	✓ computer for work	✓
Training sessions (nb)	10 *for Miniguide*	7 *for Miniguide*	9 *for Breeze*	5 *for Miniguide*
Training session time (min.)	60 to 110	95 to 150	60 to 90	75 to 100
Total time all sessions (h:min)	13:40	12:50	11:30	7:20
Time spent in learning AT functions (h:min)	9:50	3:50	5:35	2:45
Time spent using AT (h:min) Functional mobility Community life Active leisure Socialization	3:50 ✓✓✓	9:00 ✓ ✓ ✓	5:55 ✓✓ ✓✓✓✓	2:25 ✓

Table 2. Performance and satisfaction at MCOP before (T1) and after training (T2), and follow-up at 3 months (T3).

	Participant 1 (Miniguide)[1]						**Participant 2** (Miniguide)[2]						**Participant 3** (breeze)[3]						**Participant 4** (Miniguide)[4]					
Occupations	Performance from 1 to 10			Satisfaction from 1 to 10			Performance from 1 to 10			Satisfaction from 1 to 10			Performance from 1 to 10			Satisfaction from 1 to 10			Performance from 1 to 10			Satisfaction from 1 to 10		
	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
Functional Mobility							7	9	10	7	9	10	5 4	10 10	10 10	5 5	10 10	10 10						
Community life													3 6 4 6	9 9 8 10	9 9 8 10	4 8 8 6	9 10 10 10	9 10 10 10	3	8	8	5	8	8
Active leisure	8 7 3	9 9 N.A.	8 9 N.A.[7]	7 6 3	10 9 N.A.	8 9 N.A.[6]	7	8	N.A.[5]	7	9	N.A.[5]												
Socialization							1	8	N.A.[6]	1	7.5	N.A.[6]												

Note 1: Participant 1 is evaluated for taking a walk; to go to the workshop located in the backyard and to take the bridge in a park.

Note 2: Participant 2 is evaluated for moving on his property (in the garage, around the pool, the swing or doing compost) to move inside the bowling center, participate in the social group activities.

Note 3: Participant 3 is evaluated for getting back at home during the day; getting back at home at night; to do the bus ride to go music store; to go to a grocery store during the day (near the house), to go to a grocery store at night near the house; to go to the creamery during the day and at night; to go to a shopping center – unknown path).

Note 4: Participant 4 is evaluated for going to get her son at school and to get back at home at night.

Notes 5 and Note 6: N.A.: not applicable. Someone was accompanying him at the other time measures. Therefore the participant did not need to use the Miniguide.

Note 7: N.A.: not applicable. One of the goals was to walk for the pleasure on a bridge. It was inaccessible at that time.

Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-565

Computer-based Assistive Technology Device for Use by Students with Disabilities in Mainstream School

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Abstract. The increased implementation of Information Communication Technology (ICT) in education means that it is important for students with disabilities to keep up with students in general in computer-based activities in school. *Method:* The design of this study was cross-sectional, with group comparisons in 287 students with motor impairment and 113 with neuropsychiatric diagnosis, who used and did not use a computer-based assistive technology (ATD) in mainstream school. *Result:* The prevalence of using computer-based ATDs was about 42 % of students with disabilities. More than half of those students were dissatisfied with all aspects of the service. Students who use a computer-based ATD are also less satisfied with their computer use at school than those who do not use an ATD. *Conclusion:* An individual plan could be beneficial for each student to: focus on the aim of the computer use, examine the student's needs in terms of computer-based ATDs and their inclusion in education.

Keywords. Assistive technology; disabled children; ICT; service delivery.

Introduction

The increased use of Information Communication Technology (ICT) has changed the everyday life of students in school (1, 2). Therefore, it is important for students with disabilities to keep up with students in general in computer-based activities in school, such as writing reports and taking notes, searching for information and making presentations (1, 3). Consequently, availability of computer-based assistive technology devices (ATDs) and ICT as an educational tool might be of importance for students with disabilities. Unfortunately, many studies concerning the participation by students with disabilities in computer activities in school indicate suboptimal access to and use of computers and computer-based ATDs (2-5). Nevertheless, it is important to be aware that students who use and need computers both as an ATD and as a tool in education to reach their educational goals (6) need to have access and may need to use them more frequently and in more activities at school than those who do not use computer-based ATDs. Despite the increased implementation of ICT in education,

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research into the prevalence of children and youths with physical disabilities who use computer-based ATD is sparse. To date, research in computer-based ATD has mainly focused on benefits of ICT use in students with physical disabilities. Previous studies in adolescents with neuropsychiatric diagnosis found that ICT can also promote academic skills e.g. motivation for learning in this group of students (4, 7). In order to promote students with disabilities' who need an ATD, further knowledge concerns whether a person perceives that he or she has access to and is satisfied with their computer use in the school setting. Therefore the aim of the study was to investigate the prevalence of both students with motor impairment and students with neuropsychiatric diagnosis who used a computer-based ATD in mainstream school, and to examine their satisfaction with computer use and services with the application of computers for in in-school activities.

1 Method

The design of this study was cross-sectional, with group comparisons in students with motor impairment and neuropsychiatric diagnosis who used and did not use a computer-based ATD in mainstream school. The Regional Ethics Committee in Stockholm approved the study (2006/1101-31).

Seven habilitation centers (HC) in central Sweden, encompassing both urban and rural areas, were invited to the study, and four agreed to identify participants for this study. The inclusion criteria were students aged between 10 and 18 years, with motor impairment due to neurological dysfunction or injury and neuropsychiatric diagnosis, and attending mainstream schools. The HC identified 729 eligible participants aged between 10 and 18 years, 11 of whom did not have a valid mailing address, resulting in 718 information packs (a cover letter, a survey instrument, and a coded and stamped addressed envelope) being distributed. A total of 419 completed the survey, comprising a response rate of 58%. Fifty-four students who were attending special schools and therefore did not fit the inclusion criteria were excluded, resulting in 365 valid participants. Consent was given by returning the completed survey.

The instrument used in the survey consisted of a questionnaire with 36 main questions asking about general demographic information, and including self-reported questions concerning the students' satisfaction with and use of ICT and computer-based ATDs in school. A second section covered two assessments but was not used in this study.

The statistical analyses were performed using Statistica for Windows 8.0. A descriptive analysis was done to describe the general characteristics of the participants, and number of students who used a computer-based ATD. Cross-tabulation (X^2) with a level of significance of $p < 0.05$ was used to investigate differences between students with motor impairment and neuropsychiatric diagnosis, and those who used and did not use a computer-based ATD. Categorical data were described in terms of frequency of responses and percentages of the total sample answering the question. A one-way analysis of variance, an ANOVA was also performed to compare the mean of satisfaction in computer use among students who used and did not use a computer-based ATD.

2 Results

In this study 365 students with disabilities participated, among whom 252 students had a motor impairment (e.g. cerebral palsy, neuromuscular disorder, spina bifida, acquired brain injury) and 113 students had neuropsychiatric diagnosis such as Attention-Deficit/Hyperactivity Disorder (ADHD), disturbance of activity and attention, dysfunction of attention, motor control, and perception (DAMP). There were more boys, 225 (61.6%) than girls, 140 (38.4%) in the study, which is in accordance with available statistics. The mean age was 13 years 6 months [SD 2 y 4 mo]. All participants attend mainstream schools and about a quarter, 101 (28%), attend a class with fewer than 16 pupils.

2.1 Prevalence of using a Computer-based ATD

The prevalence of using a computer-based ATD was found to be 42% (*n*=154/365) in the age group 10-18 years with disabilities. No difference in the prevalence between students with motor impairment (*n*=104/287, 44%) and neuropsychiatric diagnosis (*n*=50/113, 41%) was found. Nor were differences found between those students who used and did not use a computer-based ATD with respect to gender and age, as well as those students who had a physical disability or a neuropsychiatric diagnosis. However, the analyses showed that the students who used a computer-based ATD walked with an aid (22%/14%) and received help from a teacher's assistant (41%/21%) to a significantly higher extent than those who did not use an ATD ($p<0.05$).

Using computer-based ATD comprised using the computer as an ATD, computer input interface, and special software. The computer input interface that the students used were: a non-standard keyboard (e.g., an extra large one, or a screen keyboard) (*n*=35/154), an alternative mouse (roller ball type, or a joystick) (*n*=20/154) and switches (*n*=10/154). Few students (*n*=4/154) used an advanced computer input device to control the computer, such as a speech recognition program, or a head mouse. Only special software, such as speech synthesis and educational software programs (*n*=31/154), was in more frequent use among students with motor impairment than those with neuropsychiatric diagnosis 26.7% vs. 8.2%, p=0.008.

2.2 Availability of Services

Concerning the service provided in relation to the use of a computer-based ATD in school, Figure 1 shows that slightly more than half of the students were dissatisfied with all aspects of the service – from the initial prescription, to the repairs and technical services, the provision of information and training from professionals, and the follow-up.

In addition, an ANOVA showed that students who had a neuropsychiatric diagnosis and used a computer-based ATD were less satisfied with their service delivery when they had a significantly lower average of the sum in each of the four variables among (Likert scale 1-5) in comparison to students with motor impairment (see Table I).

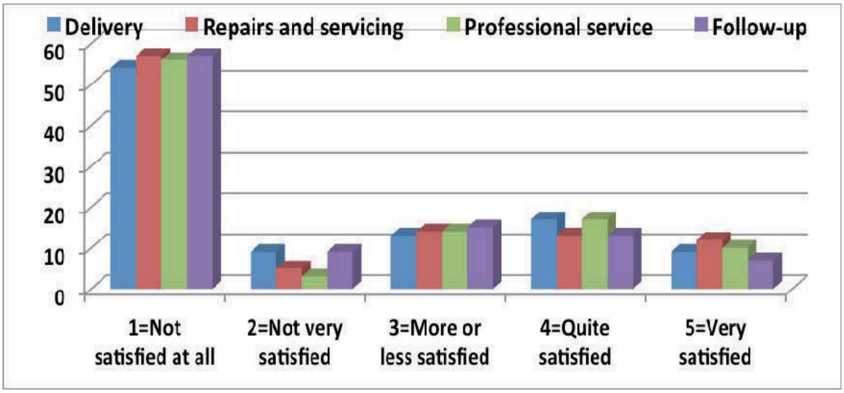

Figure 1. An analysis of responses given by 154/365 students who used a computer-based assistive technology device in school and their level of satisfaction with the services provided in conjunction with the provision of their computer-based ATD in percent.

Table 1. A comparison between students with motor impairment and students with neuropsychiatric diagnosis in average of the sum in four variables in the services provided respectively.

	Mean [SD] in each student group				
	RH	***NPT***	***p-value***	***df***	***F***
Delivery	*M*=2.47 [*SD*=1.49]	*M*=1.59 [*SD*=1.14]	0.000	*149*	13.35
Repairs and servicing	*M*=2.47 [*SD*=1.56]	*M*=1.61 [*SD*=1.24]	0.001	*146*	11.40
Professional service	*M*=2.52 [*SD*=1.54]	*M*=1.59 [*SD*=1.21]	0.000	*148*	13.63
Follow-up	*M*=2.26 [*SD*=1.40]	*M*=1.55 [*SD*=1.14]	0.002	*148*	13.35

2.3 Computer Use in School Activities

Almost all students with disabilities had access to a computer in school (91.8%). A chi-squared test revealed significant differences between students who used a computer-based ATD (87.7%) and those who did not (94.8%) concerning access to a computer in school, p=0.015. The significant most frequent (daily) computer users were students with motor impairment (39.8%) in comparison with students with neuropsychiatric diagnosis (14.3%), p=0.009); both groups of students used a computer-based ATD.

Regarding satisfaction in computer use in school, an ANOVA showed that students who used a computer-based ATD were *less satisfied* with their computer use, with a mean of 2.5 (scale 1-5), in comparison with students who did not use an ATD with a mean of 2.9, (df=349, 0.003). No significant differences appeared between all students who used a computer-based ATD grouped by students with motor impairment and neuropsychiatric diagnosis.

3 Conclusions

The prevalence of using computer-based ATDs was about 42 % of students with disabilities. Thus, supported by earlier research amongst children with physical disabilities the results show that computer-based ATDs are more common than, for example, mobility aids (44 % vs. 34 %) (8). Based on these results it is thus established that computer-based ATDs are common aids in schools for students with disabilities. In comparison with mobility aids (9) computer-based ATDs are rarely documented in research, therefore, more studies is needed and also the use of ATDs from the perspective of the child. In addition, this research found no difference in the prevalence of using computer-based ATD in school among students with motor impairment and students with neuropsychiatric diagnosis. This finding was unexpected, when one explanation for the prevalence of students who use a computer-based ATD is fine motor limitations, a common limitation in children with motor impairment (10), but also occur among children with neuropsychiatric diagnoses, such as DAMP (11). Another explanation is that previous research has generated knowledge that students with student neuropsychiatric diagnosis also have benefits of computer-based ATD such as special software in education (12).

In spite of the fact that most frequent computer users were students with disabilities who used a computer-based ATD, it is disappointing that students who use a computer-based ATD are less satisfied with their computer use at school than those who do not use an ATD. This is consistent with the finding that participation in computer activities in school is limited among children who use a computer-based ATD, compared with children without disabilities (13). The service of the computer-based ATD play a crucial role in ensuring that there is equal opportunity for students who use a computer-based ATD to come along with peers in various types of school activities. Therefore another reason why the students are dissatisfied with their computer use may also be that about half of the students are not at all satisfied with the service delivery, service, information, and follow-up of their ATDs. An individual plan could be beneficial for each student to: focus on the aim of the computer use, examine the student's needs in terms of computer-based ATDs and their inclusion in education.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-571

Outcome Assessment of Electronic Mobility Aids for Persons Who Are Visually Impaired

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Abstract. Mobility is essential for participating in daily life. For people who are visually impaired besides traditional aids Electronic Mobility Aids (EMA) can enhance their independent mobility. Despite technological advances EMA are only used to a limited extent and are not inherently incorporated in orientation and mobility training programs. This study describes the state of the art in EMA and their reported effects, it investigates the usability of several types of EMA and finally a methodology for assessing the effects of EMA on the level of participation was developed. **Methods.** The study was executed in three phases. The first phase involved two literature reviews, the second phase consisted of usability testing (n=26), in the third phase the developed measurement method was deployed in a group of persons who are visually impaired (n=53). **Results.** 146 systems were found and could be categorized in EMA for obstacle detection and for navigation. 13 studies described the effects of 6 EMA. The usability of the tested products underlined the need for individual selection of an EMA. The developed assessment method involved a combination of diaries and GPS data collection. **Conclusion**. The study underlined the need for personalized provision of EMA and contributed to a protocol for assessment, selection and training to support professionals in counseling persons who are visually impaired.

Keywords. Blindness, Low Vision, Obstacle Detection, Orientation, Navigation.

Introduction

Mobility plays a pivotal role in modern Western societies, and in a survey undertaken by Douglas et al., it was found to be the impairment-related theme of personal importance that was most frequently mentioned by persons who are visually impaired [1]. Besides a human guide, a dog guide, a long (white) cane or conventional orientation aids, Electronic Mobility Aids (EMA) can (be used to) enhance the independent mobility of persons who are blind or have low vision.

The development of EMA derived from radar- and sonar-based technological innovations in the field of object detection and acoustic location during the Second World War [2,3]. The first devices became commercially available in the 1960s. They were designed to support obstacle avoidance, landmark identification and near or spatial orientation. The introduction of the Global Positioning System (GPS) for civilian purposes combined with Geographic Information Systems (GIS) offered new possibilities for the development of EMA to assist in far space or geographical

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orientation. With "GPS Talk" the first GIS- and GPS-based navigation system for persons who are visually impaired became commercially available in 2000 [4]. This kind of EMA can provide route guidance, route planning and exploration, and can inform about the current position and vicinity [e.g. 5]. Fast technological advancements in the mainstream consumer market domain have benefited Assistive Technology Devices (ATD) such as EMA [6-9], improving their capacity, and reducing their size, weight and costs [8-12]. Due to demographic trends in Western societies, the population is ageing and the number of persons who are visually impaired is expected to increase [13]. Despite their promising potential and the rapid improvements in technology as outlined above, EMA are not widely used [14] nor do they form an inherent part of the orientation and mobility (O&M) instruction and curriculum [15,16]. A gap in knowledge on (available) devices was identified, and more insight is needed into their functionality and usability as well as into their effects on mobility and participation.

The objectives of this study were threefold: first, to describe the available EMA in technical and functional terms and to systematically review the evidence on their effects; second, to assess the functionality and usability of different devices; and third, to establish a method to investigate the effects EMA aimed at navigation on mobility and participation.

1 Methods

The study was conducted in a phased approach. The first essential step was to explore this specific field of AT in order to provide an overview of systems and products, their technical functioning, intended use and functionality. Therefore, the study started with an extensive literature and internet search to obtain an overview of EMA and recent developments in this field of Assistive Technology [17]. This was followed by a systematic review, which was performed to gain insight into the effects and effectiveness of EMA as described in the international literature [18].

Assessment of initial use, involving the performance of specified tasks in a defined context, provides insight into ATD's usability and functionality. To address several aspects in the interaction between the device and its user, different outcome and performance measures were taken into account: (1) the objective and quantitative assessment of mobility performance (EMA category 1) and the performance of 11 tasks derived from the intended use of EMA category 2 respectively; (2) the subjective and quantitative assessment of user satisfaction; (3) the subjective and qualitative evaluation of users' experiences regarding functionality, usability and perceived added value. Particular attention was paid to the development of an indoor mobility course for the assessment of mobility performance [19]. In the first round of a user evaluation, eight persons who are visually impaired evaluated two EMA aimed at obstacle detection and orientation [20]. In the second round, four EMA aimed at navigation were evaluated by 18 persons who are visually impaired on an unfamiliar outdoor route [21].

In the last phase, a method to assess the impact of the long-term use of EMA aimed at navigation was compiled, which addresses outcomes on several conceptual levels including participation, activities and functional gain. Two generic instruments were chosen. Changes in societal participation were ascertained through USER-P [22,23], and the reduction of individually identified problems related to way-finding through the

IPPA [24]. The impact on the perceived difficulty of mobility situations was determined through an impairment specific instrument, the Dutch translation of the IMQ [25]. Again, particular attention was given to the development of a measurement instrument, this time to assess outdoor mobility and travel behaviour. As a result, trips outside the home were monitored during a 14-day measurement period by means of a pre-structured activity diary, combined with a GPS data logger and a tailored software application that enabled trip identification and ensured protection of participants' privacy. The measurement method was deployed in a group of 53 persons who are visually impaired [26].

2 Results

2.1 Phase 1

While the total of 146 systems also encompassed discontinued products and prototypes, with regard to the application of EMA in practice attention was focused on those products which visually impaired persons can use without environmental adaptations. These commercially available devices were classified in two main categories: (1) devices aimed at obstacle detection and orientation, and (2) navigation systems. The detailed description of all products in the first (n=13) and in the second (n=10) categories showed similarities and differences in product specifications such as design and features, parts and characteristics, function, functionalities and intended use [17]. Categories of descriptive detail were compiled that facilitate the comparison of EMA and can serve in their selection for different purposes. Depending on the target group, information products can be tailored accordingly regarding their level of detail.

In the systematic review 13 studies on 6 different EMA available at that time were included. Two studies addressed one of the ten EMA category 2 identified while the remaining 11 evaluated five of the 13 category 1 devices. Eight studies used an experimental within-subjects (repeated measures) or a single subject alternating treatment design, while the design of the others was referred to as a field trial, survey and a follow-up study. The majority of studies reported positive effects of the use of EMA. Outcomes specified for EMA category 2 covered the performance of specific tasks such as reaching a defined destination and other tasks related to navigation. Assessed outcomes of EMA category 1 comprised perceived added value, perceived impact on quality and amount of travel, self-reported amount of use and reasons for non-use, and changes in users' mobility performance, defined in various ways [18].

2.2 Phase 2

An overview of previously applied methods and the specification of critical factors and elements for the assessment of mobility performance and for the construction of a course, served to determine the content of the developed device-specific measurement instrument and can, together with the provided explanations of choices and methodological considerations, serve as a tool to support the design of mobility courses and test situations for different purposes. Assessment of mobility performance on the indoor mobility course developed was found to be feasible and the instrument was found to be sufficiently sensitive to detect differences in mobility performance between commonly used mobility aids and EMA. Covering the course under experimental conditions enhanced users' insight into the functionality and usability of the devices [19]. Changes in mobility performance were observed with both category 1 EMA. Walking speed as well as the Percentage Preferred Walking Speed (PPWS) and the number of previously defined mobility incidents decreased and the frequency of types of mobility incidents changed. Most participants were generally quite satisfied with the EMA. On group level, no significant difference on the total score on user satisfaction between the devices was found; however some participants expressed a marked preference [20].

Execution times on the 11 tasks performed with the EMA category 2 showed a high inter-subject variability as did the scores on user satisfaction. On group level, all tested functionalities were judged better than sufficient (according to the Dutch grading system) with one exception, and user satisfaction scored higher than more or less satisfied for all but two aspects of one device [21].

2.3 Phase 3

Both parts of the measurement method were found to complement each other well in the investigation into different aspects of travel. The activity diary allowed for a more detailed specification of the mode of travel, travel purpose, and familiarity with the route. Six different types of trips were defined and quantified whose frequency was expected to change through the use of EMA category 2: covering familiar or unfamiliar routes independently when walking or using public transportation. The logger provided objective data on the total number of trips, distinguished between walking and other modes of transportation, and recorded the distance covered in km. Correlation and agreement in those aspects that both instruments measured, e.g. total number of trips, was fair [26].

3 Discussion

A uniform definition and a consistent terminology of EMA are lacking and information on EMA turned out to be highly fragmented and not easily accessible. The inventory of discontinued products, prototypes and available devices led to a categorization which established a basis for the selection of the EMA assessed in the present study, but also for the development of information products for various stakeholders like care professionals and users, as insufficient information is one of the main hindrances for the use of AT for persons who are visually impaired [10]. With a broadening of the range of EMA as AT devices through common consumer products and a growth of possibilities through combined additional functionalities, objective and updated information will become even more relevant to foster informed choices.

The results of the study emphasize the subjective and individual nature of user experiences and distinct major differences in the evaluation of EMA, even in standardized contexts of use. The qualitative data helped to clarify decisive aspects in design and features, operation and functionality, e.g. input and data entry and the kind, quantity and detail of provided information which should be considered for the individual user. Another point that deserves consideration is the extent to which the devices match users' expectations, their needs and wishes, as well as their capacity concerning orientation and mobility skills and prior experiences. For the provision of

EMA in practice, these findings underscore the relevance of careful selection, taking into account a good match between human- and product-related intended use.

4 Conclusions

The present study has provided insights into the state of the art of EMA, into the scientific evidence on available devices and their functionality and usability. Methods to assess the outcomes of the short- and long-term use of EMA on different conceptual levels and dimensions comprising user satisfaction, perceived added value, functionality, reduction of individually identified problems, impact on mobility and travel behaviour, activities and participation have been developed and deployed.

The results of this study yielded the specification of a generic Dutch guideline for the provision of AT devices for EMA, and it was possible to conceptualize accessible, tailored information on products for users, professionals and other stakeholders.

This study contributes to the field of AT outcome assessment in accentuating the need for individual selection of the most suitable device prior to the evaluation of long-term use and in providing a method for an effectiveness study that can be conducted in the design of a randomized controlled trial.

Acknowledgements

This paper describes a four year research project that was funded by ZonMw, the Netherlands Organisation for Health Research and Development (grant number 94304004) and led to the doctoral thesis of the first author. This thesis includes the publications [17-21, 26].

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-577

Return on Investment in Game Accessibility for Cognition Impairments

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Abstract. The computer game industry sales are counted in billions of dollars, and gamers with disabilities play more casual games than non-disabled gamers. Yet many potential gamers are excluded and gamers with cognition impairments have not been in focus for research and development. With recently published game accessibility guidelines as a framework, professional game producers were surveyed about the number of man-hours needed to implement basic guidelines for cognition. The survey data was compared with a previous survey on the number of people with cognition impairments constituting barriers to gaming, showing that return on investment may be achieved.

Keywords. Accessibility, games, guidelines, production.

Introduction

The U.S. computer and video game software industries reached total sales of $15.9 billion in 2010, not including gaming hardware and accessories [1]. While this is an impressive figure for a relatively young industry, many potential gamers are excluded from gaming. According to a survey, ~2% of the US population *"are unable to play a game at all*" and ~9% "*are able to play games but with a reduced gaming experience*" [2, p.86]. These potential gamers could further increase the sales if the games were more accessible.

Several studies such as [3-7] have discussed issues relating to accessibility and intellectual disability in the context of serious games and virtual reality environments for training, while cognitive accessibility issues are less explored regarding games designed for pure entertainment purposes. Such games are an important part of digital culture, where the game industry has a social responsibility for inclusion. An international study where 2700 disabled consumers were surveyed shows that disabled gamers play casual games more than non-disabled gamers [8].

While some approaches to increase accessibility are relatively common, e.g. options for colour blind present in some computer games, many games may still have unnecessary obstacles built in. One example would be excessively verbose and old fashioned style texts describing quests and goals in role-playing games, where a more concise and easy to understand language would be beneficial for players with cognition impairments. This is of special interest as Yuan et al. [2] concludes that there has been

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few games developed for gamers with cognition impairments. The data in [2] implies that such impairment barriers potentially affect ~4% of the US population.

Over the years, several suggestions to increase accessibility have been presented such as [9], and [10]. During 2012, a set of guidelines for game accessibility was collectively published online by a group of game studios, specialists and academics [11]. The guidelines in [12] were published almost simultaneously. This study focuses on the cognition guidelines in [11] which has six basic guidelines, versus the two "level one" guidelines in [12]; thus [11] provides more detailed data. It should also be noted that the guidelines are organised somewhat differently in each set; e.g. control of speed is a "level 3" guideline (the highest) in [12], while considered an intermediate guideline in [11]. The result presents the implied development costs resulting from following them, examining the possibility of return on investment due to the increased potential number of gamers.

1 Related Research and Theoretical Perspectives

Accessibility relates to the concept of normality as discussed by Moser: *"as long as reality is built on the assumption that there is a universal and so normal body, non-standardized and disabled bodies will always come out as problematic"* [13, p.388] As long as game worlds are designed with the idea of a single generic gamer, disabilities will be viewed as a problem to compensate for. By showing return on investment for implementation of game accessibility guidelines, a key argument for not accommodating for impairments becomes obsolete.

Accessibility is also related to Heidegger's concept of *breakdown* and the related terms *ready-to-hand* and *present-at-hand* [14]. When attempting to play a game it may be ready-to-hand; i.e. the gamer does not need to reflect upon how to play. This may be the case if the game is consistent with a game genre with which the gamer is familiar. E.g. if a first person shooter breaks the convention of moving using the WASD keys, the game introduces a breakdown where the game as an artifact becomes present-at-hand [14]. The gamer then experiences a breakdown and has to learn how to interact with the game. Gamers with various cognition impairments face critical or non-critical game accessibility barriers [2]. In doing so, breakdowns are likely to occur more often.

Breakdown also provides a perspective on normality in general and game accessibility specifically. As discussed by Ryan and Siegel [15] breakdown in interactions may be beneficial from a learning perspective, but breakdown in illusion has to be avoided, as that would break players' immersion [15]. Such breakdowns constitute an accessibility threshold to overcome for players whose cognition impairments prevent them from adapting seamlessly.

Yuan et al. [2] present a set of high-level strategies such as reducing input, versus low-level strategies such as guidelines, to address game accessibility issues. This study focuses on low-level strategies, based upon existing guidelines [11].

2 Problem and Research Question

The guidelines provided in [11] provide an overview and description of desirable functionality from an accessibility standpoint. However, the guidelines contain no estimates of the time necessary for implementing the suggested features, which is a key factor in calculating game development costs. A problem is that without this information, return of investment (ROI) cannot be assessed, even when the size of the potential additional target audience is known. The research question is: Can implementation of features for increased game accessibility with focus on cognitive impairments give return on investment?

3 Method

3.1 Methodology

The cognition related game accessibility guidelines provided in [11] were used as a framework for empirical data collection regarding corresponding implementation costs (in the form of necessary time investment) from game developers. A multi-framed, cluster sampled survey was conducted with the aid of the International Game Developers Association (IGDA) Production Special Interest Group, as well as the Swedish Games Industry organization. Game producers who were active members of either of these two organizations (~100 in total), were asked to complete an on-line questionnaire stating the time needed to follow the cognition related guidelines, in their current or most recent game development project. Both organizations were previously aware of game accessibility. The IGDA has had an active Game Accessibility Special Interest Group since 2003 [16], organising game industry events regarding this topic. The questionnaire survey approach was chosen as this allowed the study to include producers in many locations. Through the aforementioned organizations we were able to target producers specifically.

3.2 Data Collection and Analysis

The survey data was collected from game producers during February-March 2013. The questionnaire comprised nine questions. It was anonymous and did not ask for game titles due to non-disclosure agreements in the game industry. It included an open question regarding the game genre of the most recent project. Next, a checkbox section asked which of six basic game accessibility guidelines for cognition were included in each project. Further, respondents were asked to estimate the time (in man-hours) required to implement each basic cognition guideline from [11] in their current (or most recent) game project. The evaluated guidelines for each game are explicitly stated in the results. Also, the total number of hours spent (or to be spent) during the game project in question was asked for. By dividing time to implement game accessibility guidelines by the total development time for the game project, a factor was calculated. To discuss possible return on investment, this factor was compared with the number of people unable to play or having a reduced gaming experience due to cognitive impairments, calculated using data from the study by Yuan et al.[2].

3.3 Ethics

No information about the identity of the persons responding has been recorded, nor about the game projects he or she refers to. This is vital as each game company may have strict non-disclosure agreements with their employees.

4 Results and Analysis

Eight producers, all representing different game projects responded to the survey. The average total time reported by the producers to implement the six basic guidelines was 695 man-hours. Divided by the average total project time of 24366 man-hours, this results in ~3% additional time to implement the guidelines. Using the figures provided by Yuan et al [2], the estimated percentage of the US population, who either can not play games or have a reduced gaming experience due to a cognitive impairment, can be calculated to ~1% and ~3%, respectively. In total, ~4% of the US population would benefit from the basic guidelines for cognition. Considering the ~3% additional required development time in relation to the potential increased audience of ~4%, it seems likely that following the basic guidelines for cognition may well provide return on investment. It should be noted that while not all of these ~4% may want to play computer games, there may also be an added value for gamers without cognitive impairments. Further, while guidelines provide design heuristics, they are not guaranteed to make each game accessible for all individual needs; empirical accessibility testing should also be done with end users.

By relating each game to the additional time required to implement the guidelines, the research question can be further investigated. E.g. P7: hidden object adventure, ~5%; P6: Role-play, Multiplayer, ~4%; and P2: Sports, ~2%. This indicates that ROI may differ due to the game being developed. To better understand how different games relate to each guideline, Table 1 presents which guidelines were implemented in each game. Table 2 presents man-hours for each project; in total, for all six guidelines and for the implemented guidelines. Percentages are ratios of man-hours of all or implemented guidelines respectively, divided by total man-hours per project. At the bottom of Table 2, averages of total man-hours and all six guidelines are calculated, as discussed above. The information about which guidelines were actually implemented may be useful to understand e.g. P5, which have an extraordinary high ratio of 76%. An abductive interpretation is that 25 man-hours in total most likely represent a prototype game. Further, the guidelines actually implemented in P5 represent a total of 6 man-hours, i.e. 24% of the total man-hours, which is reasonable for a prototype. In any case, including P5 in the average total time reported by the producers to implement the basic guidelines, does not affect the conclusion that achieving ROI is possible.

The basic cognition guidelines included in the survey is presented below. The name in brackets below is used as reference in Table 1.

- Allow the game to be started without the need to navigate through multiple levels of menus (Quick start)
- Use an easily readable default font size (Font size)
- Use simple clear language (Clear language)
- Use simple clear text formatting (Clear formatting)
- Include tutorials (Tutorials)
- Use step / pause / replay to allow progression at the player's own pace through narrative or instructions (Pace)

Table 1. Implemented basic cognition guidelines per producer and game.

Producer	Genre	Implemented basic cognition guidelines
P1	Social Facebook	Quick start, Clear formatting, Tutorials, Pace
P2	Sports	All
P3	Platformer	Quick start, Clear language, Tutorials

P4	Interactive Drama	Quick start, Font size, Clear language, Clear formatting
P5	Puzzle Game	Quick start, Tutorials
P6	RPG, Multiplayer	Font size, Clear formatting, Tutorials
P7	Hidden Object Adventure	Font size, Clear language, Clear formatting, Tutorials
P8	Children's game	Quick start, Font size, Clear language, Tutorials

Table 2. Man-hours; guidelines and total project time. Averages (at bottom) were used to calculate ROI.

Producer	**Project, total man hours**	**All six guidelines, man hours**	**% of total man hours**	**Implemented guidelines, man hours**	**% of total man hours**
P1	62400	1277	2	1221	2
P2	60000	900	2	900	2
P3	6000	1060	18	680	11
P4	15000	11	0	11	0
P5	25	19	76	6	24
P6	25000	950	4	590	2
P7	25000	1260	5	260	1
P8	1500	85	6	44	3
Averages	24366	695			

5 Discussion

The instrumental rationale of return on investment (ROI) may be further compared with a normative rationale, i.e. motivations of why game accessibility is important, as in [17]. While some guidelines may not provide ROI, this may be put in perspective by relating to work about normality and information and communication technology by Moser [13], as well as Heidegger's concept of breakdown [14]. The basic guidelines likely improve the game play for most gamers but may be an actual prerequisite for those with cognition impairments. Game accessibility is dependent on the game environment, which is a man-made artifact. This paper has shown that it may be possible for the game industry to achieve return on investment when accommodating for a larger diversity of gamers. Further research could be to either examine all the basic guidelines across all impairments, or examine the intermediate and advanced guidelines for cognition, as well as other sets of guidelines.

Acknowledgements

The authors would like to thank members and managers of both the IGDA and the Swedish Games Industry, for their support with the survey.

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Technology for Cognitive Impairments

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-585

Lisling 3D: A Serious Game for the Treatment of Portuguese Aphasic Patients

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Abstract. The game described in this article was developed for the treatment of lusophone aphasic patients. Various information technologies were used in order to create a multimedia platform of rehabilitation. The objective of this software is to provide a complementary tool for the classical speech therapy, which enhances the patient's recovering through the completion of exercises adapted to the different symptoms of the disease. The principal features of the game are: i) a realistic 3D virtual environment that enables the interaction with modeled objects and ii) a dynamic interface that allows the addition of new therapeutic tasks in order to get a customizable and easily upgradable platform. One of the main scientific contributions of this project is the fact that it is the only product of this sort tailored to the Portuguese population of aphasics.

Keywords. Stroke rehabilitation technology, serious games, 3D virtual environment, Human-Machine Interaction (HMI).

Introduction

1.1. Aphasia and Rehabilitation Technologies

Aphasia is an acquired disorder of language functions, which surges after a stroke. The main characteristics of this disease are alteration of oral expression, auditory comprehension, reading and writing. Speech and language therapy has revealed its efficiency in the treatment of aphasic patients [1].

In 1967 the first results that applied a therapeutic technique using a personal computer were published [2]. From this date, many other rehabilitation programs have used Information Technologies (IT) as a complementary or, even more, autonomous therapeutic means. The purpose of the large majority of the existing software is only to treat some specific linguistic impairments of the patient. For example, these computer programs target oral naming of objects [3], auditive identification of objects [4], writing of nouns [5], writing identification of nouns [6] ...

On the contrary, the first version of the "Lisling" program [7] belongs to the limited group of therapeutic software that aims to provide a holistic treatment of the different types of aphasia (for other examples, see [8] [9]). Another emblematic feature of this software is the fact that it uses bi-dimensional visual items. This paper presents "Lisling 3D", which provides a 3D graphical environment and natural user interfaces in order to transform the previous multimedia program into a serious game.

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1.2. Why to Create a 3D Therapeutic Game?

Creating a computer game as a rehabilitation tool allows the patients to practice the therapeutic exercises at any time and with increased autonomy. This method takes advantages of displaying diverse types of stimulus such as animations, 3D models, sounds and texts, making the tool more enjoyable. In addition, the patients may receive instantaneous feedback regarding their performance, which is a crucial motivational factor for the treatment [10].

Using 3D virtual environment makes it possible to add more innovative tasks than the ones existing in the traditional tools. A large part of the aphasic patients have difficulties in understanding orders. For instance, if you ask such patients to put a glass on the table, they may understand what the glass and the table mean and correctly identify each single object, but they may not be able to comprehend the entire meaning of the instruction [11] [12]. Virtual environments enable the training of the understanding skills through the completion of tasks that involve object manipulations and/or everyday life activities, which are impossible to simulate with a 2D environment [13].

2. System Description

The therapeutic tool for aphasic patients, "Lisling 3D", is developed as a 3D serious game (implementation based on the Blender game engine) that can be used at home, under the supervision of a relative or autonomously. Exercises take place in an environment that simulates a realistic house, modeled in 3D. The software uses tri-dimensional representations of objects, animations, synthesized speech and writing items. Five categories of tasks have been developed by a group of speech and language therapists from the Saint Mary's Hospital of Lisbon, in order to enable a complete treatment adapted to the different aphasic symptoms (Fig. 1). A XML database is used to allow the integration of new exercises and to save the data of the patients.

Writing exercises/texts	Substantives Infinitive Verbs Phrases – Insert Nouns Phrases – Insert Verbs in Present Phrases – Insert Prepositions Phrases – Phonological Errors Phrases – Disordered Words Texts – Insert Nouns Texts – Insert Verbs Texts – Insert Function Words Texts – Insert Words
Word selections	Responsive Naming Word Intruder
Object identifications	Object Identifications Simple Phrases Nouns Matching Phrases Matching
Questions yes/no	Writing/Auditive – Phrases Yes/No
Motor tasks	Simple Tasks Complex Tasks

Figure 1. Categories of tasks implemented

2.1. Tasks/Exercises

Writing Exercises/Texts

In these tasks, the patient has to write a noun correctly, a sentence or to fill in the gaps in a paragraph. In Figure 2, a patient is writing the name of the 3D modeled object displayed on the screen (e.g., “Toothbrush”).

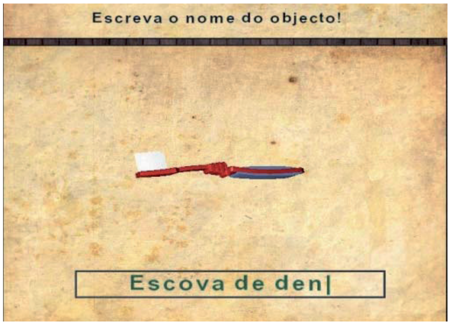

Figure 2. Example of substantive writing.

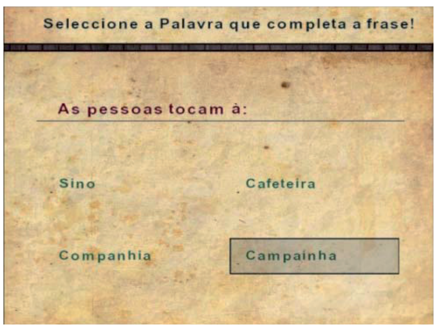

Figure 3. Example of responsive naming.

Word Selections

Here, the user is asked to select a specific word from a list of different ones, in order to follow a determined rule. The Figure 3 shows an example of responsive naming in which the patient has to complete the phrase with the right word (e.g., “People ring the < door bell >”).

Object identifications

In an exercise of object identification, the user has to explore the virtual environment with the aim of finding the object that matches the writing or auditive word displayed by the computer program. For example, if the task is carried out in the living-room, the patient may have to point out (red circle) specific home furniture, such as a chair (Fig. 4).

Figure 4. Example of object identification.

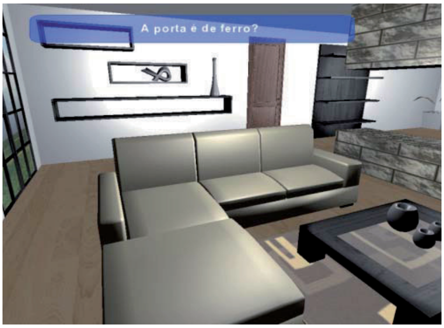

Figure 5. Example of questions.

Questions Yes/No

This category is similar to the previous one, but you must respond to a question. For instance, the system may ask: “Is the door iron?” (Fig. 5). So, the users have to move inside the room in order to seek the information that enables them to answer the question.

Motor tasks

These last exercises are quite different from the other ones because they allow us to train the comprehension skills of the aphasic patients through completion of natural movements. The tasks are related to day-to-day activities such as transporting an object, turn on/turn off a machine, open/close a door (Fig. 6) ...

Figure 6. Example of simple tasks

2.2. User Control Interfaces

In our system, the question of the implementation of the user control interfaces is crucial for two main reasons. First, aphasia is usually associated with motor disabilities, which obliges us to interface natural and intuitive commands. Second, in order to get closer to the kinematic of a movement performed in the real world, which is especially relevant for the category of motor tasks, we must provide a control mode with enough degrees of freedom (DOF). Thus, besides the traditional input systems existing in a common computer (keyboard and mouse), a 6 DOF joystick and a Wii Remote command were connected with the software. The sensitivity of the control can be adjusted by the user with the intention of being adapted to a large number of patients.

3. System Evaluation

3.1. Materials and Methods

Experimental protocol

At present, we have not carried out any tests with patients, due to the fact this tool is still a prototype and we do not want to create false expectations. However, after a demonstration of Lisling 3D, we asked nineteen speech and language therapists to evaluate the relevance of this software in the treatment of aphasia, through a seven level scale questionnaire using a visual Likert scale ranging from 0 to 6 points. The therapists were in average 31 years-old (20 – 62 years) and had an average of 7.4 years professional experience (1 – 31 years).

Questionnaire

Questions asked to the speech and language therapists are listed below:
1. Do you think the tool will be easy/intuitive to use by the patients (especially for the task completions)?
2. How easy is the navigation through the software (in the sense of finding easily the options you are looking for)?
3. Is the computer program appealing/enjoyable (in the sense of the user having the desire to use it frequently)?

4. From the therapeutic point of view, is the tool well organized/structured?
5. How would you evaluate the visual/graphical definition?
6. How would you evaluate the audio/vocal definition?
7. How would you evaluate the completeness of the therapeutic tool, regarding the different dimensions of language (expression and comprehension), if you compare it with the traditional approach (pencil and paper)?
8. Do you believe this tool would be useful/complementary in your professional activity?
9. Is the software globally appropriate for the rehabilitation of aphasic adults?
10. In your opinion, are the exercises proposed relevant?
11. Is there a sufficient variety of exercises?
12. Do you agree that the types of help provided are appropriated?
13. Are there sufficient types of help?

3.2. Results

All the answers of the questionnaire are above average (Fig. 7). The question about the usefulness/complementary of the tool regarding professional activity gets the highest score (5.8 points). The lowest score is about the sound quality (3.3 points).

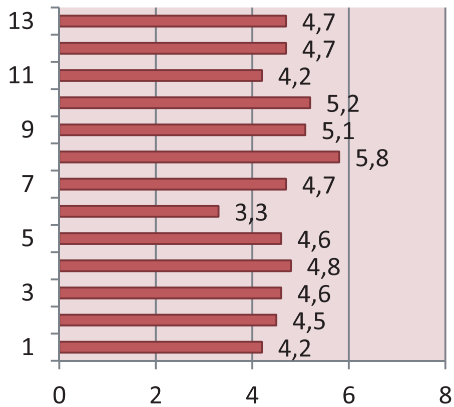

Figure 7. Average evaluation for the 13 questions.

4. Conclusions

The paper presents a therapeutic tool with the purpose to stimulate the global language functions. The software uses a realistic 3D graphical world, in order to provide a high sensation of immersion/presence for the patient. The advantage of such computational therapy is to increase the practice of rehabilitation exercises and, consequently, the expectations of recovery [14]. The tool is implemented on the bases of a serious game, in the sense that i) it displays playful exercises and ii) it presents the patient's score at the end of each task (a history of the performances is also available). The natural desire to improve the score at each session allows an effortless intensification of the rehabilitation process, thanks to the motivational factor. Overall, the computer program is assessed as useful and hopeful by the speech and language therapists. The next step will be to test the software in an aphasic population to evaluate the relevance of session training on the patient's daily activities, and to compare the performance with a traditional speech therapy.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-592

Usability and Usefulness in Assistive Technology for Cognitive Support in Respect to User Goals

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Abstract. The aim of this study was to examine the usability of different assistive technology (AT) products for cognitive support by identifying features that promoted and/or impeded cognitively impaired users' performance of tasks that were identified as hindering engagement in valued activities. An additional aim was to examine how the users could reach their goals and expected gains as a result of the support of the AT, that is, the usefulness of the AT.

During two six month interventions, persons who had experienced a stroke or had Alzheimer's disease tried out AT for cognitive support that intended to meet their needs and desires. Data from interviews and field notes collected during the intervention periods were analysed. One hundred identified factors judged as promoting or impeding the performance of the tasks and/or the user goals, were categorised.

The findings are shown in seven preliminary themes that focus on the interaction between the user and the AT and, further, on how the AT is customised to the user's needs and incorporated into the user's own everyday context.

Keywords. Stroke, dementia, everyday life, context.

Introduction

During the last decade, electronic products of varying complexity, aiming at providing support to the user have become more common, less expensive and can accomplish more than before. Products that have shown great potential in the field of assistive technology (AT) for cognitive support is, for example, support from automatic, regular reminders [1,2] and AT for time orientation [3,4]. How the AT promotes engagement in the users' valued activities with respect to their own needs, intentions and goals has been examined to a lesser extent. This type of knowledge could be of importance, for example, when designing, customising and introducing AT.

One important concept for this type of examination is the concept of *usability*, which has been defined in different terms [5,6,7]. Nielsen [7] describes usability as how well the user can use a system and that usability is a part of *usefulness.* According to Nielsen, the issue of usefulness is whether the system can be used to reach desired goals. Researchers emphasise that usability is subjective to a great extent [8,9]. Krantz states [10] that *the user himself/herself* must be the person that assesses to what extent the AT enhances the value of an activity. One reason for this is

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that AT can be usable, but not worth using from the (potential) user's perspective, based on his/her expectations and experiences of using the AT [9].

Studies that examine how the features within the AT for cognitive support are experienced by the actual users are rare and studies conducted including persons with cognitive impairment using the product within his/her own context, performing tasks that support his/her actual goals during a longer period of time are needed.

Against this background, the aim of this study was to examine the usability of different AT for cognitive support by identifying features that promoted and/or impeded cognitively impaired users' performance of tasks that were identified as hindering engagement in valued activities. An additional aim was to examine how the users could reach their goals and expected gains as a result of the support of the AT, that is, the usefulness of the AT.

Method

The data for this study were gathered during two six month intervention projects, which aimed to examine how needed and desired AT influenced the users' everyday lives [2,11]. The AT was, for example, easy-to-use telephones, support for home surveillance, and support for time orientation. The participants comprised fourteen persons who had either an Alzheimer's disease or had had a stroke and who experienced difficulties in everyday activities that were perceived as related to cognitive impairments (altogether eight men and six women, mean age 69.6). Fourteen significant others, chosen by the participants, were included in the study as additional informants.

Interviews and field notes from the intervention period were used for analysis. The interviews included questions about how the users and the significant others perceived the AT and their experiences of using the AT. There were also discussions about the features of the AT. Field notes included reports from home visits and from telephone conversations with the users and significant others. Additionally, notes were made by the interviewers from observations and from conversations with manufactures of the products involved.

For the analysis of the collected data, the definition of usability and usefulness, formulated by Nielsen [7] was the underlying concept. To analyse the usability, the question asked was: *How do features of the AT promote and impede the performance of tasks that have been identified as hindering the achievement of the user's goals in daily living?*

For the analysis of usefulness the question was formulated as: *Does the user achieve his/her goals and his/her expected gains, when the use of the AT takes place in the relevant context of use in the performance of the hindering task?* The users' *desired goals, expected gains* and *hindering tasks* were retrieved from the data collected before the provision of AT.

In the next step, the interviews performed after the AT provision were read through and data that could provide answers to the research questions were transferred to a structured table for analysis, together with field notes. Data related to the context, to user experience and to how the features of the AT promoted and impeded the use, were extracted to enable an analysis of how the features influenced the achievement of user goals. All included material was examined in order to remove duplicates and to condense the material. One hundred factors, derived from user experiences, remained after the condensation. These factors were judged as promoting or impeding the performance of the tasks and/or the user goals.

In the next step the one hundred factors were organised in a first categorisation [12]. Seven preliminary themes were formed and named in relation to the content.

Results:

Each of the seven preliminary themes represents several important factors found in the data. The factors capture how the features of the AT promoted or impeded the performance of tasks that were identified as hindering the engagement in valued activities and, further, how these factors influenced the users' goals. The preliminary themes were named: *1) Constant access to information conveyed a sense of control which promoted user goals, 2) Recurrent reminders enabled the development of routines and promoted user goals, 3) The inappropriate design of the buttons for interaction risked impeding the user goals, 4) Communication technology that the AT was connected to influenced the achievement of user goals, 5) How the AT was incorporated into the context of use influenced the achievement of user goals, 6) A routine for charging the AT was a prerequisite for achieving user goals* and *7) Customisation of AT in line with abilities and routines promoted the user goals.*

Conclusions

The results show how features within the AT that might have been viewed as of little relevance in the beginning, risked jeopardising the goal achievement and thereby also the usefulness of the AT. These results imply that usefulness assessments of AT would benefit from including users' own goals in their everyday context over time. This type of more comprehensive assessments might also provide an insight into how the users value or weigh the AT support in relation to other factors, such as social or contextual aspects. The results in this study showed that those factors can have a great influence whether the AT actually is used by the potential user in real life.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-596

"Mole Hunter" Math Game for Little Kids and Students with Intellectual Disabilities

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Abstract. Today we cannot believe our lives without computers. Even children become acquainted with computers in kindergarten, however, it matters a lot which web pages or computer games do they use. The aim of the investigation was to create an ability developing game for little kids and for students with intellectual disabilities, with which they can practice the first steps of mathematics with a playful method.

Keywords. Math Game, Intellectual Disability, Flash.

Introduction

Nowadays the Internet is a significant part of our life. Children begin to use computer at younger ages unlike the tendency several years ago, for that reason it is important to pay attention which kind of contents are available for them on the web. Our purpose was to develop a skill improving program for 3-10 years old children. The game is available for everyone on the Internet so it was created in Flash, because that is one of the best-known and widespread multimedia environments, which is very useful for developing this kind of applications. After a brief literary summary we will show the development of the game and its usability for children with mental disabilities.

1 The State of the Art in This Area

Since multimedia technologies have been sufficiently highly developed, a growing number of teachers are using computer technology to strengthen their classroom teaching-learning process. Instructional computing is widely used for classroom multimedia digital media presentations and interactive exercises for interactive computer-based training. There may be real benefits in using games for learning: "…research has shown that learning is much more effective when the student has fun" [1]. This is one of the main reasons for using games to educate, as much more is learned when the student is enjoying the education. Another reason is that "…computer games provide a good environment for learning because they are able to give instant feedback to the player, which is highly beneficial for learning" [2], [3].

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2 The Methodology Used

The software is being made using Adobe Flash CS4 and with the help of ActionScript-language. During the development we used the W-model. [4] It completes the V model by processing the test results, or rather debugging and correcting the mistakes.

The developing steps in the development process of this software were:

- Requirements and architecture
- Detailed design
- Implementation
- Integration, test and verification
- System verification and validation

During the development process we put a great emphasis on the graphic design. At the components the usage of clear and simple forms was really important. The elements should not be overcomplicated, since the essence of the game is to maintain attention, to use concentration skills and the mathematical exercises have an important role as well. These points can easily be sidelined, if the figures are too spectacular or extremely meticulous which, considering the function of the game, are unnecessary to exaggerate. Since the program was created for children, we tried to develop forms, which they would like; therefore we used round, plain sketching shapes. After this we had to keep several important viewpoints in mind considering the choice of colors. In the creation of a game we have the possibility to diverge from the reality both in the choice of forms and colors. We opted for the representation which is close to the natural, so everything received a color with which we can find it in its natural environment. Another important point was to emphasize the details, which the player should concentrate on. Our solution for this problem was that despite the usage of dark brown, green and black for depicting the scenery and the moles, we used lighter colors for the task field and yellow for the helmets of the moles (Fig. 1).

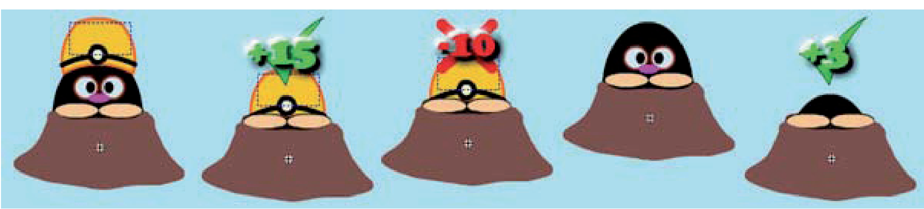

Fig. 1. Main conditions of moles.

The mole figures of this variant have two kinds of appearances, the one without a number and the helmeted carrying a number. These appearance-types have different conditions. From these conditions two can be found in both of the appearance-types, the condition of being up and the right hit. At the numbered-type there is another condition for the wrong answer. To the conditions the occurring motions can be bound to. Being up: the mole comes out from the hole, if the mole does not get a hit, goes back to the hole; if the mole gets a hit, changes to the other right condition. The condition of the right case follows, if the solution of the task is equal to the answer and in all the cases of hitting a mole without number. In the case of a wrong answer of the numbered moles another condition exists (Fig. 1.). The design of such a clear form is very important for creating game software for children with intellectual disabilities.

The user interface is very simple and very clearly organised. It is important for the target group, because in this way they are able to concentrate on the new information being presented rather than any additional burden created by non-intuitive navigation [5], [6].

3 The Research and Development Work

The idea of "Mole-hunter" game is based on the traveling fairs' and amusement parks' popular game. According to the original game, a mole hill is located on a playing field, from which moles are popping up, which need to be hunted down by mouse click. The mole tracks present some calculation examples for the player and if the solution is correct, and the player hits the correct amount of moles, he can collect points. The game is based on the game named Mole hunter.

The rules are written and read out several times. The buttons are flowers, which get active after you have read and listened to the instructions, to enter the playing area you have to click the moles (Fig. 2).

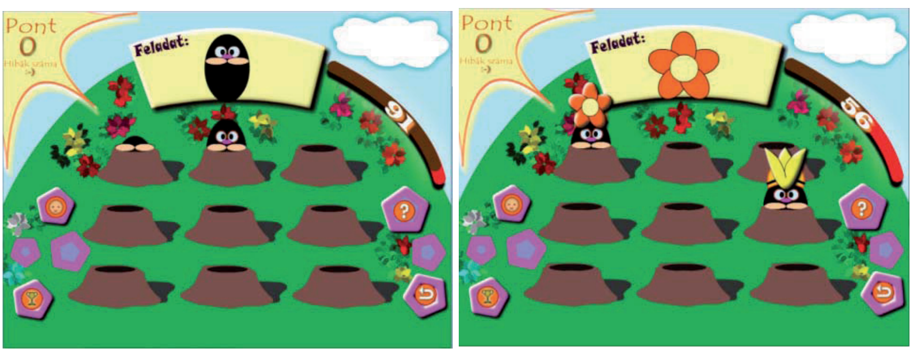

Fig. 2. Field of the flowers submenu.

The flowers submenu game lasts for 100 seconds. The task is to catch the moles by mouse click. The game structure is shown in Fig 1. In the task (Feladat) field it is shown how many moles should be collected. When picture of a mole without a helmet is shown, the user hitting an animal without a helmet gets 3 points. When an image representing a flower shows up, and the user hits the mole bearing the same flower as is shown, he gets 15 points. If the user clicks the wrong flower, the player loses 10 points.

In the calculating game submenu the rules are written and read out several times too (Fig. 3). The „calculating" submenu has five rounds, which are held for 50 seconds each. In the upper right corner of the screen is written the number of the level. The task is to catch the moles by mouse clicks. The game's structure is shown in Fig 2. The task (Feladat) field shows how many moles should be collected. When a picture of a mole without helmet is coming up, the user should get the animal without a helmet to get 3 points. When a math problem is presented, the user should click on the mole wearing the correct solution and get 15 points. If the user clicks the wrong solution, the player loses 10 points.

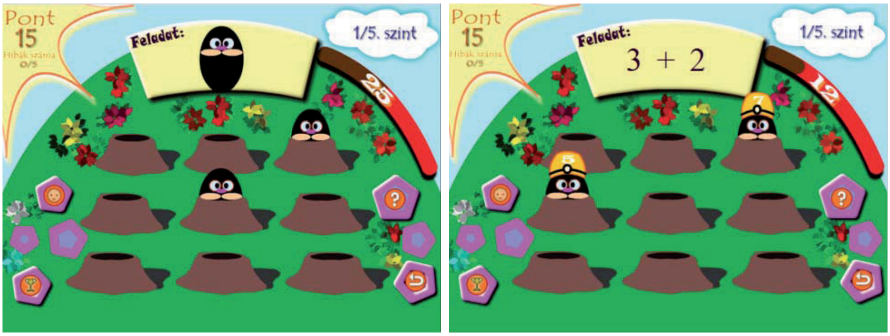

Fig. 3. Field of the calculating submenu.

If the player made the mathematic calculation very quick, they get some rewards. At the end of the game there is champion list of the best player too. It motivates the children very well.

4 Testing the Game

The tests were made on home PCs and laptops. During the tests we investigated how easily do the children participating in the test, become acquainted with the game, how unambiguous is the usage of the game for them. Several other viewpoints may arise, which we did not think of with the customer, but on the other hand can make the usage of the program difficult for children and would need further changes.

Despite the didactic function the game was created for free-time usage. Accordingly, we imagined the testing in home environment, so we were looking for test subjects between our acquaintances and relatives in spite of schools. We tested the program with 3 kindergarteners' and 6 pupils' collaboration.

Everyone tried the program twice as to show the difference between the results of becoming acquainted with the game, and the game already known. We asked at least one parent to be present at the usage of the game, in the case the child needed help. As the basis for correlation we also played through the games, first, at the calculating field we clicked the mole which gave plus points, than we clicked only on moles which gave plus points but not extras. Apart from this we also asked a special education teacher, who has not seen the software before, to play with the game in order to find out how an adult is able to use the software. The record of scores is shown in Table 1.

In every case trying out the game for the second time showed better results and better score points than before. Some of the youngsters got tired for the second probation. They were able to use the flower game, but they were also interested in the moving forms and colors of the calculating game. The results of the boy, shown in the first row are outstanding. Despite his age he knows numbers very well, his mother helped him with the calculation and he could easily find the moles carrying the right answers. The older children could play with the games more without any problem. The younger generation, who does not know all of the mathematical operations, also needed the help of their parents.

After the testing, we asked several questions of using internet and computer from the participants. Comparing the heard information with the results, we found out that players, who had higher scores, use computer more frequently and their handling of the mouse is much better. We were also interested in whether the children have any difficulties in the knowledge of numbers or the recognition of forms. None of the children had such problems; only some of them got tired during the testing and did not want to complete the tasks.

Table 1. Test results.

name	age	flowers1	flowers2	calculating1	calcualting2
Lacika	5	198	-	634	-
Levente	3	88	-	-	-
Bogi	7	119	220	281	515
Domi	10	270	288	738	1310
Patrik	6	147	248	-	-
Anita	4	75	91	-	-
Livi	10	235	241	567	1023
Lindus	8	187	228	493	876
Zolika	8	153	209	607	945
special teacher	29	-	-	1016	-
Szilvia (author)	-	288	-	1463	816

We needed the results from adult participants, to know how many points may be accomplished with a good knowledge of calculating and the knowledge of the game. Comparing the children's results with the adults' it is clearly visible that higher scores can be reached than the usual level of the target audience's abilities, which can mean a challenge for the prospective users of the games.

Considering the potential mistakes in connection with the creation of the program, the velocity of the motion of the moles caused a problem for some of the players. However we do not think this mistake should be corrected, since after the results of the second probation, we think that with the help of the program and with some exercising this obstacle can be overcome and can also help the improvement of handling the mouse.

The testing of the special teacher was important to gather information whether the program is usable for students with intellectual disabilities. The special teacher tested the game with two students who were older than 10. We did not get any concrete data, however according to the teacher's opinion the games will be well-usable at the schools, because it is necessary for these students to announce information on diverse manners. This game is interesting and vividly descriptive. The students do not feel the usage of the game a learning method.

5 The Impact or Contribution to the Field

We would like to make the learning of elementary school pupils with intellectual disabilities easier. The presented mathematic game is interesting and motivates the children with intellectual disabilities. Originally it was not developed for teaching but for the free time activities, so the children can learn while using the games and they have the feeling as if they were only playing, but they learn too in the same time.

6 Conclusions and Planned Activities

In this paper we have discussed the design and evaluation of the "Mole-hunter" math game and its user interface. This game was developed for students with learning difficulties to help them in the learning of basic mathematical tasks. As a final result, a successful game was created to help them getting over handicaps and getting integrated smoothly into the society. Our further plan is to pedagogically test the "Mole-hunter" game's usability in Kozmutza Flora Special School in Veszprem.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-602

How Individual Should Digital AT User Interfaces Be for People with Dementia?

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Abstract. A literature review of papers that have explored digital technology user interface design for people with dementia is reported. Only papers that have employed target user input directly or from other works have been included. Twenty four were analysed. Improvements in reporting of studies are recommended. A case is made for considering the population of people with dementia as so heterogeneous that one design does not suit all, this is illustrated through some case study reports from people with dementia. Furthermore it is proposed that by grouping people into functionally similar sub-groups interfaces may be designed for these groups that will collectively establish a sequence of 'stepping stone ' interfaces that better address appropriate functioning and maintain self-efficacy.

Keywords. Dementia, Alzheimer's, Design, Information, Communication, Assistive Technology.

Introduction

As the numbers of people living with dementia escalate in developed and in developing countries [1], there is increasing and urgent attention being paid to how these people can be supported to live independently [2,3]. Digital technologies are being considered because of the hope that they can support individuals affected in a cost effective way[4,5]. A fundamental question for design of any digital AT is always, how heterogeneous is this population? That is more specifically, in terms that affect the design of technology or services just how much variation is there? Are they a large single population of people: who have essentially similar requirements that can be met by a traditional one design fits all approach; who can be considered as a number of large sub-populations each having similar requirements; or, where each individual has a unique combination of requirements? These questions are highly relevant to the focus of this discussion paper, namely the user interface of interactive digital devices that people with dementia will use themselves.

The ramifications for how care or support for independent living can be delivered from the answer to the above considerations are very important. This is not just in technological sense but also, as alluded to before, being able to afford the required amounts of human resource to allow a good quality of life for people living with dementia[3,5]. The latter is evidently a potentially bigger issue in countries where the general population demographic is going to result in fewer working age people being available to care for the elderly in general.

To address the above, examination of the literature of studies that have involved people living with dementia in developing or evaluating digital technology designed for

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their use is appropriate. Adding theoretical papers focusing specifically on the user interface for such technology is also appropriate. All such articles might be expected to have discussed and addressed the issues of homogeneity. Before describing the methodology in detail it is useful to have a concise overview of : what the umbrella term dementia encapsulates as it is sometimes treated as if it is a single well defined condition; the main contemporary models of how the population of people with dementia are considered when providing AT; and, how indications of capability of an individual with dementia are obtained in studies and practice.

Dementia

Dementia is a term used to describe an extensive collection of diseases that cause neurodegeneration and result in a number of difficulties for the sufferer, including language, memory and organizational problems, as well as personality changes. Table 1 summarises the three most common dementia diagnoses. Dementia, whatever the specific diagnosis, is progressive [6].

Table 1. Summary of the most common types of dementia. Data taken from www.nhs.uk/conditions/ and www.alzheimersresearchuk.org/dementia-types/.

Dementia type	Description	Symptoms
Alzheimer's Disease	Progressive loss of brain cells	Early: minor memory problems, word finding difficulties, reduced judgement. Later: disorientation, personality and behavioural changes.
Vascular Dementia	Caused by blockages in the small blood vessels of the brain	Similar symptoms to Alzheimer's, more specific symptoms differ depending on part of brain affected.
Dementia with Lewy Bodies	Caused by protein deposits in brain nerve cells	Again similar to Alzheimer's, more specific symptoms include: changes in alertness, attention and confusion. Slowed movement, muscles stiffness and tremors. Visual hallucinations, sleep disturbances, fainting and unsteadiness/ falls.

Table 1 is not exhaustive. There are many other causes of dementia but the three types are sufficient to illustrate different causes that have associated symptoms that appear to follow a more uniform pattern. They lead to a functional interpretation of these diagnoses, namely a response based in similarity.

Another way of framing dementia is to use a social model [7]. This approach views dementia as a disability produced from social processes of exclusion and focuses on creating a unique framework for each individual with dementia. Therefore, support can be individually tailored, and needs targeted to prevent exclusion, differences in treatment and greater emphasis placed on skills and capacities retained [7]. Thus the social view is one that suggests personalization and uniqueness of solutions.

Validated Assessment Tools

Validated assessment tools for use of digital interactive AT do not exist. More general ones are sometimes used to define study recruitment criteria. One of the most common tools for assessing mild cognitive impairment (an indicator of dementia, or susceptibility to developing it) is the Mini Mental State Exam (MMSE). This 10 minute pen and paper test allows a wide range of functions to be tested, including memory, language and attention [8]. Although the test is quick and easy to administer, there are some serious considerations that must be taken into account when interpreting the results. Firstly, the questions are structured such that people with a high IQ can score highly, whilst those with a low IQ or educational background may score less well, with the absence of any cognitive impairment. As with all test batteries, cultural and language barriers must be accounted for, as well as any mental or physical disabilities [8]. More comprehensive tests are available, yet these are still susceptible to some of the above mentioned difficulties. Therefore, rather than incur great time and financial cost, the MMSE is preferred by clinicians as a means of identifying cognitive impairment.

1 Methodology

A knowledge baseline to show the state of the art is always necessary at the beginning of any new research programme. The standard approach of exploring the literature was selected. However consultations with people living with dementia and their carers were conducted to add a contemporary local perspective and to illustrate heterogeneity/ homogeneity of users' needs/wants.

1.1 Literature Review

The project resources did not allow for a full systematic review of all appropriate literature. So a restricted literature review was conducted that employed narrative synthesis and many of the features of systematic reviews. Table 2 summarises the specific details of the search design. Data extraction sheets were also used to systematically extract data.

1.2 Consultation with People Living with Dementia

An approach was adopted where local people living with dementia (including carers as appropriate) became a consultative extension to the research team. Their role was to discuss, as part of the team, ideas and share what would suit them. There was no intent or expectation to make this group representative of the whole or even part of the general population of people living with dementia. Each individual chose how the meetings operated and dictated their own engagement. Minutes were made of discussions.

2 Results

2.1 Literature Review Analysis

The search protocol described above resulted in a total of 756 references, removing duplication resulted in 612. After excluding those judged by their title and/or abstract as being irrelevant there were 41 left. In the end only 24 aimed at people with dementia as direct users of envisaged digital interactive technology [9-32]. Of these 5 used inferences from the literature with no new input from people with dementia to infer user interface design features. The types of settings in which evidence was based or collected varied: attending dementia day services dominated (14); place of domicile (6); and, non-specific or unreported (5). The types of user interface hardware varied: non-portable touchscreen (8); portable touchscreen (9); and, other(7). The collective scope of activities to be supported was wide including: private and public reminiscence through photos, video or audio recordings; singing along; companionship, e.g. through videotelephony; conversation; activities of daily living; memory through calendars, alerts and information; health and safety information; topics of interest including the news; virtual reality games; use of the Internet; and listening to music.

Table 2. Main characteristics of the literature search conducted for the review.

Search feature	Description
Search terms	(dementia) OR (Alzheimer*) AND (technology) OR (digital) OR (tele*) OR (computer*) OR (assistive) OR (device) AND (interface*).ti,ab.
Publishing period included	2003 to 8th Feb 2013
Sources searched	Medline via OvidSP; PsychINFO via Ovid SP; PsychARTICLES via Ovid SP; Scopus; Web of Knowledge & Science. References listed in primary sources.
Article selection	Agreement between two independent researchers at title-abstract review stage. Single researcher at full paper review stage.
Article inclusion criteria	_Setting_: any regular location or non-specific _Participants_: people with dementia or a similar diagnosis of cognitive decline. _Necessary content_: discussion of user interface requirements and/or its design for any ICT based assistive technology. _Study design_: any primary study or evidence based approach. _Technology_: any assistive technology with the aim of being actively used by person/people living with dementia in order to meet a specified need.
Article exclusion criteria	_Setting_: any short term occasional temporary location, e.g. in hospitals _Participants_: if only carers were involved. _Necessary content_: insufficient user interface description or of its development. _Study design_: literature reviews, systematic or not, speculative works. _Technology_: not intended to be used by people with dementia themselves.

Examination of this literature almost exclusively presents solutions derived from studies that appear to be poorly defined and evaluated to permit generalisation. For instance the recruitment of participants mainly appears to be based on 20 or less participants who are sampled for convenience. It is also often unclear if, or definite that, the people with dementia who specified solutions were also the evaluators. Table 3 summarises more features from all 24 papers or just those 19 that involved people with dementia as participants to inform design. Where recruits have been identified as a stage of dementia (i.e. in 4 articles) use of MMSE is either explicit or can be assumed. In fact it is likely that MMSE will have been used for at least some of the people in the more heterogeneous studies but it is unknown and indeed whether it has formed any real impact on inclusion of participants.

Table 3. Counts of a selection of reported information from the appropriate articles.

Reported information	No that gave details
Recruits/population of interest were heterogeneous including stage of dementia	17/24
Recruits/population of interest were less heterogeneous and at one stage of dementia	4/24
Numbers recruited were statistically significant	0/19
Satisfaction with design clearly rated by people with dementia different to those who specified it	0/19
Amount and/or type of help from carers explicitly described	2/19
User interface features were explicitly described	8/24

2.2 Consultation of People Living with Dementia

Exploring with people living with dementia as part of the team what in ICT works and does not work for them, and what services are most useful, has led to observations that confirm commonality and variability of needs. With a group of people living with dementia who are all younger, i.e. in the age range 40-70 years, examples include:

- They were very happy with the idea of using computers, most claiming to be computer users with support from carers, they also preferred the use of technical terminology, e.g. being familiar with “home page”, “back”, etc.
- Individuals within this group expressed the desire to have music categorised and presented in quite different ways. While all but one of this group liked a simpler user interface (with large buttons and text, and reduced choices).
- Each individual desired at least some content that was not what others wanted.
- Many but not all in the group were strongly affected by self-efficacy, getting upset at seeing an advocacy service (i.e. a web page for a volunteer organisation), and, not wanting to burden their carers with another thing they need their support for.

3 Discussion

3.1 Quality and Strength of Reported Evidence

The articles analysed have their own validity and value. However strictly from a standard hierarchies of research evidence perspective, the observations of the published information imply relatively low strength or quality of evidence in what appear to be the state-of-the-art digital AT designs and their corresponding user interfaces for people living with dementia. In most studies :

- There is an unstated specificity to results of evidenced benefit, allowing the mis-interpretation by the uncautious to generalise findings.
- Convenience sampling was used making conducting studies easier; it also makes measuring benefit and/or improved independence very difficult. A component of the latter is, the degree and form of help necessary to deliver benefit from the use of the AT/ICT by the people living with dementia.
- The degree and form of help is under-reported, it is fair to note however that for any comparative analysis, there are issues of how to measure benefit, independence and

carer loading.

- Reporting direct involvement of people living with dementia as a methodology to get good design has dominated over specific design features being described.
- Choosing the best or better detailed design features is impossible from this evidence. While a different literature research may show evidentially strong discrimination between different features of human computer interaction for people with dementia, this literature provides little or none.

3.2 Implications from Considerations of People with Dementia

The above comfort with ICT contrasts with at least one instance of elderly people (age range 70 – 100 years without dementia) naïve to computers [33]; they preferred plain language, i.e. avoiding any computer terminology. Indeed, for a few to even avoid the idea that they were using a computer. Thus suggesting that strategies that just simplify everything could be seen as threatening self-efficacy and thus not a one suits all solution. Both groups clearly shared variations in desire for specific content – as much as might be expected in any group of people not brought together because of a specific shared interest. Fundamentally people living with dementia are unique individuals with unique specific needs. A priori, in life experiences, interests, willingness to learn, environmental factors and co-morbidities they are as varied as any of their age peers. One thing they do not share with those peers is the degenerative consequences of the specific dementia they have. The progression of their disease also follows a unique timeline – even if the general symptoms (and thus perhaps functional ability) change in a fairly predictable order. In the face of these statements it might be inferred that it is most likely that people with dementia require individual but adaptive (to progression of the disease) bespoke solutions for sustained independent living.

ICT and digital AT can be designed to be adaptive and can be designed to make use of Web 2.0 and cloud sourcing strategies to develop appropriate bespoke content. It is difficult to imagine this approach as feasible for user interfaces. The challenge may be summarised as designing to allow a person living with dementia to start from anywhere on a spectrum of a standard operating system user interface to the most simple, intuitive, perhaps single choice activity – maintaining self-efficacy throughout.

One response to the above discussion is to suggest that consideration of people living with dementia in sub-groups may be appropriate. This would fit with a Design for all approach [34]. The latter pragmatically deals with variation in user interfacing requirements by a combination of allowing user choice of features from a finite set, where many members of the set are in themselves adaptable to need. So how might appropriate sub-groups be identified? Currently the usually medically couched tools to help categorise stage of dementia are of little help in establishing functional capability for design purposes. Indeed functional capability assessments for independent living do not target people living with dementia and their ability to use ICT or indeed digital AT. As many people living with dementia retain some capacity to learn, such assessments need not only to evaluate existing levels of knowledge and skills but also ability and willingness to learn. Some exploration of this is warranted in future research.

4 Conclusions

Given the breadth of individuality in people, the effects of dementias and indeed their progression it is impossible to view them as a single homogeneous population in terms of specifying a single user interface. In consequence rather than simply designing for all people living with dementia it is suggested that design for populations at stages of functional ability be investigated. Methods that set out to identify shared and bespoke requirements are needed to systematically establish any generalizability. Currently studies on design of digital AT and indeed other ICT for people living with dementia need to report much more detail on: describing their participants; details of user interface features that worked well; how much and what form carers help took. More attention also needs to compare strategies and features that work to identify those that are best or at least best for specific functional ability or tasks.

Acknowledgements

The authors would like to thank our collaborators, that's all the people with dementia and their carers, HMA Digital Marketing and the Social Care Institute for Excellence.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-610

The Person Living with Dementia, their Carer and their Digital Technology

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Abstract. The paper focuses on appropriate consideration of end users in the development of software that is part of an ICT or AT intended for use by people with dementia and their carers. Extracting data from a literature review leads to the conclusion that papers exploring the design of such technologies do not adequately report all that is needed to have a detailed understanding of the roles of carers, their ICT skills and likely workload. In the light of this the paper goes on to propose use of a research framework which if operated appropriately would ensure correct consideration of all end users – that's people with dementia and their carers – needs and feedback ion the design and evaluation phases of innovation. It is noted that the framework would work for individuals, populations or situations where there were only one type of end user, what makes it different is what you do within the framework steps.

Keywords. Dementia, Alzheimer's, Carers, Assistive, Information, Technology, Computer, Design, Framework.

Introduction

Designing for people living with dementia is far more easily expressed than achieved. In initiating a well-informed design process aiming to meet users' needs, complexity either is extant or soon creeps in. There are many things that vary and affects the day-to-day lives of people living with dementia and their carers[1,2]. For example, there are many diagnoses that are labeled as 'dementia', individuals have their own combination of skills, life experiences, interests, goals, self-efficacy, and response to living with the diagnoses. The state of the art of knowledge on dementia is not well advanced for highly effective interventions - with insufficient scientific answers to many questions in epidemiology, aetiology, characterising progression of the diseases, efficacious pharmacology, functional capability and indeed, in meeting the needs of people with dementia. This is reflected in international and national responses to have effective interventions [3,4]. This paper is concerned with one specific aspect of the process of meeting needs of people living with dementia. Namely, who should be the end-users in designing effective software in the context of ICT or digital assistive technology products intended for use by both carers and people living with dementia together.

From a user centred design point of view the latter seems to be a question that answers itself. That is, all the people who are anticipated to use, rather than prescribe or fund for example, the product are the end-users. There is an obvious case for the carers to be included. Typically they will be required to facilitate the use of the product or even play a significant role in setting up, maintaining and facilitating use of the product

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alongside the person living with dementia. This is particularly true as dementia progresses into the mid and late stages. Another role for the carer may be as an equal participant in use, i.e. doing the same things as the person with dementia. So it can be observed that conceptually the person living with dementia, their carer and the technology are constants and form a 'triad'. One purpose of the authors' investigation is to examine how well published articles account for the role of the carer.

Involvement of end-users of AT (or any ICT) is a fundamental of user centred design [5], and so their inclusion is essential. Understanding the functional impacts of dementia is clearly important for context so a very brief summary follows. Dementia describes a collection of neurodegenerative and progressive diseases [1,6]. The diseases are differentiated through biological cause of the neuronal loss but the symptoms and functional abilities (e.g. memory loss, reduced judgment, and decline in problem solving skills) are present across diseases [7] and are useful pointers for design[8]. The variability in functional ability between individuals with dementia, compounded with different co-morbidities, life experiences and skills, means that it can be anticipated that much greater detail is needed to optimally tailor software user interfaces and solutions for individuals. Attention should be given to the skills and capacities retained by the person living with dementia [8]. Clearly all of these factors should be considered in designing the product.

1 Methodology

Table 1. Main characteristics of the literature search conducted for the review.

Search feature	Description
Search terms	(dementia) OR (Alzheimer*) AND (technology) OR (digital) OR (tele*) OR (computer*) OR (assistive) OR (device) AND (interface*).ti,ab.
Publishing period included	2003 to 8th Feb 2013
Sources searched	Medline via OvidSP; PsychINFO via Ovid SP; PsychARTICLES via Ovid SP; Scopus; Web of Knowledge & Science. References listed in primary sources.
Article selection	Agreement between two independent researchers at title-abstract review stage. Single researcher at full paper review stage.
Article inclusion criteria	_Setting_: any regular location or non-specific _Participants_: people with dementia or a similar diagnosis of cognitive decline. _Necessary content_: discussion of user interface requirements and/or its design for any ICT based assistive technology. _Study design_: any primary study or evidence based approach. _Technology_: any assistive technology with the aim of being actively used by person/people living with dementia in order to meet a specified need.
Article exclusion criteria	_Setting_: any short term occasional temporary location, e.g. in hospitals _Participants_: if only carers were involved. _Necessary content_: insufficient user interface description or of its development. _Study design_: literature reviews, systematic or not, speculative works. _Technology_: not intended to be used by people with dementia themselves.

A systematic search of the literature most likely to reveal research practice employed to characterise carers' roles was conducted. Available resources did not allow for a full systematic review of all appropriate literature. So a restricted literature review was conducted that employed narrative synthesis and many of the features of systematic reviews. Table 1 summarises the specific details of the search design. Data extraction sheets were also used to systematically extract data. This is the same literature search as reported elsewhere in the same proceedings as this article[2].

The analysis for this paper examined the reported or assumed involvement of people living with dementia and/or their carers in the design and evaluation process. This included the degree of description provided, the amount of detail, what they would need to do and how much work it would be for them. If there was sufficient description of these details then the intent was to summarise this and make any possible general inferences.

2 Results

The search protocol described above resulted in a total of 756 references, removing duplication resulted in 612. After excluding those judged by their title and/or abstract as being irrelevant there were 41 left. In the end only 24 aimed at people with dementia as direct users of envisaged digital interactive technology. The references for these articles can all be found in the parallel publication to this one and so are not repeated here[2]. Of these 5 used inferences from the literature with no new input from people with dementia to inform user interface design features.

Table 2. Summary of reported/unreported involvement of carer(s) and/or people living with dementia.

Feature	Articles count
Involvement of people living with dementia in the design and evaluation clearly **without** their carer(s)	1/19*
Clear involvement of **both** people living with dementia and their carer(s) in the design and evaluation	14/19*
Publication provided explicit information about how much input, and of what sort, the carer might be expected to provide in using the software	2/24
Publication gave some consideration to the role of the carer but failed to provide explicit information regarding their role	17/24
Publication provided no consideration of the carer and their role	5/24
Publication specifically considered the carer's level of computer literacy	0/24

* These figures exclude the articles where there was no new data from participants.

The types of settings in which evidence was based or collected varied: attending dementia day services dominated (14); place of domicile (6); and, non-specific or unreported (5). The collective scope of activities to be supported was wide, i.e. private and public reminiscence through photos, video or audio recordings; singing along; companionship, e.g. through videotelephony; conversation; activities of daily living; memory support through calendars, alerts and information; health and safety information; topics of interest including the news; virtual reality games; use of the Internet; and listening to music. Table 2 above summarises the pertinent observations to the consideration of characterising the role and involvement of carers in the research.

3 Discussion

Even from limited representation of the results above, it is apparent that people living with dementia and their carers have usually been jointly considered in the AT design process. In the details however, there is much less consideration given to the role of the carer in the actual end-use of the technology. Few studies provide explicit details regarding, for example, how much time and effort may be required from carers to set-up, maintain and facilitate the technology. Similarly there is little detailed analysis of the precise activities required of the carers. Included in this is the limited account of the computer literacy required by the carer to facilitate the use of the technology. A synthesis of what there is will be presented at conference as there is not space to do this here. Nonetheless it can be stated when such technologies have been designed and evaluated, insufficient consideration is given to the interaction between the triad (i.e. the people living with dementia, their carer(s) and the technology) in the literature. Given the importance of considering the carer it seems unlikely that researchers had this information and not reported it. The lack of citations to an underpinning methodological framework for user specification and evaluation in these works also suggests there may not be one known or thought suitable.

3.1 A Proposal for a General Framework User Centred Design of ICT Products

A general framework is hypothesised for designing which incorporates the triad of the person living with dementia, their carer and their technology. Table 3 below shows proposed steps in the design process that would work whether for designing software or whole solutions. The term ‘test-bed’ is used to mean anything that represents the software or solution. This may be anything from a storyboard sequence of software screens to a fully functioning prototype. Designing for individuals, e.g. as in the social model, would in principle seem unlikely to actually generate a commercial product, but this terminology is still shown because a product-quality is still desirable. It should also be assumed that input from experts and the literature will impact the design – not least to attempt usefulness over progression of the disease. This framework is sufficiently generic to be usable whether it is an individual or a population that is being designed for. It is also important to note that as shown the framework is actually applicable to situations where there is just one end-user of the product.

Evaluations for risk and safety and ethics can be considered within the framework: in steps 3, 6 and 9 there should be exploration and documentation of them; in steps 4, 7 and 10 any new/unpredicted factors/events should as appropriate stop further work and/or flag this for use in decisions made in steps 5, 8 and 11. Step 12 should have all the appropriate risk, safety and ethical information documented as part of the ‘product’.

People living with dementia and their carer(s), as end-users, should have a major role in Steps 1 to 4, 7 and 10. Inclusion in Step 2 allows the researcher(s) to adapt their process model to that of the users as required. In a more inclusive or participatory approach, users can also be active in all the other steps too. For instance, confirming interpretation and decisions. If generic design is aimed at, this then would mean it would be important to consider inclusion of independent validation and evaluation.

Table 3. Steps in a User Centred Design Framework.

Step	Description
1	Establish the desired activity or activities.
2	Establish a process model of the activity/activities.
3	Produce the best 'test-bed' and an experimental protocol to explore acceptability, usability and scenario-based functionality with end-users.
4	Conduct the exploration.
5	If changes are indicated, return to the appropriate step above. Otherwise go to the next step.
6	Produce a user–informed, fully functional prototype and an experimental protocol to validate acceptability, usability and scenario based functionality with users over a short time.
7	Conduct the validation.
8	If changes are indicated, return to the appropriate step above. Otherwise go to the next step.
9	Produce a user-informed, fully functional pre-production prototype and an experimental protocol to evaluate full functionality and usefulness with users over a period of time, which is long enough for regular use to be established and, as appropriate, to make natural use of features and allow critical events to occur.
10	Conduct the evaluation.
11	If changes are indicated, return to the appropriate step above. Otherwise go to the next step.
12	Deliver the working production software

It is useful to consider the involvement of the user dyad within the framework as has been stated Table 2 is also fine for use with a single user. In step 1, initial dialogue should be with both and should involve a period of getting to know the users. Separate investigation of goals and skills of the individual person living with dementia and their carer is also necessary. In step 2, if the activity and thus the process model is the same for both members of the user dyad, then this and the remaining steps can be conducted always with the dyad. However, if there are marked differences in the activities that the carer and the person living with dementia require, then each need a tailored process model. The designer/researcher should ensure these conform to each other. Whichever end-user is involved in conducting a task within the process model(s), matching involvement of the individuals or the dyad in the exploration, validation and evaluation should occur. It should be observed that no specifics details of the qualitative, quantitative, mixed or use of particular tools have been stated. This is deliberate primarily because it is up to researchers to select what is appropriate in their circumstance[5].

Pragmatically, the involvement of people living with dementia, their carers and indeed the software represents a triad with highly variable members. A person with dementia in the early stages retains more of their cognitive abilities, and is therefore likely to be more independent. As their disease progresses and other co-morbidities with functional impacts arise [9], it is likely that they will become more dependent on others, requiring enhanced levels of support. The current literature expects the person living with dementia to use their new technology with the support of their carer(s), but often without consideration of the computer literacy of those groups or being clear about how much support is needed. It is argued, therefore, that consideration must be made for the two end users with equal importance. Software is intrinsically highly adaptable in the hands of expert programmers. It is only limited by what is technically and financially possible, and, by the knowledge and imagination of those involved.

It is noted elsewhere most studies involving people living with dementia and their carer(s) employ adhoc convenient sampling[2]. It may be for this reason and others that design methodology and underlying assumptions are not reported clearly in the literature. It is suggested that the described framework would go some way to providing a basis for researchers to make their approach more explicit.

4 Conclusions

The results highlighted in Table 2 suggest a mismatch between simplistic or arbitrary consideration of the role of carers and their contribution and needs to use of the products being designed and intended actual use. The literature indicates that many studies appear to have not considered all the end-users in the product/software design appropriately and it is suggested there needs to be improvements. The management of involvement of both people living with dementia and their carers within the proposed framework in Table 3 should enable more appropriate designs to be achieved. The framework operation as described includes appropriate measures for involvement of the human dyad. The authors believe it is a viable way for design to be approached and described in future research. This needs to be tested and refined/developed through further work.

Acknowledgements

The authors would like to thank our collaborators, Gail Mountain of ScHARR, Open Directive and Kirsty Harkness from Sheffield Teaching Hospitals NHS Trust, HMA Digital Marketing and the Social Care Institute for Excellence.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-616

Language and Communication in the Dementias: Implications for User Interface Design

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Abstract. The design of user interfaces for people with dementia does not appear from the literature to take into account the concomitant language and communication deficits when choosing the language used in the interfaces. A systematic approach was used to search databases for studies relating to language and communication in the four most common forms of dementia (Alzheimer's disease, vascular dementia, fronto-temporal dementia and dementia with Lewy bodies). Studies identified were used as a basis for the commentary in this paper. Communication deficits are common in dementia. From the earliest stages of the disease, the person with dementia's capacity for communication declines as difficulties emerge with all aspects of language and functional communication. These deficits have implications for the successful interaction with assistive digital technology designed to improve the quality of life of people with dementia. More consideration should be given at the design stages to the potential impact of communication difficulties on interaction with technology.

Keywords. Dementia, Alzheimer's, Language, Communication, Disorders, User Interface, Design.

Introduction

As the ageing population increases, the prevalence of chronic disease and age-related impairments, such as dementia, is also rising. In the UK, it is estimated that as many as 40% of individuals over the age of 85 will develop dementia [1]. Dementia is an umbrella term for a group of disorders which cause impairments to intellectual function, characterised by progressive deterioration of multiple cognitive functions, most notably memory and communication [1]. Types of dementia include Alzheimer's disease (AD); vascular dementia, fronto-temporal dementia and dementia with Lewy bodies. Subtypes can often be distinguished in the early stages of the disease, but they are usually indistinguishable from each other by the late stages. There is wide variation and heterogeneity in the progression of the dementias, with different aspects of cognition being compromised at all stages due to multiple cognitive impairments[2].

There is increasing interest in the development of ICT to meet the needs of people living with dementia [3,4]. Studies have examined the services needed while others have provided accessibility guidance[5,6]. The need for simplicity in the interfacing immediately draws software engineers to consider those technologies that are often labelled as particularly intuitive, i.e. automatic speech recognition, touchscreens, and

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gesture recognition[7-9]. Clearly the use of automatic speech recognition in interfacing is of direct relevance here. Use of speech in audio prompting/feedback is also relevant.

In the existing literature however, the design of user interfaces specifically for people living with dementia is often poorly reported[10]. Indeed while the physical accessibility of interfaces for older people has been addressed to some extent, few attempts have been made to design more suitable interfaces for people living with dementia [11]. The studies which report new digital technologies for people living with dementia, usually offer no clear rationale for why an interface has been chosen, how it has been arrived at – e.g. if the design has been based on any evidence of best practice for people living with dementia. Furthermore, actual design features are either not described [10] or only in terms of the needs that are being met rather than a technical description. As such, there is not a set of user interface design features for people living with dementia for new innovators to refer to for guidance.

This paper attempts to identify design features that are 'best practice' or evidence-base for people living with dementia from reviewing the appropriate literature on what is currently known about people living with dementia. More specifically what can be concluded from the literature about language and communication deficits in dementia and their potential impact on accessibility and usability of digital assistive technology. Recommendations for future user interface design which takes into account these difficulties will be made.

1 State of the Art

A wide body of literature has investigated language and communication associated with dementia this century alone, e.g. 5400+ references from Web of knowledge. This literature is too large to review fully here. However the current understanding [1,2] can be sufficiently summarised for the purposes of this paper as follows. Impairments often occur across all types of dementia and from the early stages. These difficulties include a progressive loss of intelligible speech; a progressive loss of ability to use language meaningfully; difficulties with understanding spoken and written language, and word-finding difficulties. Further details of the most relevant will appear in the analysis from the literature review itself and so are not expanded upon here.

However, it is important to note that the authors have not been able to find to date any conclusions about what impact these impairments may have on user interface design. Thus a review of the reported speech, language and communication impairments associated with the dementias that may allow inference of how these impairments may impact the ability to access technology is worthwhile. Indeed, possibly leading to recommendations for future user interface design which takes into account these difficulties.

2 Methodology

The literature search in order to identify the current studies of speech, language and communication impairments in the dementias is summarised in Table 1. The electronic databases were chosen due to the range of journals/conference proceedings they provide across relevant subject areas.

Table 1. Main characteristics of the literature search conducted for the review.

Search feature	Description
Search terms	(dementia) OR (Alzheimer*) AND (language) AND (speech) AND (communication).ti,ab.
Publishing period included	2003 to 7th Feb 2013
Sources searched	Medline via OvidSP; PsychINFO via Ovid SP; PsychARTICLES via Ovid SP; Scopus; Web of Knowledge & Science. References listed in primary sources.
Article selection	By single researcher at title-abstract and at full paper review stages.
Article inclusion criteria	*Participants*: people living with dementia or a similar diagnosis of cognitive decline. Age: any Ethnicity or cultural background: any *Necessary content*: discussion of speech, language and/or communication impairments associated with dementia. *Study design*: any.
Article exclusion criteria	*none*

The most common language and communication impairments found in the four subtypes of dementia were identified. Discussion of distinct difficulties associated with specific subtypes of dementia is beyond the scope of this paper, which aims to focus on the most frequently encountered deficits across the main subtypes of the disease. These impairments are categorised into the following groups:

- Using spoken language
- Understanding spoken and written language

Communication impairments, such as word-finding difficulties (anomia), are presented within these categories. A brief description of how these impairments may present in people living with dementia is given, followed by a discussion of the potential impact on the ability of the people living with dementia to access and use technology. Finally, inferences are made for how user interface design may accommodate communication impairments.

3 Results

A total of 169 references were found, after removal of duplication there were 99. From these there were just 10 publications were judged to be useful for this review [12-21].

The findings indicate that, even in the early stages of dementia, people can experience a range of language and communication difficulties. The following tables provide examples of the most common difficulties, and how this impairment may impact on the use of digital assistive technology for people living with dementia.

Table 2. Impairments relating to using spoken language and implications for interface design across all stages and typically in Alzheimer's disease and others like sematic dementia [15,16,18].

Impairments relating to using spoken language	Potential impact on technology use and implications for interface design
People living with dementia often experience difficulties with using spoken language. These difficulties may include the following [12-21]: Semantic paraphasias (saying an incorrect but meaning-related word, eg, lion ➔ tiger). Phonemic paraphasias (saying an incorrect but sound-related word, eg, pen➔pan). Circumlocutions (describing the thing rather than using the word for it). Neologisms and jargon (using made-up and nonsense words). Some types of dementia can also cause non-fluent speech. This is speech which sounds very effortful to produce, may include stammering, and may include speech production difficulties (apraxia and/or dysarthria). Difficulties with speech production typically evolve into complete mutism (loss of spoken language).	Overall, these difficulties with spoken language can cause a lack of meaning and unintelligible speech. People living with dementia may struggle to interact verbally with technology, eg, with voice recognition software or voice commands. User interface design should avoid reliance on users providing voice commands.

Table 3. Impairments relating to understanding spoken and written language and implications for interface design across all types and early to mid- stages of dementia.

Impairments relating to understanding spoken and written language	Potential impact on technology use and implications for interface design
The capacity for reading appears to remain intact for the longest period compared to other areas of communication; only declining in the mid to late stages of dementia [15,20,21]. In particular, the ability to read single words, spelt regularly, is preserved. However, it should be noted that, due to declining vision capabilities, PLWD often experience difficulties with recognising written words [15]. They may struggle to read a word correctly. Evidence suggests that it is easier for PLWD to name a picture than to name a word [15,20,21].	In general, reading is strength for people with dementia and, as such, written information is likely to be an appropriate way for them to interact with technology. Saying that, written information should be as simple and concrete as possible and, where possible, supported with clear visual images to aid understanding.
PLWD often experience difficulties with understanding complex sentence structures in both spoken and written language [12,14-17]. This includes sentences with embedded ideas or very long sentences. PLWD often experience difficulties with understanding complex words in both spoken and written language, such as abstract concepts or 'low frequency' words (these are words which are not often used by speakers) [15-21].	Written or spoken information provided in an interface, such as a website or application, should aim to be as simple and clear as possible. Use concrete words which are common to everyday communication. Avoid 'technical' words which may be unfamiliar.
PLWD often struggle to remember what a pronoun refers back to. For example, in the sentence: The 'home' button is blue. You need to click it to return' home' [12,14,15,21].	Avoid pronouns or any language which requires the person with dementia to recall previous information.

4 Discussion

The results of this review have highlighted areas of strength (reading) and areas of difficulty (spoken language output and understanding some aspects of spoken and written language) in the communication abilities of people living with dementia. Those who design interfaces for this client group should consider the impact that their language and communication choices might have on end-users with dementia. In particular, the following general guidelines should be taken into account, in order to maximise the accessibility of the language of interfaces for people with dementia:

- Avoid use of *voice recognition* or *spoken commands* from the end-user.
- In either spoken or written information, use *simple words*, avoiding abstract, unfamiliar vocabulary.
- In either spoken or written information, use *simple sentences* with just one idea per sentence. Avoid long sentences with embedded ideas.
- Avoid *pronouns* or other forms of language which rely on the end-user having to recall information which they have just read or heard.
- *Support writing* with clear visual images to account for potential vision deficits impacting on reading ability.

It should be noted that communication difficulties tend to become universal to all types of dementia as the disease progresses [15-21]. By the late stages of dementia, it is difficult to separate symptoms into different disease subtypes. It should also be emphasised that, due to the nature of dementia and the global cognitive decline it causes, disorders of language usually affect both spoken and written language, so that one cannot be substituted for the other.

This study represents the first published attempt to collate what is known about communication impairments in the dementias and state the implications that these have for accessing technology. It is also the first study which makes explicit recommendations/inferences for user interface design for people living with dementia which are based on clear evidence and on a profile of communication disorders which are specific to dementia. To date, apparently interface design for people living with dementia has failed to take consider all these impairments. Disseminating these findings thus creates the opportunity for any interested party to investigate the recommendations through user centred evaluation.

5 Conclusions

Those who design user interfaces for people living with dementia should consider the potential barriers to access and use of technology caused by speech, language and communication impairments which are specific to the dementias. This study identifies some of the obstacles faced by people living with dementia in accessing current software applications due to poorly designed user interfaces. It highlights a gap in the knowledge of designing interfaces for people living with dementia and an area for improvement.

Acknowledgements

The authors would like to thank our collaborators, Gail Mountain of ScHARR, Open Directive and Kirsty Harkness from Sheffield Teaching Hospitals NHS Trust, HMA Digital Marketing and the Social Care Institute for Excellence.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-622

Co-Exploring Everyday Life of Adults with ADHD

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Abstract. There are relatively few studies based on an individual adult perspective on ADHD which takes into account how various factors interact and affect everyday life. Compensatory strategies can facilitate life for people with ADHD and those strategies might include the use of assistive technology or cognitive support. The purpose of this paper is to present and discuss how various factors can facilitate or challenge a person's tendency to adopt technology to better meet the demands and expectations of adult life. Participant observations and narrative interviews were used while co-exploring the life of three adults diagnosed with ADHD. By using this method the participants' own solutions, adaptions and preferences regarding cognitive support and assistive technology become visible. Results showed that factors like negative symptoms, stress, sleep deprivation, financial- or social problems effected the participant's motivation, feelings of competence, ability to identify prioritized activities and to maintain supportive routines – things that have been proven to be important for assistive technology use. Developing useworthy support and technology that meets the needs of people with ADHD is important in order to enable autonomy and compensate for the impairment.

Keywords. Adults, ADHD, Participant Observation, Co-exploring, Assistive Technology, Everyday Life.

Introduction

Even though there are numerous studies investigating treatment results or specific ADHD symptoms there are rather few studies based on an individual adult perspective of this diagnosis which takes into account how various factors interact and affect performance in everyday life. When it comes to designing support and prescribing assistive technology to compensate for cognitive impairments there is a lack of research about what works for whom and more specifically why certain solutions work for certain individuals.

However, before technology can be applied to meet the needs of people with cognitive disabilities, it is necessary to understand what those needs are and what barriers exist to technology use. A large proportion of those who own assistive devices either do not use them at all or do not effectively use them[1]. Therefore, it becomes essential that we find effective methods so that users can assimilate the technical assistance and also that we try to create technology that's useworthy [2].

Supporting the user to *make a decision* to use assistive technology, choosing technology that meets the user's needs when they are performing *prioritized activities*, support users to make *adjustments in their routines* to include assistive technology in everyday life and creating opportunities for them to experience *feelings of enhanced capacity* has been proven to be key factors [3]. By using appropriate methods for teaching and training, providing sufficient support, follow-up and assistance from prescribers and others in the immediate environment may enhance the individual's sense of security, independence and productivity.

It is also essential that prescribers have knowledge about the environment in which the assistive technology is being used. In addition to assistive technology, adaptations of the environment and assistance from other people can increase independence and facilitate performance in everyday life [4].

Purpose

The purpose of this paper is to present and discuss how various factors can facilitate or challenge a person's tendency to adopt technology or other form of cognitive support to compensate for difficulties associated with ADHD. An additional purpose is to identify and understand more about the participants' own solutions, adaptions and preferences regarding cognitive support and assistive technology in everyday activities.

1 Methodology

This qualitative study used participant observations and narrative interviews based on shared reflection combined with co-exploration of activities in everyday life. By joining the participants in various activities, the authors wanted to explore and get a deeper understanding of the lived perspective of adults with ADHD and their ability to utilize their strengths, satisfy their personal needs and fulfill their hopes and dreams.

Co-exploring is a concept found in technological and design research that emphasizes the user´s active role in the design process [5]. What a researcher see while exploring and how results are interpreted depend on the persons previous experience and knowledge. Participant observations can be useful when it comes to investigating interactions in natural settings in public space [6] and narrative interviewing allows participants to engage in an evolving conversation wherein interviewer and interviewee collaboratively produce and make meaning of joint activities and experiences [7]. Less structured interviews often give greater control to both interviewer and interviewee to jointly construct narratives [8]. During the observations in this study, unstructured, narrative interviews [9] where made focusing on the impact of ADHD symptoms and other factors when performing activities.

Seven adults who were diagnosed with ADHD in adulthood were initially invited to a joint meeting to be informed about the study. The potential participants were all patients at a psychiatric outpatient unit where the first author is currently employed. Two additional criteria were required in order to participate: that the person should have ADHD as their main diagnosis and not have an on-going substance abuse.

One male and two females (age range 30-45), that the author already had a treatment alliance with, showed interest in participating in the study. The relationship between the first author and the participants was a prerequisite for being able to access the life of the participants. It was of great importance that they would feel safe, comfortable and not singled out when interacting in everyday activities with the researcher by their side. All interaction was recorded with a discrete microphone and environmental data was documented by photographs and field notes before and after the observation sessions. The observations and interviews were made while participants engaged in different activities and daily routines; at home, at work, in school or out in the community. The participants were asked to perform the activities as they usually do, even if the author were following along.

Each of the participants was followed for three days, from morning until late afternoon. When the collection of data was completed, audio files were listened through and notes regarding topics of conversation were made. Quotes and topics were transcribed, themed into categories and analyzed. By using the first day of each participant the authors found a few main themes and then added findings from the last 6 days under each theme. In the next step of the process, the author analyzed the findings further by dividing the initial themes into subthemes.

2 Results

2.1 Results from Participant Observations

There were numerous examples where the participants experienced problems with inattention and impaired working memory. Difficulties keeping thoughts and experiences alive and present in consciousness made them forget to use technical devices, even if they *had* experienced support from them in previous activities. As a result of this participants often had to re-do their work, go back and forth to retrieve things they forgot to bring to the task, double-check things to make sure that they had done it right or control information and instructions. This resulted in work piling up and feelings of stress or overwhelm. For an observer it became obvious that internal- and external demands and expectations exceed the participants' abilities in many ways and in numerous activities in everyday life. Sensory input from the environment, for example sound-light-smell and movement, was also observed to create problems when the participants tried to concentrate, focus on tasks and use technology. This led to ineffectiveness and reinforced negative ADHD symptoms.

"Thinking in several steps ahead" and being able to see "cause and effect" seemed to be difficult for the participants. Their tendencies to "live in the moment" and difficulties with perception of time were observed to create a lot of problems when it came to anticipating- and drawing conclusions about situations that emerged or pursuing plans they made up. Ultimately, this also affected their actions and their ability to see the benefits of using technology. However, participants sometimes perceived their ability to hyper focus and concentrate on details as a *gift* that made everyday life manageable.

The inability to stick to plans was described by all participants as something disconnected from willpower. One participant struggled with maintaining a supportive routine where she tried to go to bed on time because she easily became hyperactive after 10 o'clock in the evening. Unfortunately, impulsivity often made her give in to new desirable activities that "popped up" in her weekly schedule and set the routine out of play.

Visibility was observed to be extremely important for how participants managed to organize their things or attend to tasks and shores. Two had difficulty creating supportive systems and avoid clutter while one of the participants organized the home very neatly and managed to strip down the home environment by reducing stimuli. However, it took a lot of time and energy to maintain an organized system which ultimately constituted an obstacle when it came to finding time to embrace strategies suggested by professionals. One of the reasons for things piling up was the inability to determine what might be useful to save, and what could be thrown away. Participants' felt ashamed of chaos and clutter and this kept them from inviting friends over, which became an obstacle in maintaining relationships and human support. Both the physical- *and* social environment was thus observed to be very important for their ability to compensate for their impairment and assimilate cognitive support.

The participants used utensils and kitchen items with a design that made the function obvious, and kitchen appliances that were perceived as safe. One of the participants had a stove guard installed, but had taped over the smoke sensor because he was disturbed by the sound and felt afraid that neighbors would complain when it started beeping. He had not been able to find a constructive solution for this problem, e.g. to call the installer or the occupational therapist to adjust the sound, and he now avoided to use the oven completely. Several unused assistive devices, that the participant either bought or had been prescribed, were found in the apartment. The participant stated that they were too complicated to understand and that didn´t provide the support he needed. All participants used smart phones and computers on a daily basis but were observed having difficulties utilizing different features suggesting it was too complicated to handle and required patience to learn. Their cognitive impairment and inner restlessness, originating from their ADHD, left them without enough energy and concentration to read instruction books and manuals. Instead, they often figured thing out by trial and error. Overall, they seemed to prefer- and fall back on low-tech solutions. They created their own cognitive support where possible – preferring the use of colors and pictures that was easy for the brain to interpret. The solutions involved crib sheets (easy-instruction-sheets), step-by-step instructions or weekly schedules that they often needed assistance in designing.

All three participants consciously refrained from things that took too much energy from the things they prioritized as more important for the survival. Highest ranked in this hierarchy were often things related to finances, employment or studies. On a higher level, it was about being productive and contributing to society and more importantly - making sure that no one else should have to suffer because of their disability.

2.2 Results from the Narrative Interviews

The narrative interviews confirmed findings from the observations and explained the feelings associated with the participants' experiences and added a life perspective on living with ADHD. All participants described how they early on in life had a feeling of being *different* without understanding *why*? Their inadequacies were constantly confirmed by their social environment. It resulted in a lot of negative feedback and even physical punishment. The psychological consequences of this was said to have had a great impact on the development of their self-esteem and the confidence in their own ability. Their inadequacy's associated with not being able to control impulses, find solutions and accomplish simple tasks in everyday life, made them hide their difficulties. Participants explained how attention deficits and impulsiveness created several problems and additional costs in their life. They explained how they lost bus passes or keys and how they often needed double sets of certain objects. They sometimes made unplanned, impulsive purchases that they could not afford or didn´t even need, and they spent a lot of their time worrying about money.

Receiving their diagnosis also made them analyze their upbringing. Due to the heredity of ADHD, some participants saw great similarities in personal characteristics of their parents and siblings. All participants described a childhood without security, predictability and supportive routines that probably influenced their chances to manage adult responsibilities.

They could, however, also see benefits with ADHD that some even said they wouldn´t want to live without. They emphasized the great amount of energy, willpower and inner drive that often had served them well. It was described as a strong force that helped them being creative and forced them not to give up. Creativity was stimulated by their ability to absorb all sensory input without discrimination. Being sensitive and intuitive also helped them understanding other people's needs as they had developed a high sensitivity to the moods and feelings of others while growing up. They would often get highly emotionally involved in things that felt meaningful to them – a characteristic they thought to be very valuable.

The participants described a need for hands-on-help, for example someone showing them how new things were done and carrying out activities together with them. On some occasions, the participants in this study stated that they found the everyday tasks easier to perform when they had company and that the author's presence had a positive effect on their motivation and endurance while performing activities. Participants also stated that it was quite impossible to learn or express themselves clearly when they were pressed for time or didn't feel safe with the person in front of them. Participants with a more restless and active personality explained the inner conflict between the importance of continuity and predictability and the need for variety and new challenges.

3 Discussion and Contribution

Some results in this study were expected and consistent with common difficulties related to the ADHD diagnosis. However, the participant observations gave a completely different understanding of how *often* ADHD symptoms hindered participants in activities, the *amount of energy* that was taken from them as they were constantly forced to deal with mistakes and problems and also how *relationships* with other people made life easier or harder. It became clearer how environmental factors influenced performance and it deepened the understanding of how some aspects of ADHD actually was perceived as a valuable asset. All participants developed similar coping strategies to deal with the ADHD symptoms and compensate for challenges in everyday life. These strategies were more or less efficient but were observed to have booth negative *and* positive effects.

Results from this study showed that adults with ADHD have motivation and talent for creating coping strategies but difficulties seeing the relationship between *cause* and *effect*. This has a negative impact on their inclination to embrace and adopt new solutions. This shows us the importance of monitoring and initiating continuous evaluations when prescribing assistive technology. Moreover, the results suggest that there is a hierarchy of needs that has to be fulfilled in order to change negative behaviors and reduce symptoms. The participants explained how they often needed help from other people to be able to learn and maintain new habits. They also emphasized problems with attachment to other people as well as financial difficulties as the most urgent concerns. There is a need for new technology that helps people with ADHD manage financial problems for example by clarifying finances, make records of purchases and create a sustainable budget.

One aspect of participant observation is that the researcher inevitably becomes part of the study context and thereby influences all situations by asking questions and giving confirmation by words or body language [10]. In this study participant observation was used which includes the researcher as a part of the study context. It is important that the researcher is aware of- and attentive to the fact that this “closeness” can be both a limitation and an asset. However, by using participatory methods we can develop effective technical and human assistance in which the resourcefulness and creativity observed in the participants could be of great value. The results of this study indicate a need for greater interaction between consumers and device manufacturers, a need to inform service providers about avail- able technologies and assessment methods, and a need for more training and technical support from the manufacturer or service provider[11]. This study is part of a larger project which aims to investigate how cognitive support can be designed for adults with ADHD.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-628

Inclusion through Design – Engaging Children with Disabilities in Development of Multi-Sensory Environments

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Abstract. This paper is based on outcomes from SID (http://sid.desiign.org), a three-year project where twenty-four children with profound intellectual disabilities visited three MSE centres. SID's aim was to develop and demonstrate the potentials of interactive design in and for MSE practices together with the children and the pedagogical staff. In the project, we developed artefacts that were designed to be part of and mediate the explorations rather than to become end products. The designs were explored by the children at the MSE centres and further developed depending on what the children did and what seemed relevant to them. There are few documented examples in the literature where children with profound developmental disabilities are involved as active participants in design activities. We present and discuss the participants' roles in SID's research and development process based on experiences and material from the project, with a hope that this paper can serve as an example of what such a development process might look like and as inspiration for future initiatives.

Keywords. Snoezelen, Multi-Sensory Environments, Participation, Design Engagement, Children with disabilities

Introduction

The pedagogical practices around Multi-Sensory Environments (MSE), sometimes called *Snoezelen* [1], have been growing for more than thirty years. MSEs consist of rooms that are designed to evoke interest and offer opportunities to explore, discover and experience in one's own pace. Activities in MSEs typically unfold as interplays between the visitors, the pedagogical staff and the artefacts in the room (figure 1). Every MSE room has its own theme that is varied and adapted as part of the pedagogical practice, where "demand free" use is one of the corner stones.

Today MSE centres exist in many parts of the world and there are several flavours and directions among them. The target group is in many cases people with developmental disabilities, both children and adults. Common for most of the existing practices is a strong focus on sensory stimuli and how to best adjust the environments to the particular visitor's needs. Some of them might need to wind down and find a calm to be able to take part in and explore the MSE rooms, while others need support and stimuli to be able to engage in the activities [2].

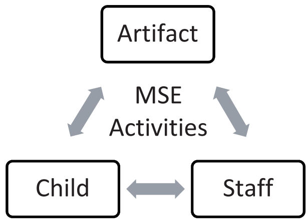

Figure 1. A triangular figure that portrays the MSE activities as unfolding in the interplays between the visitor, the staff and the artefacts.

For more than two decades now, there have been calls for a new paradigm in the development of technology, where children are involved as active and influential participants in design processes [3]. The need for increased end user participation in technology development has also been addressed in assistive technology [4] and augmentative and alternative communication (AAC) [5, 6]. However, there are quite few examples of design processes where children with disabilities are involved from the very start instead of just being "testers" in late development stages, and even fewer engaging children with profound intellectual disabilities.

This paper is based on outcomes from SID (http://sid.desiign.org), a three-year project where twenty-four children with profound intellectual disabilities visited three MSE centres. SID's aim was to develop and demonstrate the potentials of interactive design in and for MSE practices together with the children and the pedagogical staff. In the project, we developed artefacts that were designed to be part of and mediate the explorations rather than to become end products. These were explored by the children at the MSE centres and further developed depending on what the children did and what seemed relevant to them.

1. Purpose

The SID project was carefully designed to open up for and support the children's participation in the project. In the paper, we will present and discuss the participants' roles in the research and development process based on experiences and material from the project.

2. Design Process and Outcomes

Participation takes place in activities and evolves over time [7]. When deliberating how to engage the children in the project we knew that the setup of the design process in itself was crucial for the children's possibilities to contribute to the project. Staying close to the children's actions and learning from them was identified as an important factor already during the work with the project application. Since all of the children had developmental disabilities and lacked functional speech, they could not take part in discussions around scenarios, pen and paper sessions, or similar activities. This together ruled out many of the established participatory design methods [8].

Figure 2. Exploration of one of the SID designs, the “ActiveCurtain”.

Instead, we chose to iteratively build interactive artefacts that had some, often just a few, of the qualities of a possible interactive MSE design. For example, one of the SID designs, the “ActiveCurtain”, relates the feel of one’s body touching the material to color change where the interaction happens (figure 2). The ActiveCurtain might be seen as merely an interactive material. We have simply taken the raw image from a Kinect device – sensing the dents made by the children in the elastic surface – and projected the image back onto the surface, but with a sequence of colours rather than shades of grey. Another example is the “MalleablePillow” where kneading a pillow, filled with marbles and cellophane, produces light effects. When someone kneads it, the sound from the marbles and cellophane is picked up by microphones and then mapped to the output of LEDs (figure 3).

Thus, the artefacts we built became part of the exploration of the potentials SID was aiming for. In a sense the artefacts became tangible [9], interactive “questions” to everyone involved, the children, the staff and the designers. This gave the development process a distinctly different purpose than the predominant product-oriented one, where the designs are supposed to become products (see [10] for a similar discussion), whereas in this project, the artefacts were a way to ask questions about sensory experiences, interaction and other aspects of MSE practices. All in all, this established a foundation not only for methodological findings, but also for developing design knowledge [11]. Building “questions” instead of products imposed certain demands on the development process. It was of utmost importance that the children had a chance to try the designs as soon as possible. Hence, some of the designs were quite crude looking when the participants initially tried them. The children then often tried several versions as the designs evolved over time.

Figure 3. A child explores qualities in kneading “MalleablePillow’s” light.

Figure 4. A boy's favorite hugging and leaning unfolds soundscapes in the "HugBag".

Every time a child visited one of the MSE centres involved in the project, this was recorded on video; both when members of the design team were present and when not. The staff then interpreted and reflected on the children's actions, and brought this into lively discussions and later on as annotations of the videos. The narratives around the children's use of the designs were important in order to understand what happened in the activity. However, these were often hard to catch on video, so when discussing the videos with the design team afterwards, the staff often filled in, supplemented and offered other or extra information that was missing on the video through their experiences with the child.

Throughout the design process, we promoted a specific open mind-set, keeping the attention on potentials and the lived experience, and promoting what the children can do and their wishes rather than what they cannot do due to impairment. Furthermore, having the videos as the starting point weakens fixated preconceptions and judgements, as it opens up for multiple divergent interpretations. Even when there seemed to be consensus around such a mind-set, our approach has been crucial for the deliberations to stay with the children [2].

A key example is a boy with strong and somewhat repetitive movements whom the staff doubted they could do anything for. After seeing his favourite behaviour we suggested a design that could build on these movements but at the same time lead to variation, which made the staff eager to explore potentials. From this came the "HugBag", where hugging and leaning unfolds intriguing soundscapes (figure 4).

Both what happened in the concrete MSE activities and the stories around the children and their previous experiences with interactive design were important, as inspiration, as guidance for the continued work, and in pointing towards openings and design potentials. Since we had 24 children involved in the project their actions showed breadth in the ways they engaged with the artefacts. We saw a wide range in interactions for each of the designs, as well as similarities in their explorations across the different designs. Over time, patterns started to appear. One of them was the children's use of their heads when exploring and interacting with the designs (figure 5). At other times they used their hands, as seen in (figure 2).

Figure 5. Children using their heads when interacting with the "ActiveCurtain" (left and right image) and the "LivelyButton" (center image).

3. Discussion and Conclusions

It is hard to reason about things that one has never seen and has no previous experiences from. The design and development process became an important part of realizing the children's participation in the project. What the participants did, how they reacted and what seemed relevant to them guided the further steps in the design process.

Overall this was a successful setup that strengthened the children's role, and they became an influential part of the design process as they in their way contributed to grounding design knowledge with them and the MSE practice. Through staying with the children's activity and by the participative mind-set, the many deliberations around the actions of the children has led us to a) identify key pedagogical aspects around interactive tangibles, as well as to b) a rich set of design exemplars accompanied by annotated port-folios [12] made with the staff, which may have relevance beyond designing for MSE. All in all, the children have explored 11 fully interactive designs of which most have been made in several versions. On top of that we have built a handful of various other designs to raise debate with the staff at workshops and the like. In a sense, the design artefacts have been giving form to exchanges between all participants.

In many cases, children with disabilities are left to passive roles as recipients of readymade products and treatments. There are few documented examples in the literature where children with profound developmental disabilities are involved as active participants in design activities. Our hope is that this paper can serve as an example of what such a development process might look like and as inspiration for future initiatives.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-634

Attempt at Treating Tinnitus with Brain Cognition Sound

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Abstract. This study sought to develop an effective novel treatment method for tinnitus which uses phase-shift sound stimulation. In this method physical audio signal processing is performed to convert sounds resembling subjective tinnitus to use as sound stimuli. In addition, the experimental study involving subjects with tinnitus demonstrated the reproducibility of time delays. These results suggest that the present method can be applied as a novel tinnitus treatment in clinical practice.

Keywords. Tinnitus, Treatment Method, Phase Shifted Sound, Auditory Brain Response.

Introduction

It is said that about twenty percent of Japans population had experienced a tinnitus. Of them, the numbers of people who have various troubles for their life are estimated to reach into five percent or more. A curative treatment for tinnitus is difficult in many cases due to occurring as complication of a basic disease. Therefore, treatment for the basic disease becomes a first-line choice. It is reported that almost 85 percent of patient who was seen in a clinic have persistent hearing loss. Additionally, it is often the cases of that tinnitus continued, despite a curing of the basic disease or due to an intractable basic disorder, a mental disorder or an unknown etiology. Although tinnitus has been studied extensively, there is little effective therapy for tinnitus treatment. On the other hand, it is also a fact that many folk therapies what are invalid medical evidence are present.

Now, there are mainly two types of treatment methods, one is the method what is decreased tinnitus by using a masking noise and is called “tinnitus masking therapy”, and other is the method that patient naturalize to tinnitus with psychological counseling and is called “tinnitus retraining therapy (TRT)”. But, these therapies have a lot of problems such as a brief duration of a treatment efficacy (a few minutes in general), a poor possibility of a complete healing and great differences between patients.

We have been studied a relief of tinnitus by physical acoustic stimulation and have been proposed a novel treatment method. The purpose of this study is to research whether the novel method what gives a phase reversing sound for tinnitus is dispersed tinnitus as if the electric signal disappears by adding an electric sin-wave signal to an electric cosine-wave signal.

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1. Method

A preliminary test using healthy adult volunteers without tinnitus and main examination intended for patients with tinnitus were demonstrated for evaluating an efficacy of a novel treatment method. In the preliminary test, two types of a virtual tinnitus model were proposed. The Ipsi model was assumed as an Intracochlear sound synthesis model of tinnitus caused by cochlear lesion.
A tinnitus stimulation sound and a phase shifted sound were input in ipsirateral ear using bone conductive transducer and headphone speaker.

The Contra model and was defined as a sound synthesis model in central origin. In both models, an auditory response was measured using auditory brainstem response (ABR) audiometry system (M4104/MEB5304, NIHON KOHDEN CORPORATION). (Fig.1)

Figure 1. ABR audiometry system

Figure 2. Shows the look of the examination.

A tinnitus stimulation sound was in one ear by bone conductive speaker. A phase shifted sound was given in the other ear using headphone speaker. Masking noise was given in the opposite ear at bone conductive speaker. These sounds was given in add on 35dB from each frequency hearing loss level.

Fig.2 shows the look of the examination. The virtual tinnitus sounds that have frequencies of 500Hz or 2000Hz was used in the standard sound of ABR test as a benchmark. The latencies of wave-five in ABR were measured during the test. And then, the auditory response was evaluated by the comparison of the latencies.

Preliminary test using healthy subjects

Seven healthy adult students without tinnitus and any disease were joined as subjects (five men and two women, mean age ± SD: 23.0 ± 1.0 years). Two types of a virtual tinnitus model were prepared and were described as below;

a) Ipsi model

Ipsi model was assumed as an intra cochlear sound synthesis model of tinnitus caused by cochlear lesion. In this model, a tinnitus simulating sound and a phase reversal sound were prepared and these sounds were given in one ear. The virtual tinnitus sound was input using the bone conduction transducer what was fixed to the skull behind the ear by a headband. Then, a phase reversal sound was entered via the air conduction in the ear on the same side as the input side of the virtual tinnitus sound by utilizing a headphone speaker. The latencies of wave-five of ABR were measured during the test. When only the tinnitus simulating sound was input, the latency of ABR was recorded as a control. And then, the auditory response was evaluated by comparing the latency of when the inputs were the dual-audio with that of control.

b) Contra model

Contra model was defined as a sound synthesis model in central origin. As is the case with the Ipsi model, a virtual tinnitus sound and a phase reversal sound were prepared in this mode. But, a virtual tinnitus sound and a phase reversal sound were respectively loaded into each ear. Although a virtual tinnitus sound was input using the bone conduction transduce in the skull behind the ear,

a phase reversal sound was entered utilizing a headphone speaker via the air conduction in the ear on the side opposite to the input side of the virtual tinnitus sound.

Similarly to the Ipsi model, this test was also measured the latencies of wave-five. The latency was also compared to that of control.

Experiments with tinnitus patients

In this examination, 3 patients with unilateral tinnitus participated. Patient information was shown in table 1. Seven healthy adult students without tinnitus and any disease were joined as subjects (five men and two women, mean age ± SD: 23.0 ± 1.0 years). Two types of a virtual tinnitus model were prepared and were described as below;

Table 1. Experiments with tinnitus patients.

Patient No.	Years	Auditory act.	tinnitus	THI score(category)	VAS
1	47	Normal	Right	48 (moderate)	38/100
2	34	Normal	left	24 (mild)	26/100
3	64	Hearing loss	both	38(moderate)	21/100

The phase reversing load test was executed in patients who had tinnitus as a major complaint. After obtaining a written informed consent from patients, patients filled out Tinnitus Handicap Inventory (THI) and Visual Analog Scale (VAS). Next the tinnitus sound such as frequency and loudness was researched by pitch-match frequency test and loudness balance test. And then, the additional tinnitus test with sin wave signal generator was given for analyzing the frequency of the tinnitus sound in detail. A phase shift sound of the identified frequency at the additional tinnitus test was input to patient via bone-conduction transducer. In the generation of phase shift sound, phase shift system was utilized. In the system what we produced, the phase of sin wave could be shifted ranging from 0 to 360 degrees of the angle by a computer program built by Lab View (National Instruments Corporation). The phase shift sound that tinnitus was suppressed minimally was loaded to patients during ten minutes. And then, patients filled out VAS again.

2. Results

Preliminary test

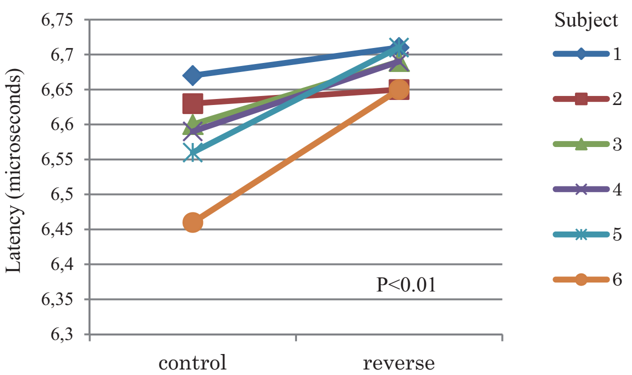

Figure 3. High Tone of Ipsi model.

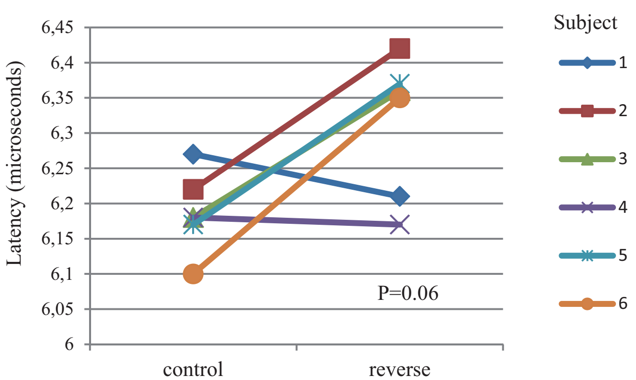

Figure 4. Low Tone of Ipsi model.

Main examination with patients

Table 2. Shows results of "main examination with patients".

Patient No	1	2	3
Post VAS	26	24	21
Loudness Balance Test (dB)	20	20	15
Pitch match Test (Hz)	2000	8000	8000
Tinnitus Approximate Frequency (Hz)	2250	10200	8850

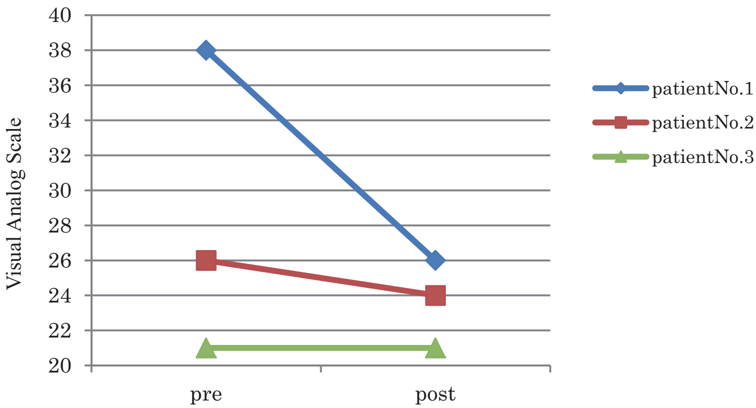

Figure 5. The changes of score after test by Visual Analog Scale (VAS).

3. Discussions

Preliminary test with healthy volunteer

a) Ipsi model

The changes of the latencies of when the both sounds of the virtual tinnitus stimulation and the phase shifted sound were loaded and of control were shown in fig.4. In five out of seven volunteers, the latency of wave-five in ABR test of when the both sounds were input prolonged by the phase shifted sound to the virtual tinnitus sound, compared to that of control. Although the latency became delayed up to 0.66msec in the case of the virtual tinnitus sound of 500Hz, the latency became shortened in the case of the virtual tinnitus sound of 2000Hz. In the results of t-test, a comparison showed no significant differences in the delay of the latency.

b) Contra model

In five out of seven volunteers, the latency of wave-five in ABR test of when the both sounds were input prolonged compared to that of control and the latency became delayed up to 0.87msec in the case of the virtual tinnitus sound of 500Hz. In the case of 2000Hz, the latency became delayed in three out of seven volunteers and the delay time in that moment was up to 0.58 msec. However, there was no significant difference.

Main examination with patients

The delay times of the latency after the input of the phase shifted sound were 16.0 microseconds and 18.0 microseconds. On the other hand, VAS score of the both patients also decreased, the score of a patient became from 36 to 28 points and the score of an another patient reduced from 26 to 24 points. (Table 2.) These results mean the improvement of tinnitus and suggest the efficacy of a novel treatment method for tinnitus. Additionally, the results might suggest the potential of that the system was able to convert the subjective tinnitus to objective information. However, a further investigation about the treatment method utilizing a phase shifted sound for tinnitus would be needed because there were no significant differences in this study.

4. Conclusions

A novel treatment method for tinnitus was proposed and the efficacy of the method was evaluated with healthy volunteers and patients with tinnitus. In the results, the prolonged delay time of the latency and the decreasing of the subjective symptom were shown and these results suggest the phase shifted sound to tinnitus sound might have the noise-reduction effect.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-640

Development of a Handwritten Note-Taking System for the Support of Hard-of-Hearing Students Participating in Lectures

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Abstract. Objective Note-taking can be used during lectures to make reasonable accommodation for hard-of-hearing students. Focusing on handwritten note-taking, we have developed a new system aimed at providing better support in terms of reasonable accommodation.
Main Content In Japanese higher education, there is an increasing awareness of the importance of reasonable accommodation for students with disabilities. Hard-of-hearing students are provided with note-taking support that helps ensure understanding by providing them with note-takers who write down the lecture content. Usually, two note-takers are assigned to sit together with a hard-of-hearing student. This three-person group typically sits in the first row of the classroom, away from the rest of the class. The eyes of the assisted student are often focused on their notes and tend to miss the subtle facial expressions of the teacher as well as any visual aids that may be projected on the classroom screen. These classroom conditions may decrease the sense of involvement or participation in the class for hard-of-hearing students. To address these issues, the author developed a handwritten note-taking system.
Results and Conclusion The results from experimental use of the device in a classroom environment suggests that it can help hard-of-hearing students regain a sense of involvement or participation in their class, because they are able to sit away from their note-takers and find seats of their own and can choose to sit closer to their classmates.

Keywords. Hard-of-Hearing, Reasonable Accommodation, Note-taking, Digital Pen, Assistive Technology.

Introduction

There are two types of note-taking: handwritten note-taking and computer-based note-taking[1][2]. For handwritten note-taking, a hard-of-hearing student (hereinafter, the assisted student) sits next to note-taking assistants (hereinafter, assistants) and accesses information by viewing the content that has been written in pen on notepaper. For reasonable accommodation in university lectures, there are normally two assistants for one assisted student, and support is generally provided by having the three people sit together in a row, with an assistant on either side of the assisted student [2].

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Computer-based note-taking is becoming more prevalent because more information can be provided per unit time than is possible with handwritten note-taking.

When 20 hard-of-hearing students were asked whether they preferred handwritten or computer-based note-taking, 7 replied "handwritten," 6 replied "computer-based," and 7 indicated no preference. From this result, we can see that there is persistent demand among students for reasonable accommodation based on handwriting. On the other hand, observing the situation from the standpoint of the teaching staff, there was a strong impression that, with handwritten note-taking, the assisted student is stretched to full capacity just looking at the notepaper because of the positional relationship between the assisted student and the assistants. The assisted student does not have sufficient spare capacity to direct their gaze toward the facial expressions of the lecturer or toward the writing on the blackboard and slides being projected (Figure 1).

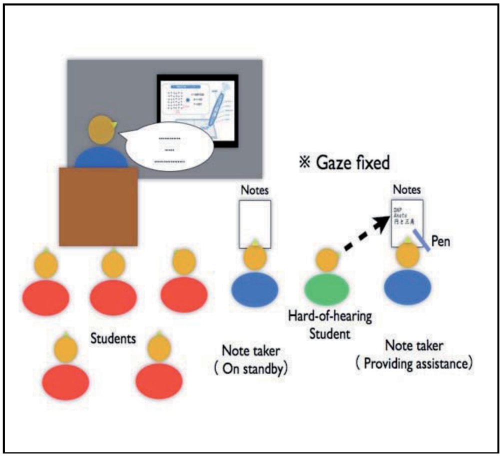

Fig. 1. Schematic diagram of support based on handwritten note-taking.

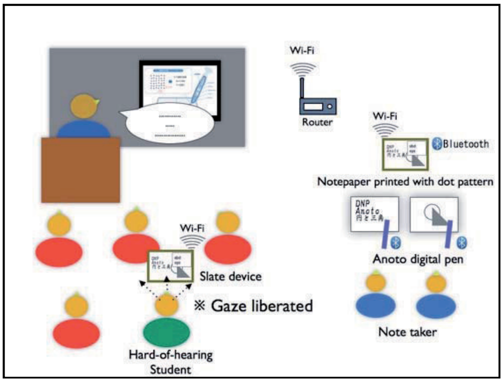

Fig. 2. Schematic diagram of proposed system.

Generally, reasonable accommodation for hard-of-hearing students is envisioned as providing the words spoken by the lecturer as text information as accurately as possible. However, we believe that genuine reasonable accommodation is possible only by providing support in a way that enables hard-of-hearing students to take classes with a sense of participation and inclusiveness, in a way that includes other students and teaching staff, as well as the environment that surrounds them. We also believe that a key point is to produce relationships that make it possible to perceive the facial expressions of those present and the atmosphere of the venue[3].

1 Proposed Handwritten Note-taking System

Figure 2 shows a schematic diagram of the proposed system. The assistants use digital pens (manufactured by Anoto Group AB) to record the content of the lecture on special notepaper printed with a dot pattern. The handwriting data from the digital pens are sent to a Windows OS 7 computer. The assistants can use the computer screen to check whether the data is being transmitted correctly.

The assisted student receives information support on the screen of a slate device such as an Apple iPad that is connected to the computer via wireless LAN (Wi-Fi). Splashtop Streamer is installed on the computer and Splashtop Remote Desktop (Splashtop Inc.) is installed on the iPad, so that the content displayed on the screens of the computer and the iPad mirror one another.

With note-taking situations in mind, we tested several digital pens that are currently commercially available in Japan, and found that the digital pen manufactured by Anoto (a Swedish company) allowed for a normal writing speed. Figure 3 shows the mechanism of the Anoto digital pen[4]. A digital pen with a camera embedded in its tip is used to write on paper printed with a fine dot pattern. Real-time handwriting data is sent to a computer via a wireless Bluetooth connection.

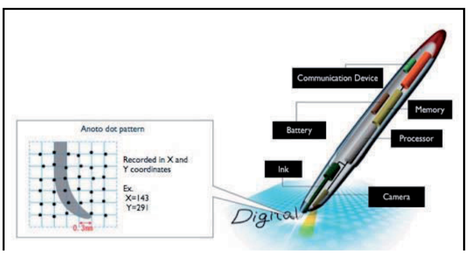

Fig. 3. Mechanism of the Anoto digital pen (Source: Dai Nippon Printing Co., Ltd.).

With this system, multiple digital pens can be used simultaneously (up to four at a time). For example, one way in which the system could conceivably be used when support is provided by two assistants would be to prepare two identical sets of notepaper printed with dot patterns and then have one of the assistants transcribe the content of the lecture while the other assistant fills in supplementary explanations or diagrams. Furthermore, by providing the assisted student with a digital pen and paper printed with a dot pattern, the assisted student can transmit messages to the assistants via the computer display. Because the assistant's computer and the assisted student's iPad are connected via a wireless LAN, the assisted student is able to sit next to their friends or anywhere they like, even in a large lecture theatre, and still participate in the lecture.

Fig. 4. Scene from a classroom trial run In the image above, the assisted student is located at the far right, where they can access information via a slate device that is readily at hand.The two people on the left in the foreground are the assistants.

2 Trial Run of the Development System

Figure 4 shows a scene from a classroom trial run. The assisted student decides for his or herself where to sit, so that they can see the lecturer and the screen easily. The two assistants sit on either side taking notes (Figure 4).

After each lecture, we sought feedback from the assisted student and the assistants, and made modifications where possible if there were aspects that needed improvement. Assistants swap roles when they reach the end of each notepaper page, so that the primary note-taker becomes the secondary note-taker and vice versa. Because of this, we devised a design for the notepaper so that assistants are clearly aware of whether they are the primary or secondary note-taker. Figure 5 shows the content displayed on the assisted student's slate device (iPad).

The handwritten information from the two assistants is unified in a single screen.

3 System Assessment

We conducted a four-month assessment of the note-taking system in an actual classroom environment with the cooperation of 4 hard-of-hearing students (A, B, C and D; "assisted students"), all of whom have sensorineural hearing loss and had received assistance from handwritten/computer-based note-taking systems in the past. We also enlisted the cooperation of 3 note-taking assistants (E, F and G; "assistants"), all of whom had at least one year of note-taking experience.

We asked the assisted students to assess the system with regard to three aspects: (1) utility ("Is this system useful?"), (2) reliability ("Can the system be trusted to work when needed?"), and (3) expectation ("Are you looking forward to the system being put into common use?"). We also asked the assistants to assess the system with regard to three aspects: (1) operability ("Is the system easy to use?"), (2) reliability ("Did the system work when needed?"), and (3) expectation ("Are you looking forward to the system being put into common use?"). We rated each item on a five-point scale from 1 (lowest) to 5 (highest).

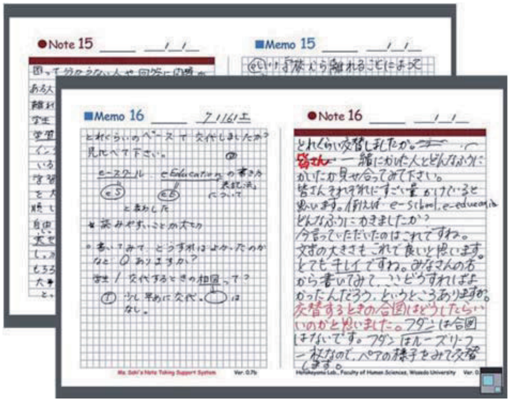

Fig. 5. Example of content displayed on the assisted student's slate device (iPad).

The results of these surveys are presented in Figure 6 using a rader chart. In the free-response question section, we asked the assisted students and assistants what they considered were the benefis of the system and what points they would like to see improved.

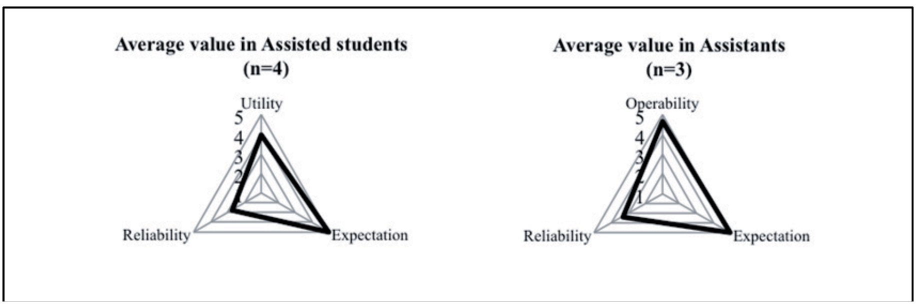

Fig. 6. Survey results.

3.1 Benefits

a) Comments from assisted students
- It's nice to be able to sit with my friends instead of next to an assistant.
- It's much easier to pick up information now that the assistant's hand is no longer in the way.
- I like the way that the assistant can use various colors to emphasize certain points; it makes things much easier to understand.
- It's easier on my neck, now that I don't have to keep looking back and forth between the notes and the lecturer's screen, or to keep peering down at the notes.

b) Comments from assistants
- I can immediately see what the other assistant has written, so it's much easier to fill in the gaps.
- Because the assistant and assisted student setup the devices together, there is more two-way interaction, it is no longer a case of us simply helping them.

- Physically speaking, it makes note-taking quite a bit easier, in that we no longer have to contort ourselves into strange postures so that the assisted student can see what we write.

3.2 Points for Improvement

a) Comments from assisted students
  - I felt somewhat uneasy, because if something goes wrong and you are seated away from the assistant, there is no way to let him or her know.
  - I wonder if you can't make the system lighter; I feel bad when I see the assistants lugging around so much equipment.
  - It would be nice if it were possible to input the lecture notes beforehand so that we could see exactly where the lecturer is within his or her presentation at any particular time.
  - It would be great if you could combine the handwritten text with the keyboard input sometime in the future.

b) Comments from assistants
  - The grip on the digital pen is too thick. It would be nice if it were thinner, so our hands don't get tired after writing over a period of time.
  - The system is heavy with a weight of about 3 kg including the carrying case. On rainy days, it's hard to make it to the classroom with that in one hand and an umbrella in the other.

4 Discussion

The results of these assessments show that both assisted students and assistants generally think well of the note-taking system. Furthermore, everyone seems to be looking forward to the day when the system is put into common use. With regards to its strong points, we note that the system does indeed contribute toward our efforts to promote participation and inclusiveness on both sides, with the assisted student taking a more active role in the learning process and the assistant freed of some of the burden of providing assistance.

Some trouble was encountered early in the trial when the assistants found themselves unable to enter handwritten notes. Although this problem was later resolved by correcting a software bug, it did act to diminish the general sense of system reliability. The lesson drawn from this is that, even with one case of system trouble ,it can produce considerable anxiety on the part of the assisted student, who is generally seated away from the assistant and thereby unable to communicate with him or her, thus raising serious doubts about overall reliability.

5 Conclusions

In our ongoing efforts to develop a note-taking system to help hard-of-hearing students participate in lectures, we have proposed such a system and tested its applicability within actual class situations. We found that our system is indeed effective within such classroom environments and that both assisted students and note-taking assistants are eagerly looking forward to the time when the system is put into common use. We have identified several issues for improvement and will seek to resolve them as we work towards that goal.

Acknowledgements

The authors thank Ms. Saki Shimamura (now at the Speech Pathology and Audiology Department of the College of the National Rehabilitation Center for Persons with Disabilities); Mr. Takuo Suginaka, who worked enthusiastically to improve the support environment for the assisted student; the staff of the Disabled Student Services Office, Waseda University; and Mr. Soichi Tsurukawa and Mr. Kosuke Sugihara of Dai Nippon Printing Co., Ltd., who provided technical support.

The authors are grateful to Mr. Kevin Gallagher of the Icebreaker Project in Taiwan who has been in active discussion with us regarding assistive technology .

This work was supported in part by KIBANKEISEI 2012 MEXT Japan, MEXT KAKENHI Grant Number 25350298 and a Waseda University Grant for Special Research Projects（Project number : 2012B-226）.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-647

Continuity of Tactile Walking Surface Indicators and Audible Pedestrian Signals at Crosswalks

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Abstract. Crossing an intersection is one of the most risky actions for a visually impaired person. A visually impaired pedestrian is guided to the crosswalk entrance by the tactile walking surface indicators "TWSIs". It is then important that he/she safely and smoothly cross the intersection using the audible pedestrian signal. However, neither connectivity nor the continuity between the TWSIs and the audible pedestrian signal travel support systems has been verified. The purpose of this research is to verify this connectivity and continuity. It should be possible to acquire basic scientific data for developing guidelines from the findings of this research.

Keywords. Tactile walking surface indicators, Audible pedestrian signals.

Introduction

Crossing an intersection is one of the most risky actions for a visually impaired person. The authors have been researching the standardization of tactile walking surface indicators “TWSIs” for blind or visually impaired persons. The International Standard of acoustic and tactile signals for pedestrian traffic lights for vision impairment and persons with vision and hearing impairments was promulgated in November 2007. The International Standard of TWSIs for blind or visually-impaired persons[1] was promulgated in March 2012. A visually impaired pedestrian is guided to the crosswalk entrance by the TWSIs. It is then important that he/she safely and smoothly cross the intersection using the audible pedestrian signal. However, neither connectivity nor the continuity between the TWSIs and the audible pedestrian signal travel support systems has been verified.

An independent experiment has already been conducted to evaluate the walking characteristics of the crosswalk. Experiments have also been conducted on many electronic travel aids such as Talking Signs[2]-[8]. However, no research has examined the interrelation of the TWSIs and the audible pedestrian signals at intersections. The purpose of this research is to verify this connectivity and continuity. Figure 1 presents examples of crosswalks in the Netherlands. The lamp pole and the audible pedestrian signal are installed in the center of the crosswalk. Figure 2 presents an example of a crosswalk in Japan. A common pole is installed outside the crosswalk for the lamplight

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Figure 1. Example of a crosswalk in the Netherlands

Figure 2. Example of a crosswalk in Japan

Figure 3. Indoor laboratory.

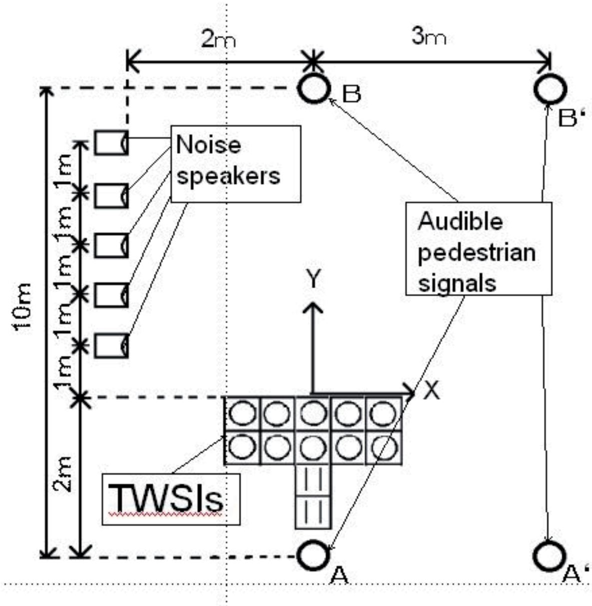

Figure 4. Experiment layout.

and the audible pedestrian signal. Lamp posts for pedestrians are installed in the centers of crosswalks in the Euro zone in Germany and in the Netherlands. A pedestrian can cross from the center of the crosswalk entrance to the opposite side using the lamppost alone. Because the audible pedestrian signal is installed on a common pole with vehicle signals in Japan, it cannot often be set up at the center of the crosswalk. It should be possible to acquire basic scientific data for developing guidelines from the findings of this research.

1 Methodology

Our laboratory can reproduce a crosswalk and an intersection (Figure 3). These speakers in Figure 3 reproduce the noise in an actual intersection. This laboratory facilitates safe and reproducible experiments. The TWSIs for a visually impaired person, a speaker for audible pedestrian signals, and the speaker for the noise were set up as shown in Figure 4 to simulate the intersection surroundings. The speaker for audible pedestrian signals was positioned 3m from the center of the TWSIs and the center of it. “A” in Fig. 4 is the center of the crosswalk entrance. “B” is center of the opposite side. “A’ ” is positioned 3m from the center of the crosswalk entrance TWSLs. “B’ ” is positioned 3m from the center of the opposite side. Speakers annunciating four audible pedestrian signals were placed at the crosswalk entrance and exit. The height was 3m. The speakers for intersection noise were 1.12m high and placed at intervals of 1m.

The experiment was conducted as follows. The subject stands on the caution patterns at the crosswalk entrance and always crosses when the noise and the audible pedestrian signals are playing. The intersection noise simulates a car is approaching in parallel and to the left of the crossing direction. The audible pedestrian signals are generated at the entrance and exit of the crosswalk. The audible pedestrian signals were sounded in pairs. The subject stands in the guiding pattern block behind the crosswalk entrance. This position lies on the centerline of point A at the center of the crosswalk entrance. The subject is told that this a crosswalk entrance. When the subject walks along the guiding pattern block, he/she is told that the attention pattern block is on the boundary of the crosswalk and the roadway. The subject acquires the travel direction by detecting this guiding pattern and attention pattern block through the soles of the shoes. The experimenter directs the subject to walk as usual in the crosswalk. In this walking experiment, the subject did not use the white cane. There are no TWSIs at the exit of the crosswalk, and the experimenter stops supporting the subject's walking about 6m into the crosswalk. The experimenter records the position at which the subject was stopped and calculates the deviation from the center from the measured position data. The actual experiment was conducted with speakers for the audible pedestrian signal in three combinations "center – center", "right edge- center", and "right edge - right edge". There were 20 trials per combination, for a total of 60 experiments, and there were 20 subjects. All subjects ware blinds. Table 1 lists the subject's characteristics.

2 R & D and Results

The relation of a visually impaired person's behavior and the installation position of audible pedestrian signals was examined when the person crossed the crosswalk. The subjects' deviation from the center is presented in Figure 5 through 7. Figure 5 illustrates the result of the center and the center at the speaker. Figure 6 illustrates the result of the right edge and the right edge at the speaker. Figure 7 illustrates the result of the center and the right edge at the speaker. Here, the crosswalk is 4m wide. When the distance from the center is 200cm or more, the pedestrian walks off the crosswalk. Table 2 presents the ratio which comes off from the crosswalk of deviating from the crosswalk for each combinations. Clearly, the pedestrian follows the sound of the audible pedestrian signal. Table 3 lists the average and the standard deviation of the deviation for each combinations. A significant difference was revealed by the Student's t-test. There was a significant difference at a significance level of 1% in all combinations.

Table 1. Subject characteristics.

	Number of subjects	Average of Age	SD(age)
Male	10	56.0	8.67
Female	10	63.9	7.96

Table 2. The ratio which comes off from the crosswalk of deviating from the crosswalk for each combinations.

position of signals	Frequency which deviates to the right side	Frequency which deviates to the left side	Deviating ratio (%)
center - center	10	0	2.5
right - right	40	0	10.0
center - right	54	0	13.5

Table 3. The ratio which comes off from the crosswalk of deviating from the crosswalk for each combinations.

position of signals	center-center	right-right	center-right
Average(cm)	30.1	65.2	87.6
SD(cm)	264.7	270.1	277.2

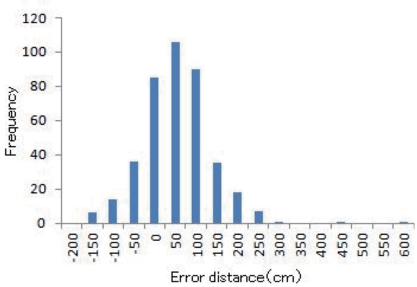

Figure 5. Histogram of error distance "center – center"

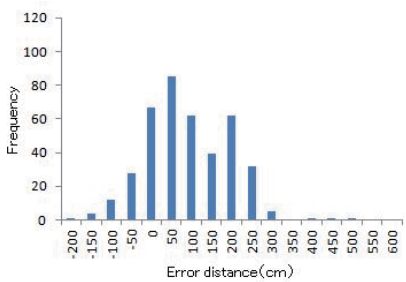

Figure 6. Histogram of error distance "right edge - right edge"

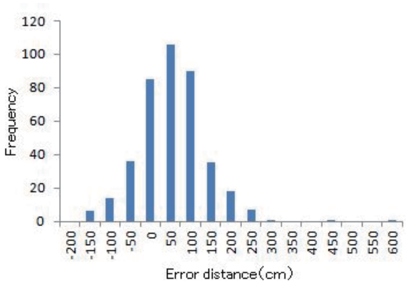

Figure 7. Histogram of error distance "center - right edge"

3 Impact or Contributions to the Field

Many experiments have been conducted for visually impaired persons. In such experiments, it is important to present scientific, quantitative data for system design. Even if you understand either to vaguely good or bad, it is necessary to present the evaluation quantitatively. This paper has demonstrated that the position of the audible pedestrian signals at crosswalks was important for a quantitative comparison. It becomes the mainspring of the approach for the development of laws by showing scientific grounds.

4 Conclusions and Planned Activities

Experiments were conducted in three experiment environments with speakers for audible pedestrian signals installed in different locations. The speakers were installed in three patterns "center – center", "right edge - right edge", and "center - right edge". The experiment results indicated that the continuity of the inducement of the center -

center combination is superior to that of the other combinations. Visually impaired persons are led to the center of the crosswalk on the opposite side by the audible pedestrian signal. Next, there is one-place peak in Fig. 6 besides the center. Though the pattern for the right edge - right edge combination can extend to the center of the opposite side in the crosswalk as well as the center - center combination, the subject was led to the audible pedestrian signal on the opposite side but occasionally deviated to the right. In Fig. 7, the center - right edge combination deflects more to the right than the other combinations. Because the visually impaired person is induced led toward the speaker as well as the pattern for the center - center combination. The center - center combination has come off from crosswalks most causes the subject to walk off the crosswalk the most. It is necessary to construct the TWSIs and install the audible pedestrian signals to secure their continuity. Finding an approach for development of laws is a pressing need. This work was supported by JSPS KAKENHI Grant Number 24500646.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-653

Making Brainstorming Meetings Accessible for Blind Users

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Abstract. Co-located meetings, as a fundamental part of our professional and educational lives heavily rely on visual information. In such meetings visual information consists of a) the artifact or "content" part (as for instance in brainstorming meetings the mind maps) and b) of nonverbal communication elements (like deictic gestures and gazes). Blind persons to a large extent do not have access to these important aspects of information and communication which are only available via the visual channel. Personal support is considered to be the only viable solution, but can only be made available in exceptional cases. This puts blind people at a disadvantage. This paper presents first research results focusing on tracking, analyzing and representing non-visual information and communication elements to blind people to allow more independent access and participation in communication. We present a general system architecture as well as a prototype implementation presenting visual information also to blind users, so that the information gap between sighted and blind participants is reduced in co-located meetings. These activities form the basis for our future research activities on access to non-verbal communication for blind people.

Keywords. Multimodality, Mind Map, Blind Users, Accessibility.

Introduction

In our ongoing work a brainstorming meeting using a touch table to display the artifacts as a mind map is selected as an example for co-located meetings, because brainstorming meetings include high dynamics in the communication. They include changes of speakers, changes of non verbal communication elements as for instance deictic gestures and gaze and dynamic changes of the artifact at focus during a meeting. In this paper we will focus especially on this artifact level in co-located meetings, how we could provide better access to mind maps. Besides that, research has been started on how to track and represent non-verbal communication cues.

1 State of the Art Analysis and R&D Principles

In this section we will present the results of an in-depth state of the art research related both to a) access and accessibility of software and tools used in co-located meetings, in particular mind mapping tools and b) access to non-verbal communication beyond personal support. The result of this literature research shows that very few has been

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done so far to support blind people in these settings. Reasons are most probably due to the obvious need to prioritize other domains of accessibility (e.g. text, STEM, video and other graphical elements) and due to the restrictions in technical possibilities of tracking and analyzing non-verbal communication cues. This has changed considerably over the last years, in particular regarding the availability of tracking and analyzing tools for non-verbal communication elements. We will present an overview of the basic approaches allowing independent access of blind people to non verbal communication.

In the field of access for blind users to artifacts in co-located meetings, in particular mind maps, approaches are mostly employing two dimensional haptic dynamic displays [1] which are so far not available on the market and tend to be very expensive. In addition to that, two dimensional representations may cause a blind user to become disoriented and overlooking dynamically changing elements. Two dimensional representations do not substitute the need for systematic search besides linear or linked browsing of the information provided. If used as the only tool for both blind and sighted people in the meeting, blind users would disturb the other users while reading with their hands. As mentioned above, dynamically changing elements have a high risk to disorient the blind user which is worthy of mention in comparison to geographical maps, where several efforts have been made during the past years to make them accessible to blind users [2]. The research showed that far no viable solution for using mind maps in co-located meetings by the sighted and blind user at the same time are available.

It was therefore agreed as a fundamental principle of our research approach, that we must not interfere with the visual representation and interaction. This holds true for a PC as well as modern devices like the Microsoft Pixelsense (http://www.microsoft.com/en-us/pixelsense). We therefore extended the existing mind mapping tool to provide a synchronized and structured representation on state of the art technology for blind people (Braille display and speech output) similar to [3]. Here Kamel and Linday suggest using dedicated input and output devices for the blind at cost of high synchronization needs rather than trying to hook blind users into the view of the sighted users. Moreover we decided that this representation (e.g. tree view) should support well known functionalities as e.g. searching, collapse and expand of levels and cross-linking, but also adding, deleting, changing and moving elements to allow contributing to the co-located activities. The following issues have been identified as essential for any solution for access to mind-map sessions:

- Access by blind people must not interfere with other users.
- Representations, i.e. the visual and the non visual one, always have to be synchronized.
- Blind users have to have the same options as other users (e.g. adding, deleting, moving, grouping, highlighting, linking, …)
- The blind user has to be made aware of any changes done and the system has to allow tracking the changes.

State of the art research on non-verbal communication came up with a similar result. However they are mostly restricted to the domains of a) analysis and importance of non-verbal communication [4] and b) gesture tracking and recognition, e.g. sign and sign language recognition [5]. Very few has been done regarding access to non-verbal communication.

As it comes to gesture recognition and tracking, there is an ongoing trend to utilize the availability of affordable technologies as for instance the Microsoft Kinect (www.xbox.com/kinect) as well as the upcoming Leap Motion (https://www.leapmotion.com). This technology can be also employed for complex settings like co-located meetings, as a basic source for non-verbal communication cues. However, no information was found on approaches for testing and experimenting with these tools for making non verbal communication accessible to blind users.

This in-depth state of the art analysis and intensive workshops and discussions led to first concepts and design ideas for better access to non-verbal communication and artifacts like mind maps frequently used in co-located meetings.

2 A Software Tool to Represent Mind Maps to Blind Users

In this section an overview of the implemented tool for presenting the mind map to the sighted user as well as to the blind user will be given. The tool overcomes predictable problems for the blind user as for instance positions of elements on the display, colors of elements and dynamical changes of the mind map by rebuilding the layout of the mind map and including an alert system which informs the blind user when a change occurred to the mind map.

2.1 System Architecture

The architecture consists of four layers as shown in figure 1. Based on our experiences when developing application in smart spaces [6] we employ the pub/sub paradigm. Here, communication among components happens via subscriptions to channels identified by a name. The underlying network is transparent and the involved components can even be distributed over multiple computers. In our case, this allows us to easily add and remove further components, such as additional input and output devices or further preprocessing components to infer higher-level information.

The actual model is stored in the Persistence Layer. For now, only the MindMap Model is implemented.

Following the MVC pattern, updates to the Persistence Layer are made by the Model Update Controller in the Controller Layer. Vice-versa it will also report changes of the model. Different representations to cope with individual presentation needs are thus synchronized as suggested in [7]. In future iterations we will extend this to also include reasoning e.g. to give rendering hints for particular devices. We expect model changes to occur frequently. Hence, we foresee a filtering mechanism to keep the cognitive load for blind users as low as possible.

The actual implementations of the mind mapping software for blind and sighted users reside in the Application Layer. Both are described in more detail in the following section.

Finally, the Input/Output Layer will contain the various input and output devices, such as the Microsoft Pixelsense, the Microsoft Kinect and a Braille display.

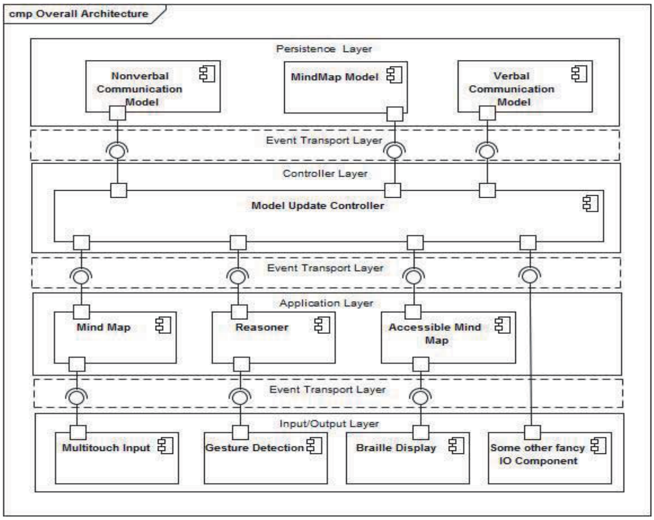

Fig. 1. Architectural overview of the system.

2.2 Model Structure for Holding the Mind Map

Despite the fact that today mind mapping tools exist, which allow for a graph structure between the nodes of the mind map, the basic structure of the implemented MindMap Model is a tree. Comparing tree structures to graphs, trees are beneficial since they feature a unique path to any element. In comparison to alternative exploring techniques of a screen by a blind user, as they were presented in [8], a tree structure has the big advantage that it can be navigated, interpreted and manipulated by a blind user in a way the blind user is already familiar with from other software environments as for instance the Windows explorer. Furthermore using a tree structure and a Braille display accompanies a small risk of overlooking elements by the blind user.

In further iterations the tree structure can be extended by using a second different type of link between the nodes. This gives the possibility to still have a clear tree structure but also represent further correlations between the bubbles. In case a node has a second link, this link can be presented to the blind user as extra information.

2.3 View for Sighted User

The mind mapping tool is running as a .net (http://www.microsoft.com/net) application on a Microsoft Pixelsense. Here, the sighted participants are able to collaborate on the map. Modifications of a standard mind mapping tool are limited to forwarding changes to the Model Update Controller and to update the view if changes have been made by blind participants.

2.4 View for Blind User

The presentation for blind users is running as well as a .net application in which all elements have to be accessible by a screen reader. In figure 2 a screenshot of the blind user view is shown.

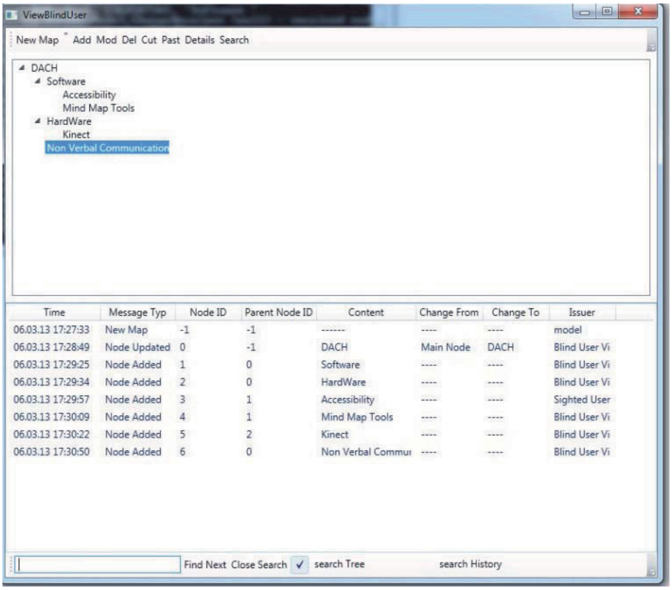

Fig. 2: Blind User View.

The view mainly consists of 4 parts. The first one is the menu bar for the buttons that includes the functionality for the blind user as for instance add or delete a node. The second part is the TreeView which represents the mind map as a tree which can be navigated by a blind user in a way he/she is already familiar with from other software environments. The third part is a ListView which includes the history of the modifications of the mind map, which gives the blind users the possibility to look up modifications later on. Finally, the fourth part is a menu bar to enable search functionality, giving the user the possibility to search the tree as well as the history for special content. To allow the blind user for an easier overview and a faster handling of the tool the search-bar can also be closed.

The presentation for blind user also includes notifications via a message box in reply to changes of the mind map. It is also used to offer shifting the focus to the modified element in the tree.

2.5 First User Tests

The prototype of the system (excluding the part of the non verbal communication) was tested in two short sessions between a sighted and a blind person. The two blind users were running different screen readers.

Despite the fact that the different screen readers showed different behavior about the accessibility of the blind user view, the view was generally accessible for both users. Only a few improvements considering the accessibility were suggested. Both blind users appreciated the intention to present the mind maps to different user groups with different views. Also the inclusion of an alert system to inform the blind user about modification of the view and give them the possibility to jump to the modification or to stay at the node where they had been before the modification happened, was judged by both user as a good solution for the synchronization of the different views. Both users positively mentioned the possibility to have a history, which can be used as a fall back strategy if they have missed some changes in the mind map.

From the perspective of the sighted participant the sudden appearance of new nodes was not considered to be disturbing. Reasons may be found in the verbal communication between the sighted and the blind user which included hints about the next steps of the communication partners.

3 Conclusions and Outlooks

In the first prototype only the artifact level of co-located meetings was considered from a brainstorming meeting. Making that level accessible and thereby not excluding blind people form relevant information as well as to give them the possibility to actively manipulate the artifacts considerably improved the integration of blind people into co-located meetings. Nevertheless blind people should not only have access to the artifact level but also to the non verbal communication level. Therefore we aim to include the non verbal communication model into the prototype as the next steps in our research.

Later on we will also extend our prototype to utilize other methods for input and output allowing access to non-verbal communication in parallel to explicit (verbal, written, graphical) information. We will also continue with evaluating tracking technology which we plan to apply for making non-verbal communication elements accessible.

Project Partners: ETH Zürich, TU Darmstadt and JKU Linz

Acknowledgements

This work has been partially funded by the D-A-CH project #CR21I2L_138601.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-659

The Impact of Presentation by Voice Media on Reading Speed when Visually Impaired Persons Read Complex Text Including High-level Content

Does Voice Presentation really improve Information Processing Speed?

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Abstract. The task of this paper is to clarify the impact of text presentation media on reading time of complex text that includes high-level content by visually impaired persons. Doubts remain as to whether the ability of visually impaired persons to hear and understand voice content more quickly would function when reading such text. Reading speed decreased in the order of presentation by voice media and braille booklets, revealing a significant difference between the two. On the other hand, it is difficult to imagine that the reading speed of complex text that includes high-level content using voice media can be approximated to the information processing speed of persons without impairment.

Keywords. Reading speed, voice media, visually impaired persons, complex text that includes high-level content.

1. Scope of This Paper

This paper analyzes the impact of presentation by voice media on reading speed when visually impaired persons read complex text that includes high-level content. Here, **complex text that includes high-level content** refers to text at a level required to be read in university or other higher education courses (abbreviated below to **high-level text**).

A perception widely shared among those involved in visual impairment support is that visually impaired persons can hear and understand voice content at higher speeds than those without impairment. This perception has been formed by observing the habit of increasing tape playback speed when listening to voice cassettes of readings from books, and the practice of setting the highest available speed of voice output in screen reader software that reads data displayed on a computer screen.

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This perception is supported not only by empirical observation but also, to a certain extent, by monitor experiments. In a multi-subject experiment, Asakawa et al. found that visually impaired persons can listen to the spoken material 1.6 times faster than the maximum speed of the tested text-to-speech (TTS) engine (878 morae per minute). They could understand at least 50 percent of the information at the rate of 1,300 mora per minute or 500 words per minute. Therefore the authors advocated the need for further improvements in the speed of TTS engines [1]. Thus it is also reasonably inferred that visually impaired persons can hear voice content far faster than sighted persons [2] .

For persons with severely impaired vision who read and write using braille or enlarged characters, the speed of reading using these textual media is severely limited. This leads to expectations of information presentation using voice media based on the ability of visually impaired persons to hear and understand voice content. Even in a research which aimed to utilize tactile perception to access to the graphical information, it is accepted that, on the speed of reading, voice output of screen reader software can be compared favorably with ordinally screen output [3] .

On the other hand, doubts remain as to whether this ability of visually impaired persons to hear and understand voice content more quickly would function in the same way when reading complex text accompanied by high-level thought processes. The format of entrance exams and qualification tests for examinees with visual impairment, and particularly the time allocated for these, will provide useful reference as a concrete expression of these doubts. For persons with severely impaired vision, exam questions are set using test media that they can use, specifically braille, enlarged characters or voice. When doing so, the test time is usually extended to prevent any unfairness arising from limitations on the speed of reading the test media. The length of this time extension is generally at least 1.5 times the test time for persons without impairment taking the same test [4], [5] . When using voice media to set questions, however, the practice of applying a reduced time extension factor to exams has not been established. In research on test questions using voice media in recent years, it has been suggested that this would require about the same time extension factor as when using braille booklets, or a higher one [6] .

There are thus two conflicting perceptions — the first, that visually impaired persons can hear and understand voice content at higher speeds than those without impairment; and the second, that the time extension factor required for questions using voice media for visually impaired persons is the same as or higher than when using media where the speed is thought to be limited, i.e. braille and enlarged characters. To reach an integrated understanding of these two perceptions, they will need to be studied in detail, and positioned within the specific problem framework adopted by this paper.

First, let us consider the perception that visually impaired persons can hear and understand voice content at higher speeds than those without impairment. In this kind of perception, the difficulty level of the targeted text is generally not seen as a matter of concern. For example, Asakawa saw her task as being to measure the ability to hear single words or sentences. In her experiment, the aim was to measure the ability to hear simple voice content; she did not attempt to measure the ability to read **high-level text** . On the other hand, Asakawa also states that the difficulty level of words and sentences presented by voice media does have an effect on the ability to hear [1] .

Next, the perception that the time extension factor required for questions using voice media for visually impaired persons is the same as or higher than when using media in which the speed is thought to be limited. The process of answering exam questions includes thought processes that lead to solving a problem and the process of entering answers in the format required by the question, in addition to the process of reading complex text. In the actual process of answering questions, these processes sometimes proceed in parallel in a barely distinguishable form, making it difficult to deduce what proportion of the question answering time is devoted to reading the text. The second reference case [6] is an evaluation experiment for a specific testing method. The possibility should be considered that the question answering time is affected by the methods of voice testing and entering answers used in this method. Differences between two perceptions are summarized Table 1.

Based on an organization of the problems so far, the task of this paper is to clarify the impact of text presentation media on reading time of **high-level text** by visually impaired persons, and in particular to compare text presentation using voice media with that using other media. The ability to read complex text is indispensable for employment in higher education and intelligence-based professions. Investigating what sort of media can most efficiently manifest ability for visually impaired persons is also important in terms of encouraging the self-reliance and social advancement of such persons. On accessing information by them, it is widely claimed that the slowness of reading contents is the most severe problem. Accepting this perception, the experiment which described below is focused on the reading speed. And a comparison is limited to between two media — voice and character(braille). In this moment, only these media are practical candidates to enable to process information in higher education and intelligence-based professions.

Table 1. Differences between two perceptions.

	Asakawa's experiment	The practice of exams with visual impairment
Compare with	Persons without impairment	The test time using braille booklets
Task	To understand simple voice content	To read, to solve and to enter answer tests
Contents	Single words or sentences	**High-level text**

2. Multi-subject Experiment

2.1. *Outline of Experiment*

To evaluate the impact of voice presentation on the time taken to read **high-level text** by visually impaired persons, the effect of two text presentation methods (i.e. presentation by voice media and presentation by textual media) on the time needed to read the presented **high-level text** was analyzed.

The subjects were divided into two groups of five for each method, totaling ten subjects in all. All of them were persons with severely impaired vision who satisfied certain conditions, namely that they were enrolled at ordinary universities, they used braille and had done so for at least eight years, and they used a personal computer equipped with a screen reader on a daily basis for their university studies.

The two methods of presentation were voice media and textual media (braille booklets) that could be used by the subjects. These were presented under the following conditions, to ensure that the subjects' ability to read the text could be properly manifested. In presentation by voice media, subjects were asked to bring personal computers equipped with their own screen readers, and the text was presented using the text reading software (word processor and editor) used by them on a daily basis. In other words, voice content was provided by computer synthesized speech. The question text (discussed later) was provided in plain text format. The readability of the text was ensured by adding manual line breaks after each paragraph. Subjects were permitted to use functions for moving text in units of phrases or sentences provided by the reading software. However, the use of character string search functions provided by the reading software was not permitted, as it was regarded as heterogeneous to reading in voice presentation.

Presentation using textual media was made via braille booklets with single-sided printing by a braille printer. The subjects had received the majority of their primary and secondary education using braille, and it was thus judged reasonable to use the standard format of braille printed material in measuring their ability to read text.

The texts targeted for reading were divided into two types, Text A and Text B. These two texts were chosen from a collection of essays containing text used in *Japanese Language* exam questions in the National Center Test for University Admissions (a national test administered by the NCUEE to select students for university admission in Japan). The aim of this was to ensure the correct level of difficulty. The average text size was 3,805 Japanese writing characters. Then this size could be represented as 3455 morae. In this paper, in order to correspond to the English rates in words per minute, the measurements is converted to morae per minute.

The procedure was based on the process limitation method, with no limits placed on time. To confirm acts not anticipated by the experiment supervisors, such as the use of special functions in the reading software, the experiment was carried out on an individual basis and recorded by video camera for verification.

Two questions were set to confirm that the reading had been completed. The questions were designed not to require any further thought, as long as the content of the text had been understood. To confirm the subjects' overall grasp of the text, their searches for individual locations, and their detailed understanding of descriptions in those locations, they were asked to state "Yes" or "No" in each case. These questions consisted of:

1. Questions on the gist of the text (e.g. whether the author thinks that the value of currency can change).
2. Questions on statements made at specific points in the text (e.g. whether or not all admixtures that determine the color of an alloy are listed).

Questions were given at the end of the text files and braille booklets, and the subjects were made aware of this in advance. The subjects were asked to say "I know the answer" as soon as they knew the answers to the two questions, and the time of that utterance was taken as the reading completion time. After this, the answers to the two questions were confirmed orally.

Due to the nature of the experiment, the same text could not be set to the same subject groups with different presentation media. Therefore, the experiment plan took the form of a repeated 2x2 Latin square method. Table 1 shows an image of a common experiment plan.

Table 2. Experiment design concept based on a two-by-two Latin square.

		Subject Group	
		Group 1	Group 2
Trial order	1	PC(voice media)	braille booklet
	2	braille booklet	PC(voice media)

2.2. Experiment Results

Valid measurement could not be made for one of the subjects, whose personal computer malfunctioned. The results from the other nine subjects will therefore be stated below.

The effects on the speed of processes will now be described. The effects resulting from the four factors (subject groups, presentation media, text for reading, and sequence) were investigated using the t-test. The impact of presentation media, the focus of particular attention this time, will be stated in detail. In the following, the level of significance is taken as 5% in each case. In each of the tests, the normal distribution and equal variance of the population was not negated. The main effects of the subject groups, the text to be read and the sequence on reading speed were not significant in any case.

A significant main effect of the presentation media on reading speed was recognized, however. The distribution of answering speeds according to different presentation media is compared in Figure 1. Reading speed decreased in the order of presentation by voice media (average 434.33 sec.) and braille booklets (average 672 sec.), revealing a significant difference between the two (p=0.01587).

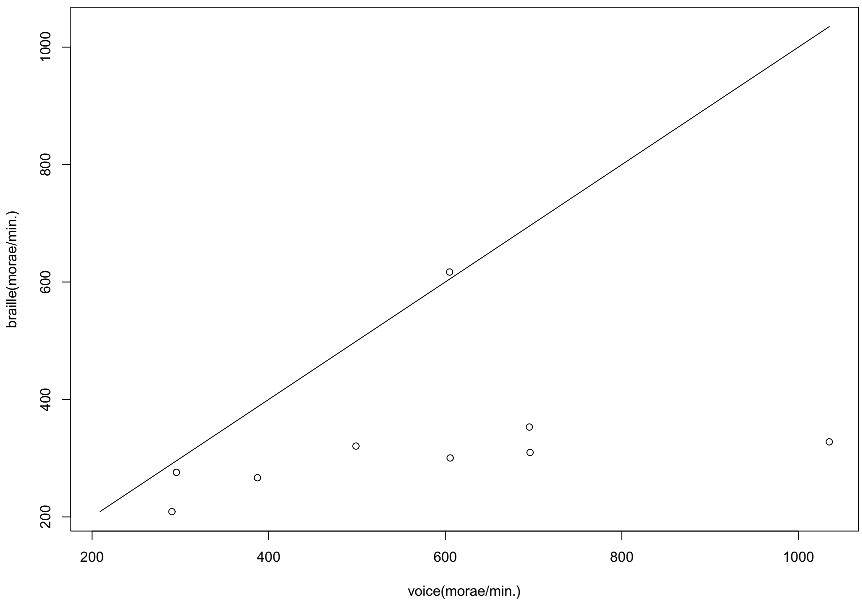

Figure 1. The effect of the presentation media on reading speed.

All of the subjects employed the strategy of reading the questions at the end of the text files and braille booklets as soon as the experiment had begun, and then attempting to read the text on that basis.

3. Conclusions and Future Tasks

In the reading of **high-level text** by visually impaired persons, it was suggested that presentation by voice media could be more effective in terms of speed than presentation using braille booklets. Effects are expected to result from researching and developing assistive technology specialized in handling **high-level text** as contents. On the other hand, it is difficult to imagine that the reading speed of **high-level text** using voice media can be approximated to the information processing speed of persons without impairment. A multi-faceted approach will surely be needed, including assistive technology that combines different presentation media and draws on the respective strengths of each [7] .

The experiment this time was designed for subjects whose mother tongue was Japanese. Similar experiments will need to be conducted in various other languages to make the analysis more universal.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-665

Virtual Mobility Trainer for Visually Impaired People

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Abstract. This paper presents a prototype [1] of a location-based and context aware system supporting blind and visually impaired people to improve their mobility skills and in particular enhancing traditional mobility training. The system supports annotating pre-defined routes with information provided in standard mobility training sessions for blind people. This allows later on to reuse the information provided in a person to person session and even to share this expertise with other people. People in need of knowing by heart a certain route can go back to the stored mobility training information to better remember and learn how to manage this route independently. The virtual mobility trainer allows making repeatedly, time independent and location-based use of information provided from a human instructor. We present a first prototype which allows designing routes, accessible to blind and visually impaired so that it can be used for mobility training. Furthermore, this tool allows performing advanced orientation tasks assisting blind people in an unknown environment. We use the Digital Graffiti framework [2] as underlying framework, which supports the needed annotation of maps with virtual landmarks.

Keywords. Assistive Technology, Mobility Training, Navigation, Localization.

Introduction

Navigation and orientation are crucial activities of human beings which need to be achieved daily. The usual way to perform these tasks involves the visual sense, which is used e.g. to recognize known places and buildings or signs and structures which are familiar to the person. This could be the sign indicating a bus stop or a store of a known supermarket chain. It is central to keeping control over any aspect of the trip. People suffering from visual disabilities need support or alternatives for these techniques. Mobility training is a well-proven method to allow blind or visually impaired people to gain such alternative skills for independent and safe traveling. People learn how to orient along haptic (e.g. white cane) or acoustic cues of the environment. Practicing avoiding dangerous situations is of utmost importance. A mobility and orientation instructor performs these trainings, which is costly in terms of time and money.
In this paper we define mobility as the ability to physically move from one place to another. People who are mobile have to navigate from one place to another. Therefore, navigation is an important term as well which includes tasks of figuring out where one actually is, called positioning. However, one still needs to know where to go to successfully travel. In Austria about 7.800 people suffer from severe visual impairment which makes it impossible for them to use their eyes for navigation and orientation [3].

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A well-proven approach to support people with visual disabilities in increasing their mobility skills is mobility training. Many individuals of this group use white canes to discover the near surrounding environment. However, the correct use of a white cane is not sufficient for an adequate mobility. White canes can be used to achieve micro-positioning but mainly to avoid obstacles. The person still needs to know the environment and store it as mental map, which is a mental image of routes and objects, such as buildings helping this person in orientation, and obstacles blocking the way. This mental map is essential for every person who has mobility issues because of a lack of eye-sight. Mobility training fuels the generation of mental maps and helps to strengthen the self-confidence of the person by re-practicing routes [4].

1 State-of-the-Art

Detailed research and studies show that there are approaches dealing with this topic. Anyhow, traditional approaches, like white canes or guide dogs, aim at detecting and avoiding obstacles [5]. This still requires the knowledge of the environment. The user would be lost without knowing his/her way from the current location to the destination. Obstacle detectors [6] are well-proven adaptations of the traditional approaches but they do not cover a broader purpose of use. Environmental image converters [7] have downsides [5] in terms of response time due to the enormous processing power which is needed to transform a sequence of images to meaningful representations understandable for the user. Besides, it is still a big challenge to additionally communicate distance. Orientation and navigation approaches suffer from inaccurate or expensive positioning methods. Tag-based infrastructures [8] are costly and time-consuming to setup [5]. Tele-assistance [9] systems unconditionally need a sighted human operator which is costly as well as decreases the independence of the user. On the other hand, some of nowadays' orientation and navigation approaches are quite cost-effective and can be operated on a smartphone. These devices are capable of positioning and communication with the user acoustically or via tactile signals. Usually they rely on GPS for positioning which works fine outdoors and provides a cheap basis for navigation, but approaches of this kind have fundamental downsides too, especially when it comes to indoor operation or accuracy in general. Applications of this category are amongst others MyWay [10], which is a system that allows blind users to create routes solely based on GPS points, or Ariadne GPS [11], which provides information about the surrounds, like street names, and the distance to preselected coordinates.

2 Motivation

The goal is to provide a way to assist visually impaired people in training their routes, which they recently learned during the mobility training lesson. For that, the last group of aids looks most promising since the lack of accuracy seems to be less important than for regular navigation systems and for indoor operation the framework, this approach is based upon, implements Wifi-positioning.

On this basis, we define that our “Virtual Mobility Trainer” [1] uses the hardware of nowadays' smartphones to achieve the positioning task and to communicate the required information in the form of acoustic and tactile signals for the blind or visually impaired user. In order to deliver a solution offering full tool support throughout the whole process, an easy-to-use editor for sighted people was developed as well which allows the intuitive creation of routes for the target group of the “Virtual Mobility Trainer” [1].

Unlike applications which provide orientation and navigation features solely relying on GPS, this approach is based upon the process of classic mobility training. It is supposed to simplify and support the process of remembering routes which avoids several downsides of traditional GPS-based applications, mainly arising from the lack of accuracy and reliability, since it involves mobility trainers in creating routes and verifying their correctness and enriching routes with essentially helpful hints of how to get from one waypoint to the next.

3 Conceptual Solution

The “Virtual Mobility Trainer” [1] consists of two applications. The first one, called “Route Creator”, allows the definition of routes of a mobility training session by a trainer or a qualified person. The second part is the “Virtual Mobility Training”, an application which allows the blind or visually impaired user to train routes and explore the environment.

Several item types can be used to represent the environment. The following four different types appeared to us to be reasonable [5]. Waypoints are connected nodes which define a route. A waypoint is capable to store information which is necessary to build up the route, like route name and position. In addition, waypoints provide information which allows a more detailed description of the way to the next waypoint. This cue could be for example the advice to use the curb of the side walk for orientation to get to the next waypoint. In fact, this information is central to provide reliable navigation support compared to other solutions in this field. Points of interest can be used to identify buildings and other interesting places and refine the knowledge and understanding of the user of the surroundings. Landmarks describe objects or places which can be located by the visually impaired user in real life, e.g. fountains can be identified as such through the characteristic noise. Coffee houses emit a characteristic smell. Obstacle markers can be placed to warn the user against objects blocking his/her way. These could be steps, fences or garbage cans.

4 Implementation

Both applications are developed on Android and based on Digital Graffiti [2] which is available for Android too. It allows the creation of location-based general-purpose information items which can be created, received and modified on mobile devices. For that reason the device needs GPS, trilateration via mobile networks is recommended in addition. Some kind of mobile internet connection is required too since the devices receive new items from a server. A digital compass is needed for orientation and a stereo headphone jack, vibra notification and a touchscreen for user inputs.

5 Concept of Operations

The “Route creator” [1] application provides an intuitive user interface (see **Figure 1**) for sighted persons like mobility trainers. One can create, modify and edit items of all four item types. It is based on Google Maps API [12] which allows developers to create their own map applications offering almost the same user experience as in the official Google Maps App when operating the map view. In particular, the “Route Creator” application allows pinch-to-zoom and as an alternative traditional two-button zooming. Besides that, the user can rearrange items via drag and drop and show additional information and edit them by pressing them. In general, this application was designed to meet the requirements of users who do not have a technical background, so its interface is simplified as far as possible and reduces the input elements to a reasonable minimum.
The whole “Training” [1] application can be controlled via gestures (see **Figure 1**) and all actions are confirmed by an acoustic and tactile feedback. The user can undo every action and can repeatedly listen to every message he/she has received. This application basically consists of three different modes. The training mode is supposed to guide the user along the route. It outputs information over the acoustic and tactile channel. The user gets informed about new events like entering the range of an item via vibra notification. If he/she is interested in the event he/she can perform a gesture which starts the playback of an acoustic description. Furthermore, the user has the opportunity to obtain additional information, like a description of the distance to the next waypoint. The exploration mode focuses in supporting the user in getting familiar with his/her surrounding environment. The user can explore his/her surroundings by holding the device in line of sight and turning himself/herself. If there are objects straight ahead, the user gets informed via vibra notification. Gestures initiate the playback of different types of information about this object. For instance, one could ask for the distance or for a more detailed description communicated via the earplugs. The orientation mode offers support to users who are not sure about their position and orientation. It indicates the direction to the next waypoint via spatial sound and vibration signals.

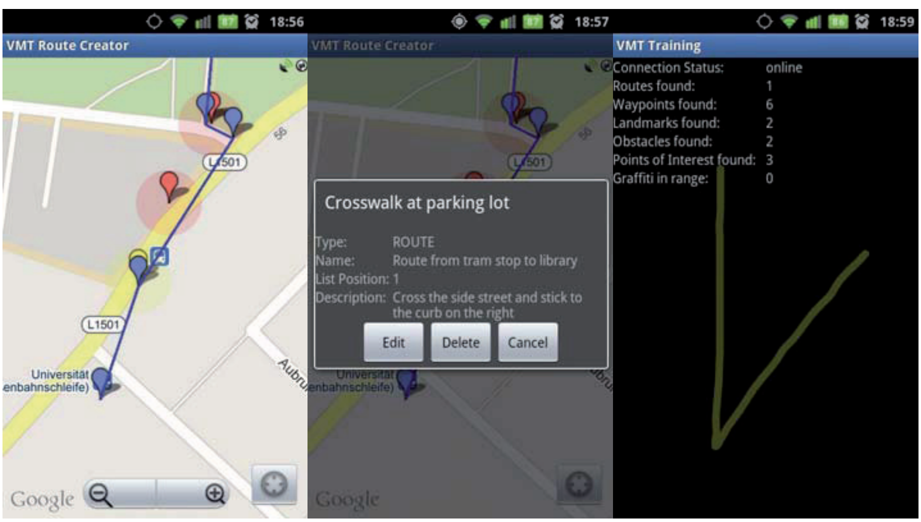

Figure 1. Screenshots of Route Creator (left and center) and Training Application (right).

6 Evaluation

The user evaluation involved four high school students, two of them blind and two of them with visual disabilities, in addition two teachers took part. Both teachers were familiar with the concept of mobility training. Despite of the small number of participants, user tests are a useful tool for verification purpose of the user interface. Regarding to Nielson [13], also a small number of evaluators is useful to identify most of the usability issues, which was the focus of this evaluation.

The evaluation consisted of the following tasks:

1. Dry practice of the gestures with print-outs made on a Braille printer.
2. The actual user test included a one-to-one test run of one proband and one instructor.
3. A questionnaire considering issues like the understandability of the concept of operations, the ease of interaction, the benefit of the different features of the application, including the orientation mode, the exploration mode and the spatial sound for orientation. These questions needed to be answered using a 5-level Likert Scale ranging from "very much = 1" to "not at all = 5". It also included a section with open questions provoking the reader to suggest own ideas for improvement.

The outcome of this evaluation was that the menu structure was found understandable (mean 1.5) and the probands found the application and the concept very helpful for exploration of the environment (mean 1). However, there are still some weaknesses, orientation during walking was found less precise and therefore less helpful, but still beneficial (mean 2.75). Orientation with spatial sound was found also beneficial too (mean 2.75). The decision of using a set of eight gestures was partly successful. The probands with visual impairment had no problems (mean 1.5), but the blind probands struggled to perform them correctly after a dry training of 30min (mean 3).

The informal interviews during the training revealed the reasons for the weaknesses of this first functional prototype.

- 30min of preparation was too short, during the actual training the students got better
- GPS was sometimes imprecise, therefore the probands were able to determine the theoretical right direction, but it was sometimes displaced to the real position, which made a relatively big difference in our test run, because of the small distances (~15-30m) between the waypoints.
- The concept of using gestures for blind persons has still some room for improvement. As blind persons hardly do handwriting, gestures based on letters require more practice for them.
- Some concepts of interaction are highly depended on the user, some prefer vibration signals over sounds and vice versa. Therefore, a configuration to a certain user would perfectly make sense.
- Another smartphone with tangibly (from the frame) distinguishable touchscreen would avoid some problems with the gestures too.

7 Further Work

In addition to the issues revealed by the evaluation, an accessible "Route Creator" is planned too. This allows blind users to define routes on the fly. They basically walk along an undefined route and at every important location or branch they can leave an item, e.g. a waypoint, and add an audio description through the built-in recorder.

We also intend to combine this project with another currently running project at our institute. It is called Viator [14] and also involves partners like the Institute for Software Engineering at JKU, the Central European Institute for Technology in Vienna, the Austrian Federal Railways ÖBB, the public transport company Linz Linien, and the Upper Austrian transport authority OÖVV. It is based on DG [2] too, but it aims at providing holistic assistance during the whole process of traveling with different means of public transport, including trams, buses and trains. It offers special features to people with limited mobility, like blind people or wheelchair users. However, it is supposed to be used by every person using public transport. Therefore, it features route planning, notifications to change means of transport, gives directions at stations, especially adapted to the needs of people with limited mobility, and it is aware of delays, informing the user and re-planning the route if required. Especially, navigation at stations is where both projects could gear into each other. Blind persons or persons with visual impairment might want to perform mobility training to get to know the environment and ensure that they are able to get from one platform to another independent from the instructions on the phone, especially when they need to do that every day.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-671

Technological Mediation for Visually impaired People in exhibition Context

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Abstract. Interactive multimedia displays are more and more present in the context of museum exhibitions. Vision is mostly involved as the base of most perceptive modalities used to receive information or feedback, and to control interaction with these displays and therefore there is a big risk to exclude visually impaired people. The "OUI" project is the result of a collaboration between cultural bodies and research laboratories. It aims at defining and developing a tangible prototype device allowing to give access to visually impaired people to information and interaction with displays of this kind.

Keywords. Exhibitions and Museums Accessibility, Artistic, Technical and Scientific mediation, Design for all, Communicating objects.

Introduction

The **OUI** project has been developed in the context of modern museography and information to museums and exhibitions visitors, where new software and hardware devices are replacing unidirectional audiovisual broadcasting as cultural, artistic or scientific mediation to the works, but also as part of the works themselves : playful artistic and/or scientific stands, installations turning the exhibition space into part of the works itself, giving to the visitor a role in the artistic process.

OUI, in French, stands for *"**O**util **U**niversel d'**I**nterfaage pour les personnes ayant des difficults de communication et/ou d'interaction avec les interfaces classiques (cran/pad/souris), personnes aveugles et malvoyantes."*, which could be translated in English as "Universal Interface Tool for people with communication and/or interaction difficulties with classical interfaces (screen/pad/mouse), blind and partially sighted people". This project is the result of a collaboration between two research laboratories : *CHArt/THIM* at University Paris 8, specialised in Human and Artificial Cognition and Assistive Technologies, and *CEDRIC* at the *Conservatoire National des Arts et Mtiers* (CNAM) ; and three Parisian cultural bodies : the French National Library (*Bibliothque Nationale de France* — BNF), *Universcience* and especially the Science Museum at *La*

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Villette (*Cit des Sciences et de l'Industrie de la Villette* — CSI) and the Quay Branly Museum (*Muse du Quai Branly* — MQB), a museum featuring indigenous art, cultures and civilisations.

1. State of the Art

There are few papers in the topic of accessibility to museums. The use of RFIDs have been explored by several researchers. In [4], a prototype application used in several museums is described, allowing visitors to continue their scientific exploration beyond the museum's walls. [1] reports a location aware tour guide based on RFID localisation and tested during a big flower exhibition in Europe. [3] is using RFIDs to locate and identify art works in the rooms. The paper focuses on orientation of the visitor in the museum. The visitor uses a PDA to listen to the relevant audio guide, which is downloaded on the fly when the user needs it. [2] discusses design principles of mobile guides for museums, from the focus of learning theories and visitor studies. [5] investigates accessibility requirements for electronic guides for museums, while [6] applies them to designing Multimedia Guides for All (MGA).

2. Access to Museum Devices

The focus of this project is the interaction between visually impaired users and multimedia devices existing in exhibitions. We have been studying existing exhibitions in Paris, especially at *BNF* and at *CSI*.

Our discussions brought us to the idea that the solution shouldn't reproduce the services supplied by the multimedia device we want to give access to, but should be a "software overlay" that would work as an intermediary between the user and the mainstream device. Therefore, the overlay has to get the relevant information from the device and communicate it to the user, then communicate back the user's action to the machine.

Unfortunately, because of the variety of multimedia devices available in museums, it is not possible to communicate the relevant information to visually impaired visitors with a single procedure. Therefore, it is simply not possible to give access to a software made for someone able to see without a prior work of analyses (what is the relevant information for a visually impaired person?) and synthesis (how to present this information in a clever, simple way?). So the software overlay can be said to have three main roles:

- analysis: to get the information between the device and the user. For example, about *cartels* – the devices we have been focusing on during the project (more details on them later) –, it is necessary to *"parse"* Hypertext Markup Language (HTML) et XML (Extensible Markup Language) to locate texts, images, videos...
- synthesis: to reorganise and regroup the information. In the case of cartels, to get all the information, the user has to browser Web pages through hypertext links. To make it simple, we have implemented a process that divides the links in two groups: internal and external navigation. The first one includes all the pages of a cartel and the second one regroups all the access to other cartels and different tools available (a lexicon, a time line, etc.)

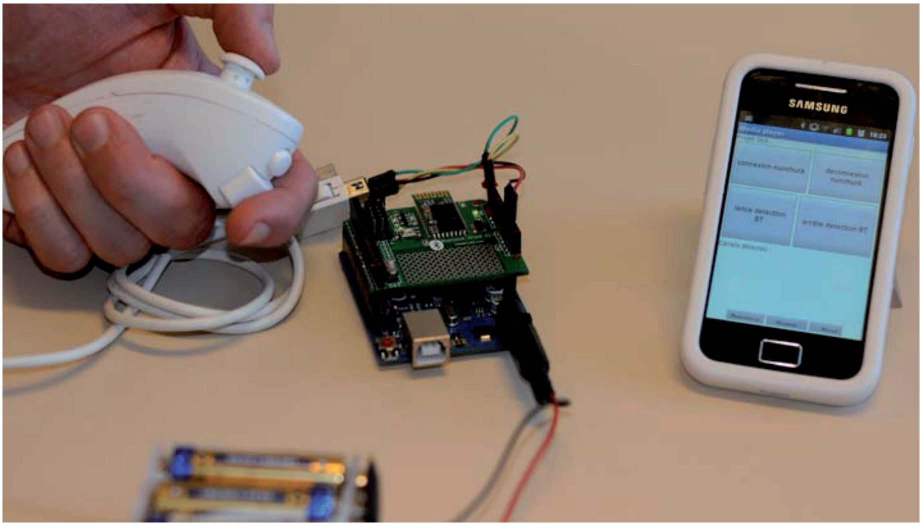

Figure 1. The OUI prototype.

- communication: to transmit the information in an accessible way. For our cartels, we have mainly used a text-to-speech system available on mobile phones.

In lots of museum, visitors can interact with so-called *“cartels”*. These devices allow more and more interactive ways of accessing to additional information, explanations, contextualisation, games, where the user is not only here to see but also to participate. These devices are using mainly tactile screens, sometimes very large ones, 3D, cameras catching the face, the gestures or the silhouette of visitors to insert them into their screens or different kind of displays after various kind of processing, *etc.*. The knowledge and reasoning capabilities of the visitor can also be solicited.

The first step has been to identify the concrete obstacles encountered by visually impaired persons to access these devices, focusing on the tasks and interactions. Then we analysed them in order to find out common elements, to classify them and to identify the more general alternative solutions. Then we specified and developed a demonstrator in order to explore feasibility and identify technical difficulties.

The primary barrier comes from the systematic use of tactile screens, where the visual control is essential, both for displaying works, explanations, contextual information, display controls and for choice or decision controls.

A technical study of the multimedia devices used in exhibitions at BNF and at CSI showed that cartels are constituted by basic computers with a tactile screen, containing HTML documents, all related to each other through hyperlinks.

3. The Prototype

The basic idea was to produce a prototype which would, at the same time, be operative and constitute a broad basis for further development. We had to select tasks that are both useful on their own and as a basis for dealing with more complex interactions in the future (e.g. simulation games).

The chosen tasks were detection, display and selection of available devices in the surroundings, and the interaction with the device. A prototype has been implemented, including a device and the *'software overlay'* over the cartels. This prototype makes them accessible to visually impaired persons and, in the future, will be the basis of the access to and communication with any kind of exhibition devices. Two services have been implemented. The *detection service* allows the user to be notified of the proximity of available devices, and to select one of them. Then the *browsing service* enables the user to interact with the device through a set of HTML content.

The short duration for this project (9 months) lead us to start from existing devices, and particularly from a smartphone and a joystick. The large availability of smartphones, including as well people with visual disabilities, as well as their computing and storage capabilities makes them good candidates for a mediation tool. The main difficulty for visually impaired users remains the tactile screen of these devices, thus we decided to use together a joystick to interact with the museum device content via the smartphone.

Beyond the usability, using a specific device associated with the exhibition presents some interest in itself, as it gives the visitor a feeling that we could call *"exhibition experience"*.

An existing joystick, especially easy to take in hand, was actually chosen for the base and modified according to our needs. It is a well known device called *Nunchuck*. Micro-controllers (Arduino) and a Bluetooth unit have been designed and added to this joystick in order to connect it to the smartphone. Then a specific Android application was developed.

The application tasks are the following :

- detect the museum devices in the close environment and classify them according to their proximity to the user
- show them to the visitor as a list and allow the visitor to select one of them
- download from the museum device its multimedia content, and store it temporarily on the smartphone
- allow the user to interact with this content, start audio presentations, read text contents using speech synthesis, *etc.*

As for the development, we created two software libraries (*NunchuckService* and *CartelDetectService*) centred on a *"Service"* class (in the Android framework, services are background processes that interact with applications through complex signals called *"Intents"*). The first one is in charge of the connection and the communication between the phone and the joystick and the second one gives all the information necessary to acknowledge the presence of surrounding cartels and to connect to them.

Then we have on the foreground different *"Activity"* classes. The main one helps the user launch the services, displays lists of the nearby cartels and allows the user to choose the cartel they want to display. The secondary activities correspond to the different cartels and allow the user to browse through them. Throughout this process, different synthetic voices are used in order to help the visitor to discriminate between navigation and content reading. The visitor uses the joystick to navigate in the various lists as well as to control the player giving access to the content.

Another important feature of the prototype is that the means of communication and detection are distinct. On the detection side, it is important that a wireless radio frequency signal is used because it allows the detection of cartels by the user's mobile phone ac-

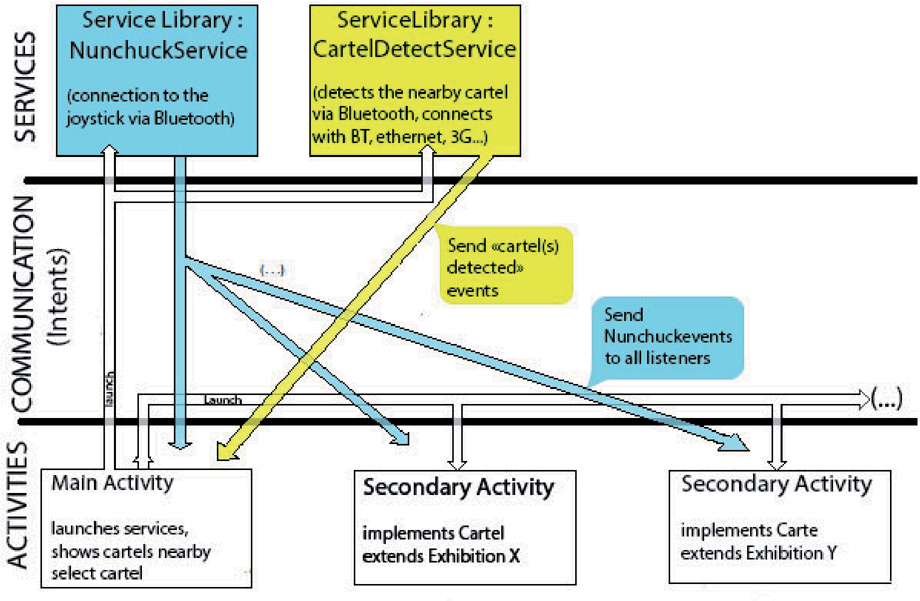

Figure 2. A model of the Android application.

cording to their proximity (this is coherent with the way a person discovers cartels as he/she walks through an exhibition). As for the communication between the mobile and the museum devices, different options have been tested and implemented : wireless network (wifi), mobile internet access, Bluetooth, *etc.* — which gives the museum different options to choose from.

A demonstration was presented to the museum participants, including visually impaired persons. This demonstration was including content from 2 different exhibitions, one about marines at BNF, and the other about invasive plants at CSI. We showed that with a elementary installation (the *".apk"* application has to be installed in the mobile phone through USB cable or wifi) and even more simple setting up (two clicks to launch the services), the prototype is working and the user can walk with it, detect and browse nearby cartels.

4. Perspectives and Recommendations

This feasibility study has strengthened the will of all the participants, and especially the museum staffs, to develop the idea. They could see the potential of the idea and the feasibility of implementation within their museums. More types of interaction must be studied, which could not be undertaken within the short duration of this project. More content must be prepared. The biggest challenge being the real implementation of into the exhibitions.

Through this first contact between scholars and museum participants, all the participants have developed a better understanding of the need for a common work in order to make museum experience more accessible to disabled people. The goals that we want to achieve are only reachable if a coordinated work is established. The software overlay that we want to implement is only possible if it is supported by some preliminary works. A first step would be the following of certain specifications — guidelines — within the development of the multimedia content of the cartels.

Together with our colleagues from museums, we realised it is necessary to go extend our approach. First we need to be enable content authentication of content (e. g., an XML document could be integrated in the directory of the software which would describe its features: content type, accessibility level...). This would help to implement more general procedures to give access to the devices. Another idea that we which to explore is the identification of visitors allowing profiling, in order to be able to adapt the information transmitted to the user (type and level of handicap but also artistic knowledge about the current exhibition, etc.). In this regard, it would be interesting to develop generic software components (or patterns) for certain interactions according to the handicap. This software would be associated with hardware components to answer to the users perceptions and action impairments.

Acknowledgements

This project was funded by the Labex Arts-H2H, from *Universit Paris 8-Vincennes-Saint-Denis*. We also would like to thank a few people for their contribution and help in this project : Holle Corvest from the *Cit des Sciences et de l'Industrie*, Anne Broquet, Aurlie Brun and Anne-Hlne Rigogne from the *BNF* and finally Jean-Michel Douin and Anne Wei, teachers at the *Conservatoire Nationale des Arts et Mtiers*.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-677

Shopping Support System using AR Technology for Visually Impaired Persons

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Abstract. The aim of this study is to create a shopping support system for visually impaired persons. To support shopping, a technology for users to navigate inside a store and assist them in looking for and identifying individual products is necessary. Using AR(Augmented Reality) technology, the authors were able to show that visually impaired persons could successfully select products with minimal difficulty in a short amount of time. Therefore, we propose our shopping support system with AR technology for visually impaired persons.

Keywords. Indoor Navigation , Augmented Reality , Visually Impaired Persons , Shopping.

Introduction

The aim of this study is to create a shopping support system for visually impaired persons. To support shopping, a technology for users to navigate inside a store and assist them in looking for and identifying individual products is necessary.

GPS can be used for outdoor navigation but not for the navigation in a building since it is difficult for radio waves to penetrate in the building and the system performance relies on the radio wave conditions. However, if AR(Augmented Reality) technology is used for position estimation, the positions of a user and products can be identified with high precision even inside the building.

For search and identification of individual products, RoboCart[1], ShopTalk[2], Grozi[3], and iCARE[4] have already been proposed based on technologies such as RFID, UFH-band RFID, image recognition, and barcodes. However, these technologies have not been put to practical use because of their problems explained as follows. RFID can make accurate recognition but cannot recognize multiple products at the same time. UFH-band RFID can simultaneously recognize multiple products but requires relatively large instruments and hence is very expensive. Image recognition technology has a low recognition precision as it is influenced by lighting and product positions. Barcodes cannot be read unless a barcode reader is placed closely and accurately to the barcodes. Compared to these technologies, AR can extract positional relation data between a camera and AR markers and simultaneously recognize multiple products in a limited view field although AR is not specialized in the recognition of individual products. Therefore, AR is a technology suitable for shopping support systems.

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The authors made a prototype of a shopping assist system based on the AR and RFID technologies for people with impaired vision or the elderly and then improved it to a system that utilized only the AR technology[5] [6]. In the present study, the system is remodeled into a more convenient system using a smartphone as a terminal and performed a shopping experiment with the new system.

We explain below our shopping support system with AR technology for visually impaired persons.

1 Shopping Support System using AR Technology

According to a shopping list made by a user, this system navigates the user along a shopping path and informs him/her of the name, price or other information about the products by voice. The user captures an AR marker with his/her smartphone camera and follows the navigation of the system for the shopping activity. The system, installed together with a database in a server at the store, uses the smartphone as a client through a wireless LAN (Figure 1).

Two types of AR markers are used for user position estimation and search and identification of products: An "intersection marker" placed on the intersections of aisles and a "product marker" placed on store shelves. The intersection markers are placed on the intersections of aisles at a store and their positional data is saved in a database. The product markers are placed on store shelves for each product group and their positional data and product information are saved in the database. The system sends an inquiry to the database with a key of the AR marker's ID and provides the position and the name and price of the product to the user. The system is assumed to be used at a supermarket or convenience store where store shelves are put in parallel and aisles are set out in a grid (Figure 2).

The user first creates a product list using a product list registration function. The system calculates the shortest path for the shopping activity and the user follows the path to buy the products. When his/her smartphone camera detects an AR marker, the smartphone vibrates to notify the user that the AR marker is detected. When the camera detects an intersection marker, an intersection navigation function is activated and an audio guide is given to show the direction. If the user needs navigation on the aisle of the shelf where the target product is placed, he/she holds the smartphone camera to the shelf and taps the screen once. Then a target product navigation function is activated and an audio guide is given to indicate the direction (left or right) and distance from the current user's position to the location of the product. When the camera detects a product marker of the target product, the target product information voice-reading function is automatically launched to identify the product. When the user finds the product that he/she wants to buy, he/she taps the screen three times to let the system know that the purchase is completed. If the user would like to know the information about the products that the camera detects, he/she taps the screen twice. Then the product information voice-reading function is activated and the information of the products captured by the camera is read out one by one. After following these steps and picking up all the necessary products, the user receives information about the path to a cashier. The AR system is used for the position estimation of the user necessary for the navigation and for the browsing of the production information, and relevant data in the database is presented by using an ID specific to the AR marker as a key.

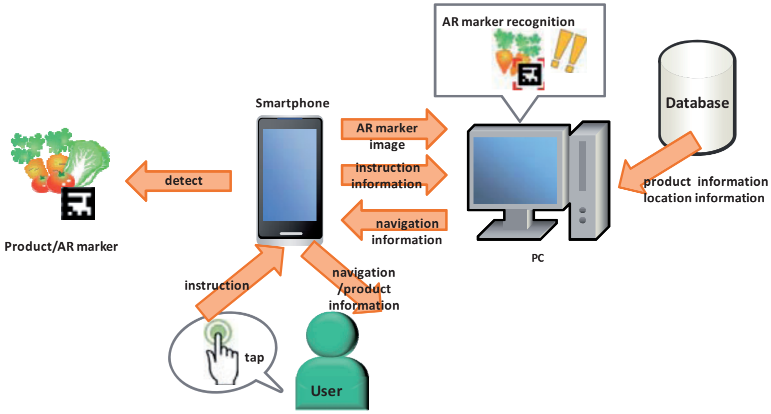

Fig. 1. System Overview.

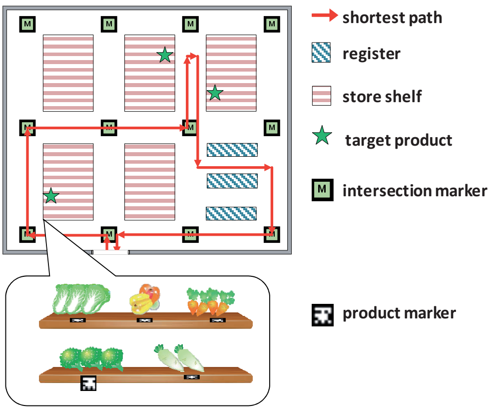

Fig. 2. Locations of AR markers in a store.

The present system has the following functions.

1.1 Registration of Product List

A user selects products that he/she wants to buy and creates a shopping list.

1.2 Calculation of Shortest Path

The shortest path to purchase all the products in the shopping list is calculated. The voice navigation is given based on the most efficient path calculated here.

1.3 Navigation Function

There are two navigation functions: Intersection navigation and target product navigation.

- Intersection Navigation. This is a function to orient the user to the aisle close to the target product. When the camera detects an intersection marker, the system automatically shows the user the direction in which to proceed from the intersection, saying e.g. “Turn left at the intersection.” or “Proceed in the twelve o'clock direction from the intersection.” If the intersection marker is located close to the target product, the system tells the user that the product is in the next aisle.
- Target Product Navigation. This is a function to orient the user to the position where he/she can detect the target product by a camera. When the user needs navigation, he/she taps the screen of a smartphone once and the system shows the direction and location of products. The navigation changes according to the position of the user and that of the target product. For example, the system says, “Cabbage is located 80cm on your right.” or “Cabbage is on the shelf on the opposite side.” To receive this navigation, the camera needs to detect at least one AR marker.

1.4 Product Information Provision

There are two product information providing functions: Target product information voice-reading function and camera-captured product information voice-reading function.

- Target Product Information Voice-reading Function. This is a function to read out automatically the information of a target product, when the camera detects the product marker of the product. Product information such as the location, name, and price of a product is provided by reading out, for example, “Center, cabbage, 100 yen.”
- Camera-captured product information voice-reading function

This is a function to read out, one by one, the information of the products whose product markers are detected by the camera, when the user presses a read-out button. The system reads out, for example “Center, cabbage, 100 yen. Right, broccoli, 120 yen.” The users use this function when they want to know about more than one product or about a similar product placed near the target product. This function does not have to be used if the users know what to buy.

2 Experimental Results

For the evaluation of this system, a shopping experiment was conducted by assuming a situation where a visually impaired person shops at a store (Figure 3).

The experiment was conducted in a room (10.5x5.7m) at the university with four desks (3.0 x 0.9 x 0.7m) and five shelf sets (upper three shelves of each shelf set of the size 0.9 x 0.5 x 1.8m) to simulate actual product shelves. Thirty four product cards, instead of actual products, were placed on each desk and nine product cards were placed on each shelf set (i.e. three on each of the upper, middle, and lower shelves). A product marker was placed in front of each corresponding card. The total number of the product cards was 181. To simulate an actual store environment, the interval between the desks was set to 1.3m and the interval between the product cards to about 20cm. Nine intersection markers were placed on the points that simulated the intersection. The shopping path was selected in such a way that the examinees started from the entrance of the virtual store, stopped at six products (product cards), and went to a cashier point. We performed three shopping experiments (Shopping 1, Shopping 2 and Shopping 3) by changing the products to buy.

The examinees were a person in his 50s with impaired vision (denoted by L) and a sighted person in his 40s wearing cloudy-lens glasses (denoted by A).

The six products to buy were changed from experiment to experiment and registered in a product list in advance by an experiment member of staff. Since the shortest shopping path is presented by the system, the examinees follow the same path if they do not get lost. The target products of the three shopping experiments were placed at places of almost the same difficulty. In the experiment, the total time for the examinees to start from the entrance, pick up the target products, and go to the cashier was measured (Table 1).

The slowest case was Shopping 3 of examinee A, which took 6 minutes and 46 seconds, and the fastest case was Shopping 3 of examinee L, which took 4 minutes and 52 seconds. The average time of single shopping was 5 minutes and 37 seconds. Several mistakes occurred in picking up products. Five products out of six that examinee L picked up in Shopping 3 were the wrong ones. Examinee L picked up two wrong products from a shelf lower than the one on which the target product was placed and three wrong products placed on the right side of the target product on the desk.

The experimental data indicates that the average time of selecting products was 56 seconds per product and hence the system could be used for actual shopping. The probability of selecting a wrong product was high in Shopping 3 of examinee L, but this was probably because the examinee changed the way of holding the smartphone and the direction of the camera changed from that in the previous shopping activity. Since the cards were used as products in the experiment, the color and hand feeling of the package of each product were not taken into account in selecting the product. If these factors are taken into account in actual shopping activity, the probability of selecting wrong products would decrease.

As for the usability of the system, the examinees said “Using the smartphone is convenient,” “I want to use the system in an actual store,” “The navigation can still be improved,” and “I needed to get used to the adjustment of the camera direction.” These opinions will be reflected in the improvement of the system.

Table 1. Shopping time of each examinee in units of [Min:Sec].

Examinee	Shopping 1	Shopping 2	Shopping 3	Average	Shopping time per product
L	05:25	05:02	04:52	05:06	00:51
A	05:27	06:11	06:46	06:08	01:01
Average	05:26	05:36	05:49	05:37	00:56

Fig. 3. A shopping experiment image.

3 Conclusions

In future study, we will improve the system's functions, reflecting the user opinions. Although the system was developed for people with impaired vision, it can also be useful for blind people. Functions for blind people will also be added.

Before using the system it is necessary to set the product marker's position coordinates and product information. However this work takes considerable time. We will therefore make a system for simple setting of the position coordinates. The data entry work of the product information could be reduced if a POS system is used for the work.

Acknowledgements

Part of this work is supported by a research grant from the Senshu University Research Fellowship (2012). We would like to thank all of the people who cooperated on our project.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-684

Development of a New System to Produce DAISY Textbooks for Math and Science from PDF

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Abstract. A new system to produce DAISY textbooks for math and science from PDF is shown. In it, correct aloud-reading and speech control can be assigned to technical contents including math expressions. What are required in accessible math/science e-textbooks concerning speech and Braille output capabilities are also discussed. By making use of our system, we work on a collaborative project with the Japan Braille Library to produce accessible e-textbooks and to provide them to various print-disabled students.

Keywords. e-Textbook, Math, Science, DAISY, PDF.

1. Introduction

In Japan, so-called “digital textbooks” (the official name of e-textbooks in Japan) are supposed to be fully adopted in elementary and junior-high school in April, 2020. However, now, a large number of those digital textbooks, especially ones for math and science are not necessarily accessible. Establishing a good method to make them accessible is our important task for future.

For accessibility-intended purpose, publishers usually provide the digital content of a textbook in Adobe Portable Document Format (PDF), these days. However, as is well known, a PDF document, itself is not necessarily accessible even if text-based information is embedded in it. Certainly, a print-disabled reader could export those texts from unprotected PDF. However, if that PDF had a little complicated layout such as a multi-column page or a table, the extracted text usually would be out of order. Furthermore, if it included math formulas or other technical notations, it would be almost impossible for the reader to understand what were written in the original PDF. In order to access a PDF book on math/science, therefore, print-disabled people have to convert it to more accessible one with OCR (optical character recognition) or something.

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“The Digital Accessible Information System (DAISY)” [1], which is becoming a standard format of accessible e-books, could be an excellent solution for making such a PDF textbook accessible to people with print disabilities. Unfortunately, however, there was no good direct way to convert PDF to DAISY, so far. Such content includes many technical characters, symbols, and notation such as math formulas, figures and tables, putting them beyond the capabilities of standard OCR. For that reason, there was no way to convert a PDF math/science textbook directly into DAISY format. A Microsoft Word document including math objects can be pretty much output in DAISY format with functions of “Save As DAISY” and “MathDAISY” [1,2]. However, PDF-to-DAISY is usually based on a lot of handwork. It requires certain computer skills, time and costs to sighted teachers or assistants. Furthermore, people with print disabilities cannot do it for themselves.

To overthrow the present situation, we started a collaborative project with the Japan Braille Library two years ago to develop a (software) system, a total solution to convert a PDF math/science textbook into DAISY, which is easy to use for all. In addition, if necessary, our system allows a user to give correct aloud-reading to math expressions or technical notations in DAISY with speech synthesis. Although, currently, only the English and Japanese versions are available, it can support other European languages. With this system, we have already produced about 20 DAISY textbooks for math and science and provided them to various print-disabled students.

Here, in Sec.2, we show the new version of our assistive tools to produce accessible e-textbooks for math/science from PDF. We also discuss what are required in those textbooks concerning speech and Braille output capabilities. Next, in Sec.3, we report our collaborative project with the Japan Braille Library, based on our assistive tools. Sec.4 is a conclusion.

2. A New System from PDF to DAISY

2.1. Infty Software

Our OCR software for mathematical documents, “InftyReader” can properly recognize scientific documents in print or PDF including complicated math expressions, tables, graphs and other technical notations. The system converts documents into various accessible formats such as LATEXand MathML. Infty software including InftyReader can be purchased from our organization or foreign dealers [3].

We recently released so-called “plug-in software” for InftyReader based on the FineReader OCR engine developed by ABBYY [4]. As is well known, ABBYY FineReader is one of the best OCR software in the world. By combining InftyReader with this plug-in, a recognition rate for European languages that use extended Latin characters including Russian is remarkably improved. As far as English documents are concerned, the recognition rate also gets better in case an original scanned image is not clear enough. Furthermore, while the previous version could not treat a color PDF, the new version, “InftyReader3,” can recognize such PDF at a certain level. In it, a user could specify text, math and graphics areas before starting recognition so that recognition errors would remarkably decrease.

An accessible math-document editor “ChattyInfty” allows blind people to access math/scientific documents with speech output [3]. Information displayed in its main window is completely equivalent to that of "InftyEditor" for sighted people. All math expressions are displayed in the ordinary print style. ChattyInfty reads aloud not only text but also math expressions. Blind people can read, write or edit scientific documents including math expressions, with speech output. People with and without visual disabilities, therefore, can share the same documents without any translation.

We worked on upgrading ChattyInfty thoroughly so that an Infty file can be converted into DAISY XML format. Thus, the new version of ChattyInfty, "ChattyInfty3" becomes also useful for people with low vision or dyslexia. In the software, as for the previous version, a blind user can read and author math documents with speech output. A low-vision reader can improve contrast or magnify the displayed content for ease of reading. Visual tracking and synchronized speech allow a dyslexic reader to maintain focus on a document. Furthermore, since a result recognized by InftyReader can be imported directly, both the sighted and print-disabled can produce DAISY math/science books easily from PDF by making use of Infty software only.

In terms of multilingual (European language) support in ChattyInfty3, users can author/change easily not only how to read math/scientific content but also captions in menu items and dialogs as they like since those things are all stored in files independent on a main program. They, therefore, could customize ChattyInfty3 for each local language if necessary. For the present, although only Japanese and English versions are available, we are working on developing French and some other-language versions. However, since the foreign-language versions other than Japanese use Microsoft Speech API, Ver.5 (SAPI5) as a speech engine, a good SAPI5 voice for that local language would be necessary. If such voice were available, users could produce a text-based/multi-media DAISY book (DAISY3), in which all the math expressions are represented in MathML. On the other hand, in terms of a non-European Language (except for Japanese), unfortunately, we would have no idea whether or not ChattyInfty3 for that language could be offered. In order to examine that, we do need to work together with experts on math/science in that language area.

In ChattyInfty3, various technical notations other than math formulas are also accessible. For instance, most of figures are treated as an embedded image with an alternative text. A table can be read out either horizontal-wise or vertical-wise. A vertical format of four basic operations is also supported.

In addition, we are now working on establishing the method of aloud reading for formulas other than math such as chemistry and scientific units. For instance, although m^2 is usually read as "m squared", it should be read as "square meters" for the unit. In ChattyInfty3, that can be treated by giving an appropriate reading table. Furthermore, in relation to this point, we introduced "the second type of superscript" in ChattyInfty3, which can be used for a superscript other than an exponent. In chemistry, super/subscripts are used quite frequently for different purposes from math.

2.2. What are Required in Accessible e-Textbooks

As is well known, there are many ambiguities in reading out math expressions. For instance, $\alpha(-x)$ can be interpreted as either "(a function) α of $-x$" or "(a coefficient) α times a quantity, $-x$." Thus, a text-to-speech engine usually makes many mistakes in reading math formulas. To solve this problem, ChattyInfty provides a new way to control how to read out each symbol, technical term or math formula locally according to their context. We refer to this new concept of assigning a pronunciation as “Yomi” (a Japanese word that means “a manner of reading aloud”).

In the next version of DAISY, DAISY4 (a part of EPUB3), the W3C Speech Synthesis Markup Language (SSML) [1] will become available to assign an appropriate pronunciation to a foreign word or others; however, this approach does not seem to meet our demand. We need “a correct word description” as the Yomi of a math formula, not just the appropriate pronunciation. Thus, to realize the Yomi function in DAISY, we tentatively present a method based on “Ruby tag,” which is expected to be also adopted officially in the next version, DAISY4 [1,5,6,7]. In ChattyInfty3, since a correct word description could be assigned to any math expressions with the Yomi function, all the mathematical content could be read out properly.

The International Digital Publishing Forum (IDPF) [8] decided to adopt DAISY4 XML as a part of EPUB3 standards in 2011. A new output capability to EPUB3 is also implemented in ChattyInfty3. This new feature is important as well from the point of view for treating Braille.

In the current version of DAISY, we have no method to embed Braille descriptions in DAISY XML. The DAISY Consortium seems to aim only at realizing the Braille translation of DAISY content in real time with a translation engine. However, at least, as far as math/science textbooks are concerned, that would be obviously impossible. As is well known, there are many different “Braille math code” in the world. Even within English-speaking countries, several different code systems are actually used. Even the Braille notation of numerical symbols such as 1 and 2 is not common to them. In Japan, the Braille math code in secondary education is not the same as that used in postsecondary education. Furthermore, as far as Japanese is concerned, Braille translation of a text part is heavily context-dependent. Taking into account those situations, we do need to embed “right Braille descriptions” such as math formulas described in appropriate math code directly in e-textbooks, themselves. On the other hand, EPUB3 seems to have flexible expandability to meet our demand. Thus, we intend to work on implementing Braille-output capability in ChattyInfty3, based on EPUB3 standards.

3. Collaborative Project for DAISY Textbooks on Math/Science

Until comparatively recently, very limited titles of DAISY books on math/science were available in Japan. By making use of Infty software, we started a collaborative project with the Japan Braille Library [9] two years ago to provide DAISY math/science textbooks to various print-disabled students. At first, as a test for math content in DAISY, we actually converted some sample math textbooks ranging from elementary school to senior high school in Japan into text-based DAISY books and got DAISY-playback software to read out them with various text-to-speech (TTS) engines. In the result, we realized that obtained speech output was usually terrible.

As was discussed in [5,6], in Japanese, four different character sets are used simultaneously in print: Chinese characters, Hiragana, Katakana and alphanumeric letters. While Hiragana and Katakana are essentially kinds of phonetic symbols, a single Chinese character or a compound of the characters usually has several ways of pronouncing, according to its context. In math or science, they are often read in a different manner from the usual. It is a main reason why the Braille translation of a Japanese text is heavily context-dependent.

Certainly, in ChattyInfty3, we can give a correct Yomi to them as well as a math formula if necessary. However, even if a correct Yomi for a math formula or a Chinese character(s) were given, a TTS engine would make errors frequently concerning breaks and intonations. We also knew that each speech-synthesis engine makes errors in their own manner. Even though a voice can read a math expression or a literal sentence correctly, the other voices cannot necessarily do the same. The speech control seems to be speech-engine-dependent job.

Unfortunately, there is no good DAISY playback/browsing tools that can treat DAISY3 MathML contents properly in Japanese. Each speech engine fails at reading text-based content in its own manner while the current DAISY has no universal method to control that. Hence, for the moment, we decided to give up such a system that it has a free choice of TTS voices and MathML capability, as far as Japanese is concerned. At first, we chose a specific TTS (Japanese) engine of high quality for DAISY production (not a Microsoft-SAPI voice) and then, developed the special version of ChattyInfty3, in which a new interface is implemented to control speech output, based on that specific engine. It can export an edited document as a multimedia DAISY2 book. In its contents, audio files of aloud reading corresponding to each of literal sentences and math expressions generated by the speech engine are embedded as well as text-based information. All math expressions are treated as images to meet the DAISY2 standards. Since we can produce this file after correcting all errors in the speech output, any DAISY browser/player can play back that book in a proper manner with the embedded voice.

We have also worked on the activity to produce DAISY2 math/science textbooks for elementary, junior-high and senior-high school and to provide them to various print-disabled students. Until the end of March, 2013, the following 17 titles have been released.

- For elementary school:
  Arithmetic (the 2nd year) 1 title, Arithmetic (the 5th year) 1 title, Arithmetic (the 6th year) 1 title.
- For junior high school:
  Mathematics (the 1st year) 2 titles, Mathematics (the 2nd year) 3 titles, Mathematics (the 3rd year) 4 titles, Science (the 3rd year) 1 title.
- For senior high school:
  Mathematics (the 1st year) 3 titles, Science (the 1st year) 1 title.

We also held instructional courses to train volunteers for producing DAISY textbooks with our software in Tokyo and Fukuoka, Japan. They are now working together with us to produce DAISY textbooks of 20 new titles and 16 revised versions (36 titles in total) in this year.

4. Conclusion

As was discussed, the new Infty software gives a total solution for converting PDF textbooks for math and science into DAISY/EPUB, which is easy to use for not only sighted people but also print-disabled people, themselves. All the DAISY math/scientific contents generated with Infty software could be read out in correct manner with the Yomi function and the new speech control. In school, a textbook should be read aloud as correctly as possible. Our system will give a certain contribution for full adoption of digital textbooks in Japan, 2020.

Acknowledgements

This research has been worked on with a subsidy from the Ishibashi Foundation, Japan. We express our warmest gratitude to the team of the Japan Braille Library, especially, Shigetaka Amano and Junichiro Sawamura.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-690

Autonomous Navigation based on Binaural Guidance for People with Visual Impairment

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Abstract. This work addresses the challenge of designing an effective, reliable and affordable navigation system for blind and visually impaired people (BVIP). Our contribution focuses essentially on the integration of accurate real-time user positioning data with binaural 3D audio based guiding techniques on mobile devices. The purpose is to produce a binaural navigation system that can be used to guide BVIP along pre-defined tracks. A preliminary prototype of this concept has been built and tested with 4 expert users obtaining encouraging results.

Keywords. Blind navigation, binaural audio, Global Navigation Satellite System (GNSS), Inertial Navigation System (INS), assistive technology.

Introduction

The population of blind and visually impaired (BVIP) in Europe is estimated over 30 million. On average, 1 in 30 Europeans experience sight loss. Furthermore, sight loss is closely related to old age in Europe, where age-related eye conditions are its most common cause, resulting in that 1 in 3 senior citizens over 65 experience it. [1].

Being able to navigate autonomously is one of the most relevant needs for BVIP. Research on autonomous navigation systems which uses spatialized audio (also known as binaural audio) information [2] for guiding BVIP has been carried out since 1985 [3]. Recently, evidence has been established that, when guiding BVIP through different routes, spatialised audio instructions are faster to interpret, more accurate and more reliable when compared to instructions given in natural language . Also spatialised audio perception is less affected by increased cognitive load on users than language information [4].

In parallel, relevant progress is being carried out regarding satellite positioning technology and currently the European Geostationary Navigation Overlay Service

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(EGNOS), which is essentially Europe's precursor to the GALILEO system, is currently providing a terrestrial commercial data service named EDAS (EGNOS Data Access Service). It offers GPS data correction for providing increased positioning accuracy and integrity [5].

Finally, significant industrial activity has been carried out in order to provide useful navigation support systems for BVIP. It's worth noticing that eAdept [6,7] has succeeded in validating a complete navigation support platform in the city of Stockholm. Besides, commercial products like the Kapten Mobility by Kapsys [8], BrailleNote GPS by Sendero Group [9], and Trekker by VisuAide [10] have successfully reached the market. Nevertheless, these initiatives are still based on instructions given in natural language, which reduces their potential from our understanding.

1 The ARGUS Guiding Concept

Taking into account previous findings, ARGUS FP7 project [11] aims to implement and validate the binaural guiding concept, which integrates both binaural sounds and precise user positioning technologies on mobile devices, resulting in a binaural navigation system that can be used to safely guide BVIP along pre-defined tracks.

Figure 1 illustrates from a broad perspective the ARGUS guiding concept. The GPS signals are corrected with EDAS data through an external positioning unit for obtaining accurate user position. Additionally, an Inertial Navigation System (INS) is used by the positioning unit in order to obtain user's heading. Later, the positioning unit transfers user position and heading in real time to the SmartPhone using a wireless communication protocol. Then, the smartphone uses a navigation algorithm that compares the actual user position and heading to the defined track, and finally the binaural guiding system emits binaural audio cues to the user through dedicated open headsets.

Figure 1. ARGUS binaural guiding concept.

2 Prototype

A preliminary prototype has been developed to test the ARGUS binaural guiding concept. Table 1 summarizes the main technical features of the prototype.

Table 1. Technical specifications of the implemented prototype to test the ARGUS guiding concept.

#	Technical specifications	Details
1	Real-time positioning using GPS and EDAS	Accuracy of 2 to 3 meters, at 1 Hz.
2	Mobile device's magnetometer is used for obtaining heading information.	Output frequency of 1 Hz. Loosely coupled data fusion between heading and positioning measurements.
3	A point navigation strategy has been implemented in the navigation module which provides the bearing to next waypoint.	Waypoints reached within a given radius will be marked as visited.
4	Acoustic module which provides guiding binaural sounds has been implemented.	Different 3D sounds are available to accommodate to users' preferences.
6	Android application which integrates the developed binaural guiding concept.	Core of the application developed in C++ to maximize cross-platform portability.
7	Open headphones have been integrated.	A wide offer of headphones is available to meet users' preferences on comfort and safety.

3 User Tests

Small scale user tests have been carried out in order to assess the performance of the preliminary prototype and gather initial users' opinions about the system. In order to minimize the positioning errors, the tests have been conducted in an open environment scenario. Table 2 summarizes the main specifications of these tests.

Table 2. Specifications of the user tests carried out to assess the prototype.

#	Protocol	Comments
1	User tests took place in September 2012, in Paderborn (Germany).	The testing site was a public meadow at the south of the Airfield Paderborn-Haxterberg.
2	Two blind and two partially sighted people were recruited.	All of them were volunteer experts on navigation and assistive technologies.
3	The users were guided by the ARGUS preliminary prototype on a route composed of 4 waypoints.	Distance among waypoints was 40 metres on average. There was no time restriction. Users were asked to perform the same route twice.
4	The task was considered as successful whenever the user reached all 4 waypoints.	Waypoints had to be reached within the radius of 2 meters around them.
5	3 users received 5 min training on binaural guiding before the tests.	The fourth user did the training after the first navigational task.
6	User positions and headings were logged for off-line processing.	Users wore two different GPS devices and a third device was fixed to floor for further off-line positioning data comparison and error analysis.
7	All users were interviewed after each navigation task.	A short questionnaire was used also during the open interview.
8	User tests were video recorded.	Users signed an informed consent document.

Figure 2. Photographs of the user tests.

4 Results

4.1 Analysis of Users' Feedback

The main test parameters that were examined, including acceptance, ease of use, reliability, accuracy, non-disturbance of the general hearing as well as the wearing comfort led to very satisfying results. All involved users outlined that the test with the prototype was a very good indicator for getting a first impression on how the binaural guiding principle works in real life scenarios. Besides, users pointed out several requirements that the prototype should meet before mainstreaming the technology. Among the suggested improvements were: the need of training before using the system in real navigational tasks, providing more personalization options in order to better adapt to personal preferences and enhancing safety by increasing frequency of binaural sound cues when user deviates from the main track.

In addition, a demonstrative video[2] has been produced for dissemination activities.

4.2 Analysis of Users' Tracks

Although diverse tracks with different shapes have been obtained, in general it has been observed that all users completed the routes, reaching all marked track points. It is worth noticing that 7 out of 9 tests have an average distance error below 5 meters to the ideal track in the four waypoint sections of the proposed route. However, some of the tracks have significant deviations from the predefined track that were conditioned on one hand, by the technical limitations of the prototype, and on the other hand by the user's perception and reaction.

In order to increase the performance of the system several improvements are needed, like the implementation of a track navigation strategy, the tight

[2] http://youtu.be/6qyrZbbeB4g

synchronization of both positioning (GPS+EDAS) and heading (IMU) measurements, the implementation of 3 frequency positioning receiver to enhance positioning accuracy and the integrity testing of positioning signals for a better reliability of the system.

5 Conclusions and Planned Activities

The ARGUS binaural guidance concept for the autonomous navigation of blind and partially sighted people has been successfully implemented and validated with a small sample of expert users.

Users reported very satisfying feedback regarding acceptance, ease of use, reliability, non-disturbance of ambient hearing as well as comfort. Additional features to enhance training provision, personalization and safety were also requested.

A subsequent analysis of the tracks performed during the tests showed that a more accurate and robust solution has to be provided in order to maximise system's performance.

Finally, the outcomes of these tests are very encouraging, and currently the ARGUS partners are implementing an updated prototype and are designing new user tests with a wider sample of users planned for the first quarter of 2014.

Acknowledgements

Authors wish to thank RNIB, VIAG, HILFSGEMEINSCHAFT, Blindenverein e.V., ONCE, FTS, University of Basque Country and INGEMA for their valuable contribution. ARGUS is co-funded by the EU under grant agreement FP7-288841. The opinions herein are not necessarily those of the European Commission.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-695

Synthetic and Natural Speech Intelligibility in Individuals with Visual Impairments: Effects of Experience and Presentation Rate

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Abstract. The present study aims to compare the intelligibility of words produced in natural and synthetic speech both with normal and fast speaking rate. The effect of several individual parameters on the intelligibility of synthetic speech was also investigated. Thirty adults with visual impairment took part in the research. The experimental design consisted of two parts: a structured interview and a psychoacoustic test. The interviews were focused on the participants' demographic data experience in using synthetic speech. The results indicated that participants performed more accurately in recognizing words presented in normal speaking rate than in a fast rate. Moreover, the results indicated that the differences between synthetic and natural speech were statistically significant.

Keywords. Visual impairments, speech intelligibility, synthetic speech.

Introduction

Synthetic speech perception is usually discussed in the literature with regard to intelligibility and comprehension [1]. Intelligibility is the listener's ability to recognize phonemes and words presented in isolation [2], whereas comprehension involves the extraction of the underlying meaning from the acoustic signals of speech [3].

There is an abundance of research carried out regarding the intelligibility of synthetic speech produced by Text-to-Speech (TtS) systems experienced by non disabled people. These studies showed that the intelligibility of natural speech is significantly greater than that of TtS synthesis systems [4]. Nevertheless, limited research is available on the perception of synthetic speech by individuals who have visual impairments [5].

Stevens et al. [6] Found that the gender of the voice and the quality of the signal in TtS synthesis affect the intelligibility. Moreover, previous studies indicate that

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synthetic speech perception in typical listeners is also dependent on listening conditions [7].

Text-to-Speech systems [8] are often used by individuals with visual impairments to meet their daily, professional and educational needs [9]. Moreover, individuals with visual impairments frequently use screen readers along with a TtS system as their reading medium [10, 11]. Hence, it is very important to investigate the intelligibility of synthetic speech by individuals with visual impairments and examine whether differences in intelligibility between synthetic and natural speech exist.

In a recent study [12] it was found that participants with visual impairments have significantly better performance when identifying words presented via natural speech compared to synthetic speech; accuracy scores ranged from 89.92% for words presented via the TtS synthesizer to 99.2 % for words presented via natural speech [12].

The results for the DEMOSTHéNES TtS platform in a series of psychoacoustic experiments using similar acoustic patterns ranged from 94.5% correct responses for sighted users to 96.47% correct responses for users with visual impairments in single word tasks and from 97.5% correct responses for sighted users to 98.1% correct responses for users with visual impairments in single sentence tasks [13].

Speaking rate can affect the intelligibility of words. Thus, speaking rate is an important variable for manipulation when attempting to maximize the comfort, acceptance, and comprehension of synthetic speech [14]. On the other hand it is known that blind persons often prefer to use synthetic speech in fast speaking rates [15].

1 Study

The present study has been designed to examine the ability of individuals with visual impairments to identify words presented via synthetic and natural speech both under different speaking rate conditions. In particular, the study aims to compare the intelligibility of words produced in: a) natural speech with normal speaking rate, b) synthetic speech with normal speaking rate, c) natural speech with fast speaking rate and d) synthetic speech with fast speaking rate. The effect of several individual parameters (gender, age, age at loss of sight, vision status, and experience in using TtS) on the intelligibility of speech was also investigated.

1.1 Participants

Thirty adults with visual impairment (blindness or low vision) took part in the research. The sample consisted of 17 males and 13 females. The age range was from 19 years to 49 years (M = 29.9, SD = 9.42). Nineteen participants were blind or had severe visual impairments (i.e. did not read visually by using any low vision devices) and 11 had low vision. The visual impairment was congenital for 13 participants and acquired for 17 participants. All the participants were members of the Panhellenic Association of the Blind. An essential requirement to include a participant in the study was not to have a hearing impairment or other disabilities, apart from visual impairments, and to speak the Greek as his/her mother tongue. Initially, we contacted by phone a random selection of 35 adults with visual impairments in order to invite them to participate in the study. From the total of 35 invited persons, 30 individuals agreed finally to participate.

1.2 Procedures

Each participant was interviewed and audio-recorded separately in a 25 minute session. The experimental design consisted of two parts: a structured interview and a psychoacoustic test. The interviews were focused on the participants' demographic data. Participants were asked about the main reading media they use by choosing one of the following: braille, synthetic speech systems, cassettes, lens, large print, and screen magnification software. Based on their responses, two sub-groups were formed. The first one include 17 participants who declared that they use TtS systems as their main reading medium. The second sub-group with 13 participants declared that they use some other reading medium. Moreover, the participants answered how often they use TtS systems in a 5-point likert scale (quite often, often, sometimes, rarely, not at all). To have a more precise indication of the frequency of TtS use, the participants stated how many years (overall) they had used TtS systems and how many hours per day, week or month they had used these systems, using a 5-point scale (more than 2 hours per day, 1-2 hours per day, 1-2 hours per week, 1-2 hours per month, none).

After the interview, each participant took part in the psychoacoustic test. In this test, they were asked to identify 200 different Greek words, 50 of which were presented in natural speech with normal speaking rate, 50 in synthetic speech with normal speaking rate, 50 in natural speech with fast speaking rate, and 50 in synthetic speech with fast speaking rate. Each participant listened to the randomly presented words one by one and repeated them orally (open response format).

The whole procedure was conducted by the researchers and ultimately all the participants' answers were audio-recorded, transcribed into the Greek orthography system, organized, reviewed for errors and analyzed using SPSS 19.0. For the transcription of the participants' answers two of the authors were used as transcribers. The reliability between these two transcriptions was high ($r = 0.92$, $p < .01$).

1.3 Instruments

A male voice was used for the recordings of the natural and synthetic speech. The speaking rate at which the material was played was 150 words per minute for the normal natural and normal synthetic speech and 250 words per minute for the fast natural and fast synthetic speech.

The recordings of the natural and synthetic speech (both in normal and fast speaking rates) consisted of 200 different words. These words came from a list of phonemically balanced Greek words developed by Trimmis et al. [16]. This list includes 200 different disyllable words, separated into four groups of 50 words, phonemically balanced and with approximately equal difficulty. The average length of words was 4.64, 4.62, 4.52 and 4.60 characters per word in the first, second, third and fourth group respectively.

For the recording of natural speech, an actor with appropriate articulation read loud the words in a recording studio. The fast rate natural speed was created with a time stretching software. For the recording of the words presented in synthetic speech the DEMOSTHéNES TtS platform [17] was used.

2 Results

Initially, the correct responses in the psychoacoustic test were estimated, both for synthetic and natural speech (in normal and fast speaking rates). The number of words that were incorrectly identified was calculated (see Table 1).

Table 1. Sum, Mean and standard deviation (SD) of participants' errors when identifying words presented via natural (normal and fast) and synthetic (normal and fast) speech.

	Sum	Mean	SD
Normal natural	15	.50	.938
Fast natural	44	1.47	1.137
Normal synthetic	111	3.70	2.938
Fast synthetic	224	7.47	5.612

The sum of the errors and the error mean indicated that participants performed more accurately in recognizing words presented via natural rather than via synthetic speech. Specifically, participants performed more accurately in recognizing words presented in normal natural (M = .50) rather than via normal synthetic speech (M = 3.70). Moreover, participants performed more accurately in recognizing words presented in fast natural (M = 1.47) rather than via fast synthetic speech (M = 7.47). The implementation of the Repeated-measures ANOVA revealed that the participants gave significantly fewer correct responses when identifying words that were presented in a normal synthetic rather than in normal natural speech [F (1, 29) = 34.964, p < .01]. Moreover, the participants gave significantly fewer correct responses when identifying words that were presented in fast synthetic rather than in fast natural speech [F(1, 29) = 37.375, p < .01]. Accuracy scores ranged from 92.60% for words presented via normal synthetic speech to 99.00 % for words presented via normal natural speech.

Likewise, the sum of the errors and the error mean indicated that participants performed more accurately in recognizing words presented in normal speaking rate rather than in a fast rate. The implementation of the Repeated-measures ANOVA indicated that the participants gave significantly fewer correct responses when identifying words that were presented in fast rate synthetic rather than in normal rate synthetic speech [F(1, 29) = 32.883, p < .01]. Moreover, the participants gave significantly fewer correct responses when identifying words that were presented in fast rate natural rather than in normal rate natural speech [F(1, 29) = 17.309, p < .01]. Accuracy scores ranged from 85.07% for words presented via fast synthetic speech to 92.60 % for words presented via normal synthetic speech.

Then, we examined possible differences in the intelligibility of the synthetic speech based on the gender, vision status (blindness or low vision) and the use of TtS as the main reading medium. The implementation of T-test indicated that the participants who use synthetic speech systems as a basic reading mean produced fewer wrong responses when identifying words that were presented via normal rate synthetic speech (t = 3.137, df = 28, p < .01) and via fast rate synthetic speech (t = 2.320, df = 116, p < .05) than individuals who use other basic reading means. On the other hand, statistically significant differences were not observed for the gender and the vision status (blindness or low vision).

Furthermore, by calculating Pearson's product-moment correlation coefficient (see Table 2), it was investigated if there was a correlation between performance on the word intelligibility test presented in synthetic speech and the following variables: age, age at loss of sight, years of synthetic speech use, frequency of use (how often) and hours of use. Regarding the normal rate synthetic speech, the results showed a statistically significant positive correlation between the number of correct responses and years of synthetic speech use ($r = .396$, $p < .05$), frequency of use (how often) ($r = .614$, $p < .01$) and frequency of use (how many hours) ($r = .479$, $p < .01$). Regarding the fast rate synthetic speech the results showed a statistically significant positive correlation between the number of correct responses and frequency of use (how often) ($r = .576$, $p < .01$) and frequency of use (how many hours) ($r = .455$, $p < .05$).

Table 2. Correlations between total score, score on each of the three subscales and participants' personal characteristics.

	Normal natural	Fast natural	Normal synthetic	Fast synthetic
Age	-.064	-.021	.135	.100
Age at loss	-.147	-.075	-.037	.137
Years of use	.009	.121	-.396*	-.298
Usage frequency (how often)	-.152	-.093	-.614**	-.576**
Hours of usage	-.052	.142	-.479**	-.455*

*$p < .05$, **$p < .01$

3 Conclusions

The results indicated that participants performed more accurately in recognizing words presented in normal speaking rate rather than in fast speaking rate. Moreover, the results indicated that the differences between synthetic and natural speech were statistically significant. Participants made significantly fewer errors when identifying words presented via natural speech. On the other hand, the findings of the present study indicate that the experience of use and the frequency of use can enhance a visually impaired person's ability for perception of synthetic speech. These findings seem to be in line with those in previous studies.

The findings of this study contribute to the understanding of issues that concern word intelligibility by individuals with visual impairments. Thus, the results of the study have implications for both educators and assistive technology developers.

The quality of the speech produced by TtS systems should be very high, especially when they render words that have similar acoustic patterns [5]. Moreover, the quality of the synthetic speech may have an impact on comprehension. According to Ralston et al. [18], there is a moderate relationship between intelligibility scores and comprehension-processing measures across different speech synthesizers. Thus, assistive technology developers should pay more attention to intelligibility scores when designing and incorporating TtS systems. The quality of the speech output of assistive technology devices can be assessed with words intelligibility tests, like the one applied in the current study.

Future research should focus on the impact of some other parameters on the intelligibility of synthetic speech. Such parameters could be text difficulty, quality of synthesizers, the impact of language background, and background noise.

Acknowledgements

This research has been co-financed by the European Union (European Social Fund – ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) under the Research Funding Project: "THALIS-University of Macedonia- KAIKOS: Audio and Tactile Access to Knowledge for Individuals with Visual Impairments", MIS 380442.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-702

Text-to-Speech Reading Assistant Device with Scene Text Locator for the Blind

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Abstract. One of the most anticipated devices for the blind is probably a wearable camera capable of translating the captured scene text into an alternative representation such as speech. However, finding signboards and capturing the text images in a form suitable for character recognition is difficult for the blind. We propose a framework of reading assistant device with a scene text locator that shows the text location by sound signals. By using a pair of base/offset notes, the accuracy of text localization has become much higher compared with our previous system.

Keywords. reading assistant, scene text detection, text locator, OCR (Optical Character Recognition), text-to-speech.

1. Introduction

Some text information acquisition devices have been developed for helping the visually-impaired to access text information [1]. However, it is difficult for the blind to find or even notice the text in the environment and to capture the text images suitable for optical character recognition. Particularly, some objects such as signboards are difficult to find since they cannot be held by the user's hands. This paper proposes a framework of reading assistant device with a scene text locator that shows the text location by sound signals. By using a pair of base/offset notes, the accuracy of text localization has become much higher compared with our previous system [2]. We have added Optical Character Recognition (OCR) and text-to-speech features to our prototype. A lot of visually-impaired people have tried our device at the Sight World 2012 exhibition in Tokyo, and we have confirmed its usefulness, found the limitations and some problems to solve.

2. Text-to-Speech Reading Assistant Device

2.1. System Outline

Figure 1 shows the block diagram of our text-to-speech reading assistant device. The system detects the text regions in the scenes, plays some guidance sounds according to the locations of the text regions, and converts the text into speech. The prototype device is equipped with Logitec HD Pro Webcam C920 as the image capture device, laptop PC, and bone conduction headphones. The camera is assumed to be head-mounted or handheld. We chose TEAC Filltune HP-200 bone conduction headphones system since

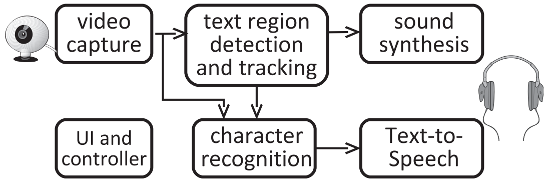

Figure 1. Block diagram of the reading assistant device.

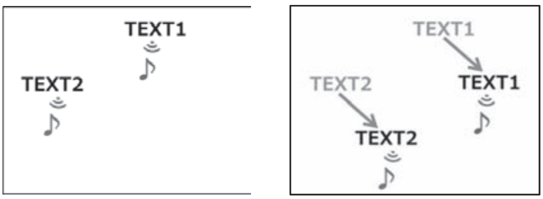

Figure 2. Text region tracking for keeping the same tone.

it does not cover the user's ears and imposes little impact on the sound perception which is very important for the blind to navigate themselves.

We chose the commercial Japanese OCR library provided by Panasonic Solution Technologies Co., Ltd. Although this product is designed for machine-printed characters in scanned document images, it can handle some kinds of scene text with small distortions. In the future, we will need an OCR engine tolerant of large perspective image distortions, uneven lighting and noise. Microsoft Speech Platform is used for the text-to-speech engine.

Text regions are detected in every video frame. Then, the first and the second largest text regions are picked up. For each text region, the sound signals modulated by the text locations are generated. The user moves the camera listening to the sound signals so the text region comes into the center of the camera view. When the user press "Read" button, the system captures a still image, recognize the text in the image using the OCR engine, and translate the text data into speech.

2.2. Text Region Detection

The first step is to detect text regions from each video frame (scene image) obtained by the webcam. The image size is normalized to 640×480 (pixels) in this step. We employed the text detection method based on the Discrete Cosine Transform (DCT) [3]. We preferred its higher recall rate and F-score compared with Huang's method [4]. The comparison results can be found in [2].

Connected components of the detected text blocks are found, and their bounding boxes are extracted as the text regions. When the text region's width or height is smaller than 8 pixels or lager than 200 pixels, the region is considered as a noise and discarded.

A simple object tracking method based on the Optical Flow is used to keep track each text region. This tracking process helps keeping the same tone, piano or beep, for each text region (Figure 2).

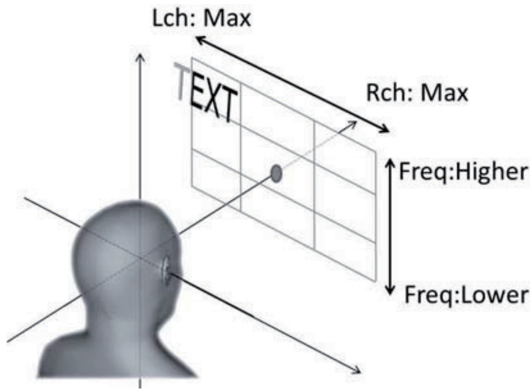

Figure 3. Text presentation using sound signals.

2.3. Text Location Presentation using Sound Signals

We use short guidance signals and sound transform instead of continuous ones to avoid hampering the user's hearing of other environmental sounds. For example, voice message such as "Upper Left" is inappropriate as it is lengthy and noisy.

Considering that multiple text regions exist, the first and the second largest text regions are picked up for the text location presentation. For each region, the center of gravity of the text region is found, and its offset from the image center is used to determine the sound. The image size is normalized to $(W,H) = (160,120)$, and the origin of the coordinates is set at the image center as shown in Figure 3.

Let the frequency of the note at the center be "base frequency." When the horizontal position is off the center, the sound panning is applied. The volume of the left channel is minimized, as defined by (1), when the target is at the right end. On the other hand, the volume of the right channel is minimized, as defined by (2), when the target is at the left end.

$$Vol_L(x) = \begin{cases} 100 & (x < 0) \\ 100 \times (1 - 2x/W) & (x \geq 0) \end{cases} \tag{1}$$

$$Vol_R(x) = \begin{cases} 100 \times (1 + 2x/W) & (x < 0) \\ 100 & (x \geq 0) \end{cases} \tag{2}$$

For vertical movement, we have introduced a new method using two short consecutive notes. The first note having the base frequency is followed by the second note whose frequency is modulated depending on the vertical position. At the top and the bottom of the view, the frequency is 1 oct. higher and lower, respectively, than the base. The frequency is changed at a halftone step.

Since the first note acts as the reference point, the user can easily know how far the vertical position is by comparing the two notes. On the other hand, in our previous system [2], it was not so easy for the user to grasp the vertical location since only one note was used.

The user hears the pair of base/offset notes periodically. If there exist more than one text regions, piano tone and beep tone are alternately played.

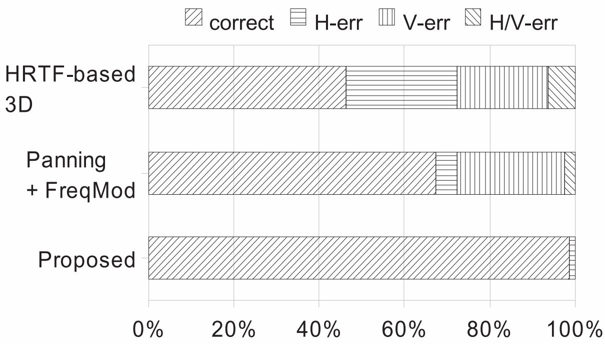

Figure 4. Text location presentation performances.

When the target text region is close to the image center, a simple special beep is played. The beep is set a little bit louder than the other signals in order to inform the user that the target is "captured." If the text region touches the left or the right end of the frame, it is likely that the text is beyond the camera view. A special sound is played in such a case so the user can fix the camera direction.

3. Performance Evaluation and Discussion

3.1. Text Location Presentation

We first tested only the text locator part to measure the performance of the text location presentation. The "captured" beep was disabled in this experiment. The image is partitioned into 3×3 blocks as shown in Figure 3. Four people with a blindfold participated in the experiments. 20 text locations were generated uniformly and randomly for each trial. The subject answered the perceived text location out of the 9 regions when the sound is played. We measured and compared the sound presentation performances using the following three methods.

1. HRTF-based 3D sound method [2].
2. Panning and frequency modulation method [2].
3. Proposed method using base/offset notes.

Figure 4 shows the result. The horizontal error was reduced very much by using the sound panning instead of the Head-Related Transfer Function (HRTF). The proposed system has outperformed our previous methods [2]. Symbolic sound method is more suitable for our application than sound field-based one. Actually, the bone conduction headphones are not good at sound field reproduction.

The performance evaluation by actual blind people is of course interesting and should be included in our future work as a lot of blind people have much better sound perception ability compared with sighted ones. Some performance improvement, especially in the text detection part, is required before extensive evaluations of the system. Our current experimental results, however, are still valid to some extent since the subjects with a blindfold resemble those who have just lost their vision quickly, for example, by an accident or by a health problem. In addition, we need to pay attention to some visually-impaired people suffering also from defective hearing. We cannot expect all the blind to have good sound field perception, and the system needs to cover a wide variety of disabilities, including poor hearing from aging.

3.2. Trial by Visually-impaired People

We presented our prototype system at the Sight World 2012 exhibition, an annual event for the visually-impaired people, volunteers, supporting companies, etc. Since the text detection feature does not work so well in complex scenes, we set up a plain wall and put some printed paper emulating signboards. A lot of visually-impaired people have tried our device, and we have confirmed that most of them can find the text location easily without any intensive training.

If the camera is handheld, the user tends to move or rotate it much greatly than we expected. Even with the wide view (77deg.) camera, the object easily goes out of the view. A super-wide angle, high-resolution camera is preferred.

A lot of people said that they wanted to use the device as soon as possible even if the performance and/or the target application are limited. The users would be able to get some clues about what they have or see, and such an ability is quite helpful for them. Other typical comments [C] and questions [Q] are summarized as follows.

1. [C] I'd like to use the device outdoors as well. (Dealing with complex scenes is desired.)
2. [Q] Can we use the device for reading the timetables at bus/tram stops and the destination signs on the vehicles?
3. [Q] Can I read signboards far away beyond my arm's reach?
4. [C] The electronical sounds and the synthetic voice are unpleasant to the ear and uncomfortable.
5. [C] I don't want to carry or wear a large equipment which makes me look different. Smaller one is preferred.
6. [C] It would be nice to have a smartphone application.
7. [Q] When will it be available in the market?
8. [C] I want a commercial product as soon as possible.
9. [C] I'm not so interested in the device as long as there is no product available now. (some elderly people)

Regarding the timetables and signs of public transport, most of the information is on the web today and developing another system utilizing it would be much more practical than our character recognition approach.

4. Conclusions

We have proposed a framework of reading assistant device with a scene text locator that shows the text location by sound signals. By using a pair of base/offset notes is quite effective in improving the text localization accuracy. The prototype is equipped with OCR engine and text-to-speech engine, and ready for trial use. The system is still in an early stage of development and further improvements are required, especially for better text detection, user interface, and camera device.

This work was supported by Grants-in-Aid for Scientific Research No.22300194 from JSPS. The work was partially conducted by Takahiro Sasaki and Akira Saito under my supervision at the university.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-708

Incorporating Typographic, Logical and Layout Knowledge of Documents into Text-to-Speech

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Abstract. Although Text-to-Speech (TtS) is considered a mature technology capable to produce synthetic speech of very high quality, current TtS systems do not include effective acoustic provision of the semantics and the cognitive aspects of the visual (such as the typographic cues) and non-visual (such as the logical structure) knowledge embedded in the rich text documents. In this paper, after the introduction of an appropriate document architecture, we analyze the semantics of the document signals. Then, by following a Design-for-All methodology, we present the Document-to-Audio approach we have developed for the automatics rendering document signals from the typographic, logical and the layout layers to the auditory modality.

Keywords. Document accessibility, text signals, Text-to-Speech.

Introduction

Text-to-Speech (TtS) constitutes a common software technology that converts in real-time any electronic text into speech [1]. It can be combined with other Assistive Technology applications, such as screen readers, to provide document accessibility through the acoustic modality to those with print disability [2]. Nowadays, TtS systems with synthetic speech of very high quality exist not only for desktop and laptop computers but also for smart phones and tablets.

Modern TtS systems have the possibility to set the prosody parameters of the synthetic speech (pitch, volume or speech rate) or to select among different voices or include sounds (e.g. earcons, auditory icons or spearcons) to render some semantic, structural or other information of a rich text document, such as the typographic attributes (bold, italics, underline, etc.). But these mappings cover a limited number of document's attributes, do not support all the kinds of the structural schema [3], in most cases have to be customized by the user, they support only tagged information (i.e. they do not include a knowledge-based extraction of non-content semantics) and finally they are proprietary or not universal.

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In a similar way, some advanced screen readers allow the user to modify how they indicate a text attribute or a combination of text attributes (such as bold, italic, underline, strikethrough, highlight, graphic, and so on). For example, a screen reader can force a TtS system to read bold or underlined text in a deeper voice or to vocalize the change of the font size. Nevertheless, screen readers carry the TtS limitations described in the previous paragraph.

Thus, current TtS systems do not include an effective and standard acoustic provision of the semantics and the cognitive aspects of the visual (such as typography) and non-visual (such as logical structure) knowledge embedded in the documents. Thereby, a blind person or one with busy eyes (i.g. a car driver) misses important information when they access a rich text document through TtS.

In this work, after the introduction of an appropriate tree layer document architecture, we analyze the semantics of the document signals. Then, by following a design-for-all methodology, we present the Document-to-Audio approach for the universal automatic rendering of document signals to auditory modality.

1 Document Architecture

Printed or electronic documents include books, newspapers, periodicals, journals, reports, articles, letters, pamphlets, webpages, and e-mails. With the term **text document** we refer to the textual content only of a document. A text document contains a number of presentation elements or attributes that arrange the content on the page and apply design glyphs or typographic elements (i.e., visual representation of letters and characters in a specific font and style). For example, the title of a chapter can be recognized by placing it at the top of the page and in larger font size than the body of the text. Moreover, text color or the bold font style can be used to indicate emphasis in a specific part of a text document.

The elements of a text document can be classified in three layers:

i. **Logical layer**: it associates content with structural elements such as headings, titles/subtitles, chapters, paragraphs, tables, lists, footnotes, and appendices.
ii. **Layout layer**: it associates content with architectural elements relating to the arrangement on pages and areas within pages, such as margins, columns, alignment and orientation.
iii. **Typography layer**: it includes font (type, size, color, background color, etc.) and font style such as bold, italics, underline. In contrast to the *rich text*, the term *plain text* indicates text in a unique font type and size, but without font style.

The above three layers are complementary and not independent. Typography can be applied to both the logical and the layout layers of a document. Moreover, typography can be applied to the main body of the text directly, for example, a word in bold can be used either for the introduction of a new term or to indicate a person's name. Also, a heading can be arranged in the center of a line (layout layer).

The organization of a document can be classified into two main aspects: the logical and the physical. The logical layer of the document architecture defined above corresponds to its logical organization with the same elements (e.g. headings, titles/ subtitles, chapters, paragraphs, tables, lists, footnotes, and appendices). At the page level, the physical organization of a document is described by its layout layer in connection with the physical realization of a number of logical layout elements (e.g. headings, titles/ subtitles, paragraphs, tables, lists, footnotes). The organization of a printed of electronic multipage document as a whole corresponds with the physical implementation of a part of its logical layer elements (e.g. chapters, appendices, indexed, references). The organization of a document is domain specific (e.g. text book, scientific paper, technical report, newspaper, magazine).

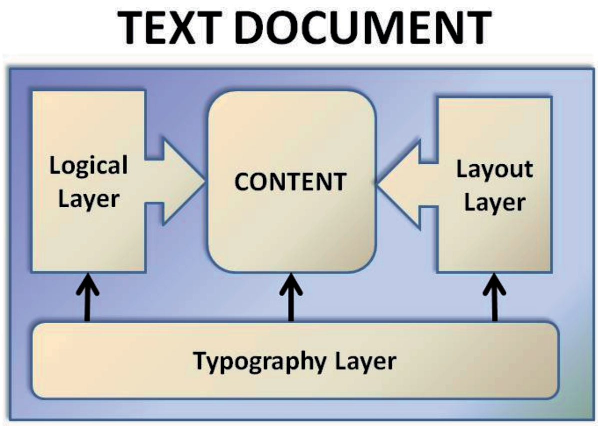

Figure 1. Text document architecture.

2 Semantics of Document Signals

A document is the "medium" in which a "message" (information) is communicated [4]. The term "signal" is introduced as "*the writing device that emphasize aspects of a text's content or structure without adding to the content of the text*" [5]. It attempts to pre-announce or emphasize content and/or reveal content relationship [6-11]. The title, heading, typographic cues are considered as signals. Also, "*input enhancement*" is an operation whereby the saliency of linguistic features is augmented through e.g. textual enhancement for visual input (i.e. bold) and phonological manipulations for aural input (i.e. oral repetition) [12].

All the text signalling devices, either mentioned as signals or layers: a) share the goal for directing the reader's attention during reading, b) facilitate specific cognitive process occurring during reading, c) ultimate comprehension of text information, d) may influence memory on text and e) direct selective access between and within texts [5].

The primary goal of utilizing text signal or presentation elements in text documents is to distinguish parts of the text and to create a well-formed presentation of the content in order, for instance, to augment the reading performance or attract the reader. Authors use typography and layout in a specific way, e.g. there are "strict" typographic rules for the documents to be published in a scientific journal. But in newspapers and books the **page designer** (or the **page manager**), and not the author, has the primary responsibility for applying the typography and layout layers. Traditional factors that play a leading role in documents formation and presentation include **readability** (*the gauge that measures how easily words, phrases, and blocks of copy can be read)* and **legibility** (*the measure of easiness to distinguish one letter from* *another in a particular typeface*). More recent factors include visual **aesthetics** and **accessibility**. On the other hand, it seems that there is a plethora of **semantics** in applying the typographic layer. For example, in contrast to the tags introduced by the W3C for the bold and italics font styles [13], we have identified [14] eight different "labels" that the readers seem to use most frequently in order to semantically characterize text in "bold" and "italics (a total of 2.927 entities, of which 1866 were occurrences of "bold" and 1061 of "italics" were manually labelled in a corpus of 2.000 articles of a Greek newspaper):

- *Emphasis:* A word or phrase that is considered significant and needs to be stressed out.
- *Important / Salient:* A word or phrase, which is near or is part of a piece of information that is considered important and should be noticeable. A word or phrase that "catches the eye" of the reader.
- *Basic Block*: A block of text, which introduces or summarizes the main content of the article.
- *Quotation:* A piece of text corresponding to a fragment of written or oral expression of a person other than the writer of the article.
- *Note:* A piece of text serving at providing additional information or explanation related to a part or to the whole of the article.
- *Title:* A piece of text corresponding to the name of a movie, play, book and so on or the title of a newspaper, television channel or journal.
- *List / Numeration Category:* A word of phrase that is part of a list or a numeration and serves as a new "instance" indicator.
- *Interview / Dialogue:* A piece of text that is part of an interview (the question or the answer) or that corresponds to a dialogue between two persons.

A few "logical" labels, such as "subtitle" or "footnote" were also mentioned by some readers, but these were not considered to be "semantic" labels and were therefore not of value for the purposes of this study.

3 Rendering Document Signals to Auditory Modality

We present here our design-for-all based efforts towards rendering document signals to auditory modality. We have introduced the relative term **Document-to-Audio (DtA)** synthesis, which essentially constitutes the next generation Text-to-Speech systems that support the efficient acoustic rendition of the presentation elements of a document (i.e. the typography and logical layers of a document).

First we have applied analytics to large corpora of text documents in both English and Greek language (selected as a representative minor language with non-Latin alphabet) in order to extract knowledge for the logical, layout and typography layers embedded in text

For the signals at the logical and layout layers in DtA we first extract the relative information from the document. Then, we model the parameters of the synthesized speech signal by: (a) combining alternative text insertion in the document text stream, (b) altering the prosody, (c) switching between voices, and/or (d) inserting non-speech audio (like earcons, auditory icons or spearcons) in the waveform stream, according to the class of metadata extracted from the document.

For the typography layer two approaches for rendering document signals to auditory modality are incorporated in DtA: a) direct mapping and b) emotional-based mapping.

3.1 Direct Mapping

Based on the relation similarity, each typographic cue is directly mapped into a respective acoustic cue. The principle of relational similarity explores two physical quantities with magnitudes that humans perceive by different senses in an analogous way. For example, the font size of a text and the volume of the speech signal when the text is vocalized comprise relational similarity in the case we perceive the change of their magnitudes in a proportional way. We have studied the existence or not of inherent relation similarities between the written and the oral aspects of a natural language.

3.2 Emotional-based Mapping

First, we measure and model the way emotional states are induced to the reader by the document typographic visual characteristics. Then, following a number of psychoacoustic experiments we determine analogous prosodic cues that produce the same emotional states to the listener when he hears the acoustic rendition of the document by a TtS system. Recently [15], we have developed an automated reader's emotional state extraction process derived by the typographic cues (Figure 2), as well an appropriate modeling of reader's emotional state response on document's typographic elements [16, 17] combined with the mapping rules of expressive speech synthesis models that

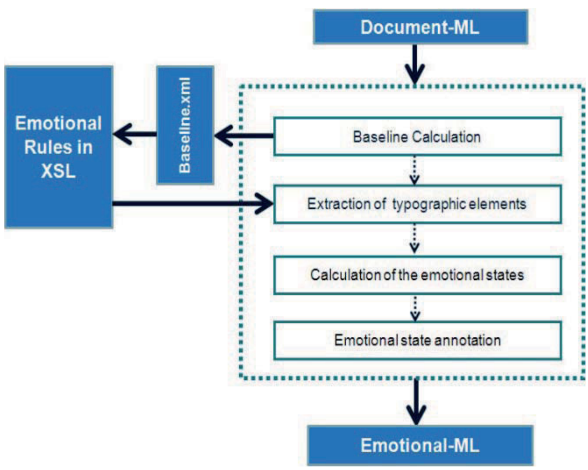

Figure 2. The emotional state extraction and annotation methodology.

4 Planned Activities

A number of experiments are in progress with blind and sighted participants in order to study the appropriate relation similarities of direct mapping typographic signals to auditory modality in DtA. Moreover, we plan a psychoacoustic experiment to compare the direct mapping approach and the emotional based mapping in DtA.

Acknowledgements

This research has been co-financed by the European Union (European Social Fund – ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) under the Research Funding Project: “THALIS-University of Macedonia- KAIKOS: Audio and Tactile Access to Knowledge for Individuals with Visual Impairments”, MIS 380442.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-714

Characterization of Proximity Sensors for the Design of Electronic Travel Aids

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Abstract. The main goal of Electronic Travel Aids is to detect obstacles and provide information to help visually impaired people safely navigate the surroundings. To achieve an efficient ETA design, the properties of the integrated sensors need to be considered for their suitability. This paper investigates the characteristics of two types of proximity sensors for this purpose. The transfer functions of an infrared and an ultrasonic sensor were determined. For the latter, we also examined the detection threshold for different obstacle distances, and reconstructed the beam shape in 3D. For the ultrasonic sensor, a width detection threshold of 12 mm was found for a distance of 3 m, with an important increase beyond 3 m. These characteristics provide insights into the suitability of two low-cost proximity sensors for ETAs.

Keywords. Ultrasonic sensor, infrared sensor, sensor beam, obstacle width threshold.

Introduction

Obstacle detection is a critical aspect of Electronic Travel Aids (ETAs) to ensure safe ambulation of people with visual impairment. To extend the detection distance and range, many sensors such as laser rangefinders, infrared sensors, ultrasonic sensors, and vision-based sensors have been utilized in ETAs. Among these sensors, the ultrasonic sensor is widely employed for commercial ETAs and research prototypes (e.g. iSONIC, UltraCane, Miniguide [1-3]) thanks to its low weight, low cost and robust obstacle detection. Understanding sensor behavior in a real navigating environment is indispensable for the design of efficient ETAs.

In addition to the data provided by the manufacturers, several papers investigated sensor properties. Borenstein and Koren [4] discussed the inherent limitations of ultrasonic sensors such as the inability of the sensors to receive the reflected waves when the obstacle is at an angle with respect to the sensor. Danko *et al.* evaluated the accuracy of the Devantech srf-04, the preceding model of the srf-05, in the presence of artificial fog. As the distance between an obstacle and the sensor increased, the error in the distance measurement largely increased due to fog [5]. However, other sensor characteristics (e.g. 3D beam shape, obstacle width threshold) crucial for the design an efficient ETA have not been investigated so far.

Ideally, an ETA should detect any close-by obstacle, small or large, in any indoor or outdoor environment. This paper investigates the characteristics of the ultrasonic sensor (srf-05) used in our previously presented Advanced Augmented White Cane

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(AAWC) [6]. Along with the characterization of the ultrasonic sensor, the transfer function of an infrared sensor, used for drop-off detection, is determined.

1. Methods

1.1. Sensor Calibration

This paper focuses on the characteristics of an ultrasonic sensor (srf-05, Devantech, USA) and an infrared sensor (2Y0A710, Sharp, Japan) with respect to their suitability for use in ETAs. The sensor signals were acquired and processed by a microcontroller (ATmega 128, Atmel, USA). The calibration of the ultrasonic sensor was performed outdoor with a 10 cm by 10 cm square-shaped paper obstacle as illustrated in Fig 1. The calibration was undertaken from 0.1 m up to 4 m by moving the sensor away from the object in 10 cm increments. The actual distance between the object and the sensor was recorded with a measuring tape, and raw sensor data were collected for 5 seconds at a sampling rate of 20 Hz at each position.

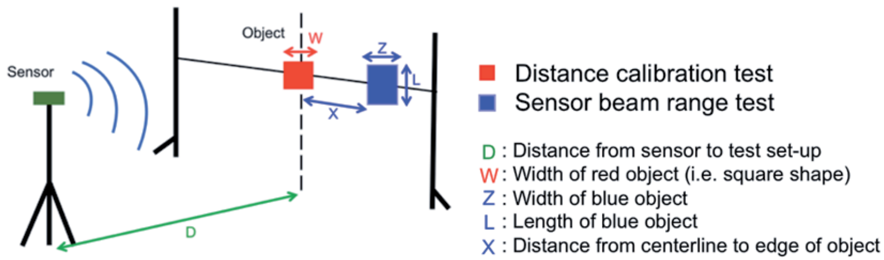

Figure 1. Ultrasonic sensor calibration rig; the sensor was fixed on a tripod at the same height as the object, which was attached to a wire of 0.5 mm diameter.

The infrared sensor was also calibrated outdoors, and a wooden pole was used as an obstacle. The sensor was moved away from the object from 1 m to 4 m in 0.5 m increments. The distance between the sensor and the object was recorded, and raw data were collected for 7 seconds.

1.2. Ultrasonic Sensor Beam Shape

Using the same test set-up, the ultrasonic sensor was placed at a distance of 0.5 m up to 3.5 m in 0.5 m increments. The object, a 26 cm by 34 cm rectangle, was also moved away horizontally from the center towards the wooden pole in 25 mm increments up until the object was not detected anymore (Fig. 1). The distance between the centerline and the edge of the object that is closer to the centerline was considered as the outer edge of the sensor beam (i.e. X in Fig. 1). The procedure was repeated on both sides of the sensor. After the horizontal beam range measurement, the sensor was rotated by 90 degrees and the procedure was repeated to determine the vertical beam range.

1.3. Ultrasonic Sensor Width Detection Threshold

To investigate the minimal object width that can be detected by the ultrasonic sensor, various diameters of wires up to 2 mm diameter and various widths of paper from 4 mm to 100 mm with 300 mm length were used as test obstacles on the same set-up used for the calibration. Measurements were made up to a distance of 4 m by moving the sensor away from the object in increments of 0.5 m.

2. Results

2.1. Sensor Calibration

The characteristics of the two used sensors are listed in Table 1. As the raw data of the ultrasonic sensor was proportional to the distance between the object and the sensor, the data points were fitted with a linear function as illustrated in Fig. 2 (left). On the other hand, the raw data points of the infrared sensor showed a non-linear decrease with increasing obstacle distance (Fig. 2, right) and were fitted with a power function.

Table 1. Sensor Characteristics.

	Devantech srf-05	Sharp **GP2Y0A710K0F**
Measurement range	0.03–4 m	1–5.5 m
Resolution	5.5 cm*	N/A
Refresh rate	20 Hz	28 Hz
Consumption	20 mW	150 mW
Size	43 x 20 x 17 mm^3	58 x 17.6 x 22.5 mm^3

* based on peak-to-peak noise (3–4 cm according to datasheet)

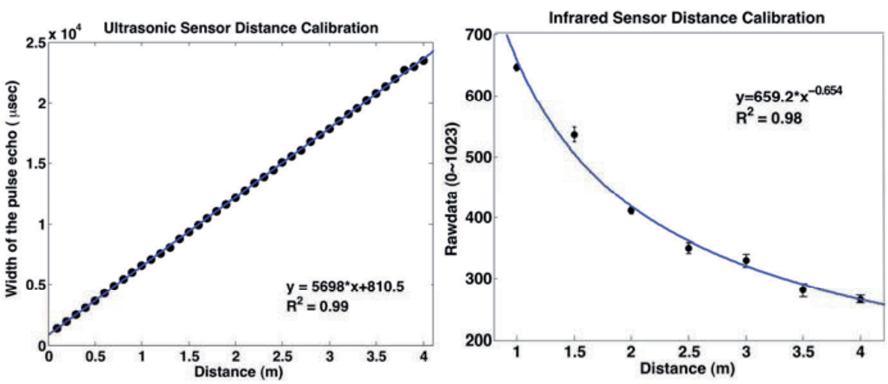

Figure 2. Transfer function of the ultrasonic sensor showing a highly linear relationship (left). Transfer function of the infrared sensor, approximated with a power function (right).

2.2. Ultrasonic Sensor Beam Shape

According to the result of the ultrasonic sensor beam shape test, the four maximum detectable obstacle limits, namely, to the top, bottom, left, and right of the ultrasonic sensor for each 0.5 m step are plotted in Fig. 3 (left). The maximum beam diameter was found at 1 m, and the major and minor axes of the inner ellipse were 75 cm and 70 cm, respectively.

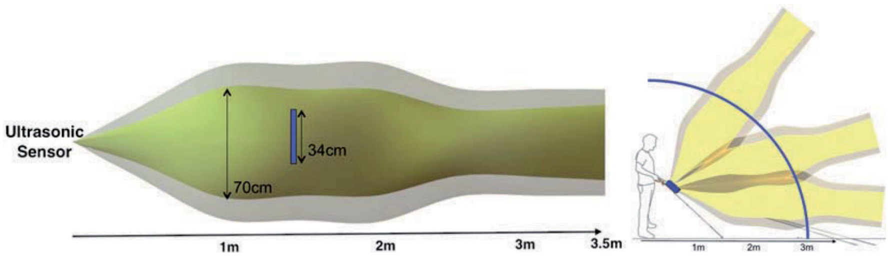

Figure 3. Ultrasonic sensor beam shape reconstructed from the detectable obstacle limits. The yellow and the grey region indicate the reliable and the unreliable detection regions, respectively (left). Beam reconstruction with optimal angles to detect obstacles in three vertical levels (right) within a range of 3 m.

Based on the reconstructed beam shape, the optimal sensor locations and orientations for a cane-based ETA were determined (i.e.. detecting obstacles in three vertical levels: head, trunk, and leg-level) as shown in Fig. 3 (right) within a range of 3 m ahead of the user. The inclination angles with respect to the white cane were fixed at 85, 58, and 38°, respectively.

2.3. Ultrasonic Sensor Width Detection Threshold

The width threshold of an object detected by the ultrasonic sensor is plotted in Fig. 4. Within 1.5 m distance, the sensor was capable of detecting a wire with only 2 mm diameter, and, at a distance of 3 m, a piece of paper of 12 x 300 mm^2 could be detected. However, the width threshold increased dramatically from 3 m to 3.5 m.

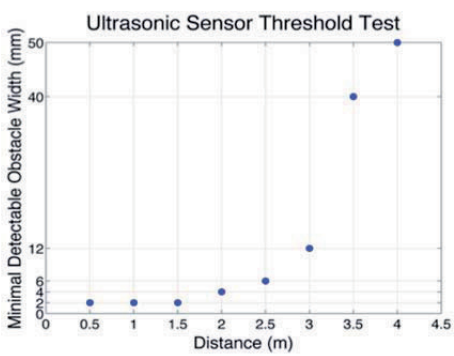

Figure 4. Obstacle width detection threshold for the ultrasonic sensor. A large change of threshold occurs when the distance increases from 3 m to 3.5 m.

3. Discussion and Conclusion

We examined the characteristics of an ultrasonic and an infrared proximity sensor in order to obtain a better understanding of the sensor behavior in an outdoor environment for the design of efficient ETAs. The sensor calibration allowed a precise estimation of the obstacle distance based on the raw sensor data with a resolution of less than 5.5 cm. Since the ultrasonic sensor measures the time of flight of the emitted sound wave, the raw data of the sensor showed a linear response with the distance. The infrared sensor determines the reflected angle of the infrared beam, and the calibration curve showed a nonlinear decrease of the raw output with distance with rather high levels of noise.

To determine the optimal number and orientation of ultrasonic sensors for the AAWC, we reconstructed the beam shape of the sensor for a medium-sized obstacle. Based on the reconstructed beam shape, we could arrange three ultrasonic sensors to mostly cover the area in front of the user's body from head to feet within a range of 3 m (Fig. 3, right). Such a dense coverage should give a reasonable preview on obstacles to the user to safely stop or avoid the obstacle unless he/she turns sharply.

Since a thin obstacle such as a wire fence can be dangerous, the width detection threshold is an important safety parameter. We found that the ultrasonic sensor could detect considerably small objects (i.e. with less than 12 mm width) within a 3 m range from the sensor, but the width detection threshold increased dramatically for obstacles beyond 3 m. However, an obstacle preview range of 3 m seems reasonable for safe navigation: Clark-Carter [7] investigated the relationship between non-visual preview distance and walking speed of visually impaired people. The average walking speed of the subjects with an ETA was significantly faster for a preview range of 2.7–3.5 m than the walking speed of the subjects with the support of a conventional cane alone [7], which typically covers a range of 1 m in front of the subject.

In the evaluation of our AAWC, we found an average reaction time to a drop-off of 0.41 ms in five blindfolded subjects [6]. Nakamura performed gait analysis in 15 sighted people and 15 congenitally blind people, and found average gait speeds at the subjects' preferred natural walking speed of 1.50 m/s and 0.86 m/s, respectively [8]. Using the reaction time and the average gait speed, we can calculate that an AAWC user would travel approximately 0.62 m and 0.35 m during reaction time, which allows 1.59 s and 3.08 s until the obstacle if it was detected at 3 m away from the user. The actual time may vary depending on the time since visual loss, the type of ETAs, the reaction time and walking habits of each individual, etc. However, we can estimate that the preview of 3 m would still give 1.59 s to react to an imminent obstacle at a typical walking speed of sighted people.

Due to many uncontrolled parameters during outdoor testing, the obtained results might vary in different conditions. For example, the beam shape of the ultrasonic sensor is influenced by the surface properties and the shape of the obstacle, as well as by the reflection angle between the ultrasonic wave and the obstacle. The beam shape may also differ depending on the size of the obstacle, and increases for larger obstacles. In our experiments, we used an obstacle with a size of 26 by 34 cm, which we found representative of typical obstacles encountered outdoors, but further investigations into the effect of shape, surface property and size of obstacles on their detection should be carried out.

For the infrared sensor, beam shape and width detection threshold were not determined since the sensor measures the distance to a single point. This would make the detection of drop-offs problematic in uneven terrain. A further limitation of the infrared sensor is its sensitivity to the illumination of the environment. Further investigation on the effect of sunlight, and the possibility of signal processing or using an optical filter is necessary. Another limitation of infrared sensor is that it cannot detect reflective materials such as glass. Therefore, another sensor based on a different measurement principle may need to be combined with the infrared sensor to achieve robust drop-off detection.

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Assistive Technology: From Research to Practice
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IOS Press, 2013

doi:10.3233/978-1-61499-304-9-720

A Virtual Hearing-Impaired Listener (VHL)

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Abstract. This paper presents a biologically-inspired algorithm that models any potential hearing loss given by binaural audiograms. It is used as a pre-processor for audio signals, enabling an otologically normal person, i.e. a person with normal hearing, to perceive sounds, music, or speech similar to a person with a sensorineural hearing loss (SNHL), given by the respective auditory threshold function or audiogram. The pre-processing engine is used as a start-up to create virtual 'test persons' or virtual hearing-impaired (HI) listeners for initial field tests to improve the quality of hearing in modern digital hearing-aids (DHA). After a newly developed DSP algorithms for a DHA shows significant improvement in specific sound perception with the VHL, this algorithm will be tested by hearing-impaired persons. This paper also presents a set of prototype results employing the VHL in masking tests to detect auditory threshold functions in the Freiburg Number Test.

Keywords. Hearing-impairment, hearing-loss, hearing test, frequency discrimination, tuning curve, digital hearing-aids, ISO 7029, auditory threshold functions, sensorineural hearing loss (SNHL).

Introduction

Technological advancements in hearing-aids have helped to partially compensate for physiological hearing losses in human listeners. Still, hearing-aids cannot compensate completely for defective hearing, which is often due to an (irreparable) physiological damage of the inner- and outer hair cells (IHC or OHC, respectively). A damage of the OHCs induces deterioration in frequency discrimination, an increase of masking thresholds, and a change of compression for low level sounds. The reduced high frequency sensitivity implicates reduced speech intelligibility and a reduced ability to suppress unrelated noise and to localize sound sources, which has substantial influence on everyday communication. For further improvement of modern digital hearing-aids, the complex interactions in the hearing system of otologically normal and hearing-impaired listeners must be modeled in more detail.

To improve signal pre-processing in digital hearing-aids, very time-consuming listening tests are to be performed to evaluate and improve the quality of various signal-processing strategies. Normally, the algorithms are evaluated with the help of psychoacoustic experiments applied to persons with specific hearing-losses. In this paper, we propose the use of a virtual hearing-impaired listener (VHI) as an intelligent pre-processing engine with the help of which one can predict and estimate the effectiveness of an algorithm before conducting human listening tests.

The wider research goal is to investigate and improve those newly developed compensation strategies for recovering the frequency discrimination in digital hearing-aids that seem prosperous when applying the VHI. The employment of a VHI can substantially accelerate the evaluation and adaptation of existing and facilitate the development of new audio signal processing strategies in digital hearing-aids and thereby provide a gain for the HI listener in everyday communication.

1. Biological Inspiration

The main research goals for this paper were i) the development of a structured model of a virtual (sensorineural) hearing-impaired listener that predicts effects of auditory signal processing in individual HI listeners according to the individual audiograms and ii) the employment in intelligibility tests for the improvement of digital hearing-aids, thereby improving the optimization process for such hearing-aids in a very effective way as to compared to conducting all tests with HI listeners.

Since deterioration of speech intelligibility and communication in noisy backgrounds vary substantially between HI listeners, depending on the individual hearing-loss(es), the VHI had to capture and adapt to specific characteristics of the individual SNHL employing individually adjustable parameters.

The signal processing in the virtual auditory pathway of our VHI is governed by serially connected models of i) the input processing in the outer ear, i.e. the pinna and the ear canal [1], ii) the impedance conversion in the middle ear [1], iii) the frequency-space transformation of the audio signal by the basilar membrane modeled by an auditory filter bank employing a set of overlapping filters or tuning curves [2], respectively, iv) the functionality (half-wave rectification) of the inner hair cells for each frequency band (or for each ‘tuning curve’) [3], and v) subsequent short term integration in each frequency band [3]; for experiments with headphones, i) and ii) will not be implemented.

Two major heuristic effects observed in listeners with sensorineural hearing loss are i) a reduction of the sensitivities of certain tuning curves in the auditory filter bank corresponding to the static increase of the auditory threshold function or audiogram of the hearing loss (measured in dB_{HL}) [3] and ii) the simultaneous widening of the bandwidths of the tuning curves due to the dysfunction of the OHC [4]. This widening can be modeled by broadenings of the bandwidths by hearing-loss dependent factors B for the respective frequency bands [4], which account for the dysfunction of the OHC given by

$$B = 10^{0.01*HLohc} \qquad \text{for CF} > 500 \qquad (1)$$

$$B = 10^{0.01*(1-(f-0.5)^2/c)*HLohc} \qquad \text{for CF} < 500 \qquad (2)$$

with

B = factor by which Equivalent Rectangular Bandwidth (ERB) is broadened in HI listeners,
CF = center frequency of the corresponding auditory filter or tuning curve in [Hz],
HL_{OHC}= part of the hearing loss that accounts for a dysfunction of the OHCs,
f = frequency in [kHz],
c = 1.23 = constant factor.

2. State-of-the-Art

Mathematical models have been published (e.g., [5], [6], [7]), which aim to predict specific results of heuristic listening experiments with hearing-impaired listeners that are conducted with listeners without hearing loss. The parameters of such models are usually detected by the measurement of pure-tone sensitivity, cochlear compression, frequency selectivity, intensity discrimination and temporal resolution in listening experiments. Common limitations of such models are that they are able to predict only one characteristic mode, namely spectral or temporal resolution of the normal hearing and the HI listener. Therefore, further listening tests have to be conducted to extend the current models to the prediction of temporal and spectral characteristics imposed by SNHL.

3. Experiments with the VHL

In order to show the general quality of the pre-processing engine, some masking experiments were conducted that emulate SNHL of different age-related auditory threshold functions. As the reference, we used average values for male listeners of different age as stated in the International Standard ISO 7029 [8].

The text corpus consisted of a subset of the Freiburg word test ([9], [10]), i.e. the words for numbers 21 to 99 (without 30, 40, …, 90). A male speaker produced well articulated speech signals for all respective numbers, which were subsequently superposed with babble noise of signal-to-noise ratios (SNR) of 0, -5, -10, -15, -20 dB, resulting in 5 sets of 72 speech signals. The babble noise was created from four different voices of two female and two male speakers by superposition of multiple randomly chosen temporal windows of the same window length, which were selected from the respective speech signals.

The sets of words were fed through the pre-processing engine VHL and presented in random order to five test persons, and the recognition score rates were calculated and averaged over the test persons according to the SNR. Each SNR test line was presented five times, i.e. without hearing-loss and with average age-related hearing losses for ages 40, 50, 60, and 70 years. The respective frequency-dependent increases of the auditory thresholds and the related widenings of the auditory filters or tuning curves were calculated according to ISO 7029 standard [8] and formulas (1) and (2), respectively. The results averaged over the five test persons representing an otologically normal listener 'Male20' or listeners 'Male40, 50, 60, 70' with a virtual hearing -loss are shown in figure 1.

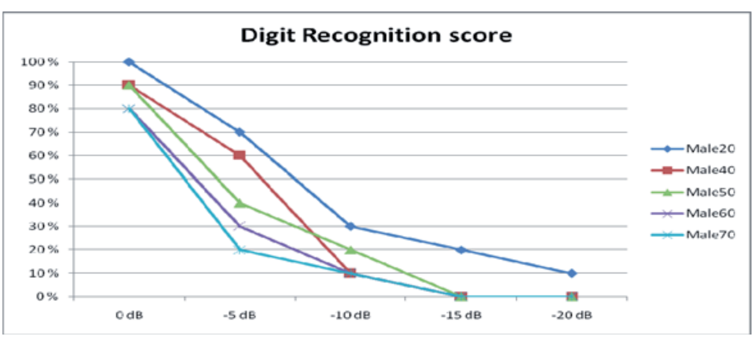

Figure 1. Word/digit recognition scores without and with four standardized age-related hearing losses, each of which averaged over five listeners, measured at five SNR with babble noise.

It can clearly be seen that the score rates decrease significantly with age, and that at higher ages, desired recognition scores demand higher SNR. The 50% thresholds for the recognition scores are shown in figure 2 (after linear interpolation).

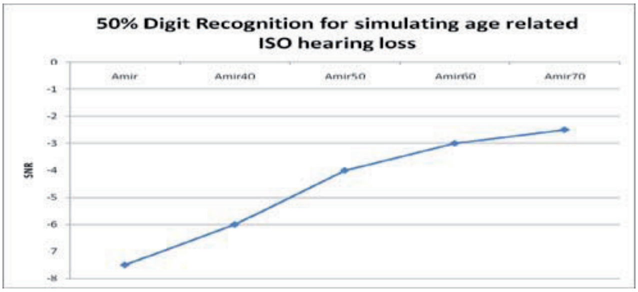

Figure 2. 50% word/digit recognition for simulating age-related ISO standard hearing loss.

For an otological normal listener, the 50% threshold is located at SNR ≈ -7.5 dB, and it is steadily increasing towards SNR ≈ -2.5 dB for the 70 years old virtual listener Amir70. This tendency is well experienced by elderly persons with an age-related hearing loss and demonstrates the principle usefulness of the VHL.

4. Conclusion and Future Activities

The VHI exists in a modular form that can be improved stepwise. Speech intelligibility tests employing masking thresholds and variable SNR were composed and tested with listeners with or without virtual hearing loss. The next step is now to quantitatively compare the data with recognition scores taken with human hearing-impaired listeners and thereby evaluate the VHL. It will then be employed to test existing and new signal processing algorithms in digital hearing-aids and to use prosperous algorithms in experiments with human hearing-impaired listeners with individual age-related hearing losses and iteratively improve the quality and quantity of new signal processing strategies in digital hearing-aids.

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Telecare

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-727

Ambulatory Activity-based Feedback for Improving Daily Physical Activity Patterns in Patients with the Chronic Fatigue Syndrome

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Abstract. To study the compliance with a physical activity monitoring and feedback intervention, as implemented for balancing daily physical activity in patients with the chronic fatigue syndrome. The intervention was implemented into an existing rehabilitation program for treatment of chronic fatigue syndrome. Feedback was provided at home with a personal digital assistant during four consecutive feedback periods. Compliance with the feedback system was around 90% during each of the four feedback periods. Fifteen patients (50%) complied with all four feedback periods. The fifteen compliers changed their physical activity level significantly into the direction of the goal, especially in the morning and afternoon. Changes in physical activity were seen instantaneously from the first feedback day on. Patients were able to change their daily physical activity into the direction of the goal. The compliance with all four feedback periods was low and might be related to the instantaneous effect of the feedback.

Keywords. Ambulatory feedback, activity monitoring, physical activity, chronic fatigue syndrome.

Introduction

The chronic fatigue syndrome (CFS) is characterized by severe debilitating fatigue lasting for at least six months [1]. CFS patients have shown to be less physically active and have a different daily physical activity pattern when compared to healthy controls [2, 3, 4, 5, 6]. Disturbances in physical activity patterns are hypothesised to be a key factor in the development and maintenance of chronic fatigue syndrome [7]. Cognitive behavioural therapy and graded exercise therapy are the most promising treatment modalities in chronic fatigue syndrome and both underline the importance of a regular and balanced daily physical activity pattern [1, 8]. However, studies that examined the effectiveness of graded exercise therapy showed mixed results, and high dropout rates suggested the ineffectiveness of graded exercise therapy for subpopulations [9]. As such it is expected that more individual tailoring of cognitive behavioural therapy and graded exercise therapy to individual needs may enhance treatment outcome [10, 11, 12].

Several studies have shown the potential value of telecommunication technology in improving physical activity levels in chronic patients [13-15]. Telecommunication technologies are often used for providing feedback on subjectively experienced physical activity behaviour [16]. The use of real time feedback on objectively measured physical activity behaviour would likely be more accurate in providing feedback than feedback based on patients' own experiences [17].

As such, in this study CFS patients have received real time ambulatory feedback on daily physical activity performed in their own home environment as supplement to an inpatient rehabilitation program comprising cognitive behavioural therapy. Real time ambulatory feedback is provided with aid of an ambulant activity monitoring and feedback system [2, 18, 19]. The objective of this study is to assess (i) the compliance with the feedback, and (ii) the change in physical activity patterns of those who comply.

1 Methods

A longitudinal study was performed, as part of a randomized controlled trial, in which a feedback program was implemented into an existing rehabilitation program. Experiments were approved at the accredited Medical Research Ethics Committee of the hospital 'Medisch Spectrum Twente' in Enschede, The Netherlands. Patients, with chronic fatigue syndrome who were considered for the clinical rehabilitation program in the Roessingh Rehabilitation Centre in Enschede (The Netherlands), were recruited for participation in the study. Diagnosis of chronic fatigue syndrome by a general practitioner or a physician was required for inclusion, following the criteria of the Centres for Disease Control and Prevention of 1994 [20].

The rehabilitation program comprised 9 weeks with inpatient cognitive behavioral therapy in week 1, 3, 5, 7 and 9. The feedback program was implemented during the four periods when patients were at home in between the weeks of inpatient treatment. Physical activity measurements were performed with a tri-axial accelerometer at baseline and during the feedback program (figure 1a). Ambulatory feedback was provided at a personal digital assistant during the four consecutive feedback periods each consisting of five days, based on the difference between the physical activity level of the patient and a predefined goal pattern (figure 1b and 1c).

Figure 1a. Wearing of the feedback system.

Figure 1b. Cumulative daily physical activity pattern.

Figure 1c. Difference with the goal, activity judgement and advice.

Compliance with the feedback system was assessed for each feedback period separately. A patient was considered compliant in case the system was worn for at least four days and at least seven hours per day. An hour was taken into account when at least 30 minutes of data was present. The patients who were compliant in all four feedback periods were referred as compliers, and patients who stopped prematurely as non compliers. Group differences between compliers and non compliers were analyzed with independent t-tests.

Changes in physical activity patterns were studied with the mean physical activity level per hour expressed as percentage of the norm. The mean physical activity pattern was calculated for the baseline period and the four feedback periods. The Statistical Package for the Social Sciences (SPSS18) was used for statistical analysis. In the group of compliers repeated measures general linear models with multiple pairwise comparisons were performed for analyzing changes in physical activity patterns. The Friedman test was used instead of repeated measures general linear model if the dependent variable was not normally distributed.

2 Results

Thirty of the forty-two patients from the intervention arm of a randomized controlled trial were included into the analysis. Twelve patients were excluded because of missing data at baseline. The mean age of the 30 included patients was 37.7 (SD=11) and the group consisted of 4 males and 26 females.

The compliance with the feedback system was around the 90% during each feedback period (figure 2).

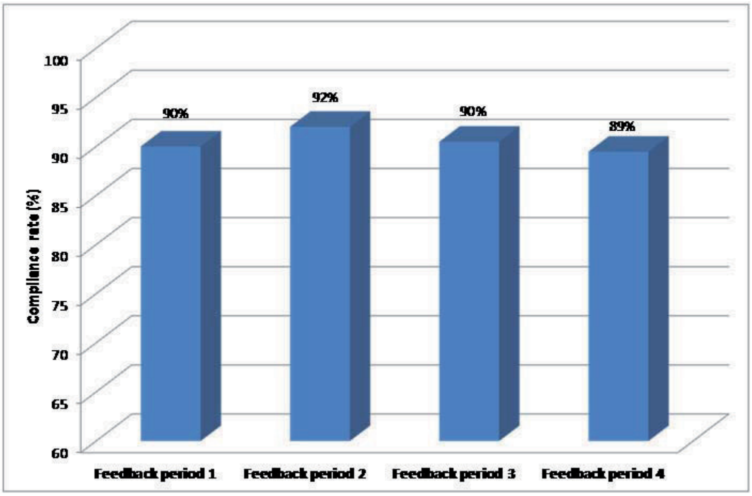

Figure 2. Compliance rate for each feedback period.

In total fifteen patients (50%) complied with all four feedback periods (compliers), while fifteen patients did not (non compliers). Twelve of the fifteen non compliers dropped out the feedback program. The most important reason for dropping out was the portability of the feedback system (n=7). Other reasons for dropping out were experienced discrepancies between activity advices from the feedback system and from the rehabilitation centre (n=2), the need of self control about planning daily physical activities without continuous interference from the feedback system (n=2) and doubts about validity in activity monitoring of the feedback system (n=1).

The physical activity level during all four feedback periods were significantly increased ($p<0.05$) and closer towards the goal compared to the baseline period. The mean physical activity level was within the range of the goal in nineteen of the twenty feedback days, and only beneath the goal at baseline (84%) and at day 2 of feedback period 3 (88%).

The baseline pattern indicated decreased levels in the morning, afternoon and evening as compared to the goal pattern, with the lowest level in the evening. The physical activity pattern was significantly increased ($p<0.05$) during the morning and the afternoon for all four feedback periods compared to the baseline period (figure 3).

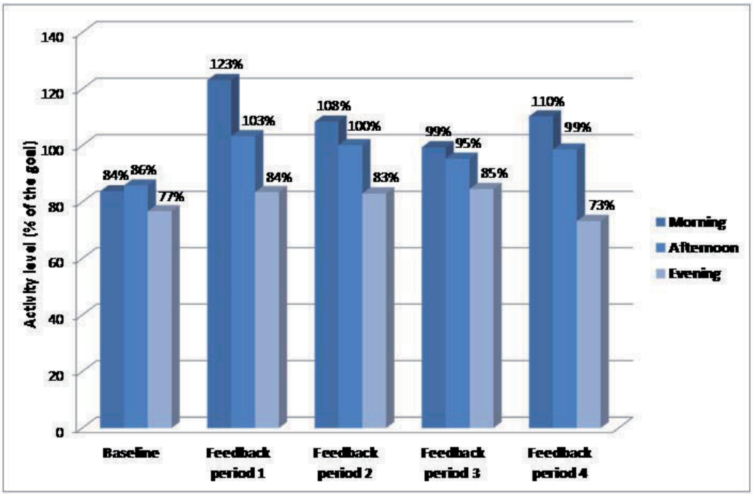

Figure 3. Physical activity pattern per day part of compliers (n=15) during baseline and four feedback periods.

3 Discussion

The ambulant feedback program has given assistance to CFS patients in performing healthy daily physical activity patterns at home. The compliance per feedback period was high, but the overall compliance was low due to dropout. The dropout of twelve patients (40%) in this study seems high compared to a review published in the Cochrane Library (2004) that showed an overall dropout rate of 14% in intervention groups with exercise therapy in chronic fatigue syndrome versus an overall dropout rate of 8% in control groups, and compared to the median dropout rate of 26% reported in a systematic review about novel technologies for the management of chronic illnesses [21, 22]. The high dropout rate in this study might be caused by the intensity of the intervention. Patients were asked to comply with the feedback system at five days per feedback period from 8.00 till 22.00, while other treatment protocols comprised 3 to 5 weekly sessions of exercise bouts with duration of 30 minutes per session. In addition, the treatment might be too long as changes in daily physical activity patterns were made directly. The compliance might also be influenced by perceived usefulness and perceived ease of use [23]. Patients may choose to not comply when the barriers outweigh the expected benefits [24]. As such, more involvement of patients and professionals in user requirements and in fulfilment of clinical needs could improve the future use of the feedback system [25, 26].

The results concerning the changes in physical activity were very promising. Patients who complied with the feedback system were able to change their physical activity pattern into the direction of the goal instantaneously. One of the reasons for this might be the objective measuring of physical activity. This excludes the possibility of misperceptions in activity levels with subjective outcome measures [4]. As such, ambulant activity monitoring and feedback has potential as treatment for patients with CFS.

Patients did only improve physical activity levels in the morning and afternoon but not in the evening. This resulted in less balanced daily physical activity patterns. The role of fatigue may be an explanation as CFS patients may be able to increase activity levels during the morning and afternoon when fatigue levels are low, but are not able to increase activity levels during the evening when fatigue levels are high [3, 27]. A second reason for the unchanged physical activity levels during the evening might be related to difficulties chronic patients have in behaviour change, as it likely requires the individual to restructure priorities in daily and social routines [28, 29]. A third reason might be a potential failure in the feedback program in providing sufficient attention concerning balancing physical activities over the whole day. According to the feedback, patients might be focused mainly on attempts to perform more or less physical activity to diminish existing gaps with the goal pattern. In future, more attention should be paid to the importance of balancing daily physical activity over the whole day.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-733

A Sensor-based Telemonitoring and Home Support System to Improve Quality of Life through BNCI: Preliminary Experience in BackHome

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Abstract. In this paper, we present the sensor-based telemonitoring and home support system currently under development in the BackHome project. The proposed system is aimed at supporting and assisting Brain/Neuronal Computer Interaction users by providing intelligent techniques to give both physical and social support, the final goal being to improve quality of life of users.

Keywords. Ambient assisted living, telemonitoring, home support, smart home control, quality of life.

Introduction

There are a number of advantages of telemonitoring and home support for both the person living with a disability and the health care provider. In particular, Telemonitoring and Home Support Systems (TMHSSs) enable the health care provider to get feedback on monitored people and their health status parameters. Hence, a measure of Quality of Life (QoL) and the level of disability and dependence is provided, which takes into account not only functional and cognitive factors, but also psychological, social, and participation ones. In fact, TMHSSs provide a wide range of services which enable patients to transition more smoothly into the home environment and be maintained for longer at home [3]. TMHSSs, as an assistive technology, facilitate services which are convenient for patients, avoiding travel whilst supporting participation in basic healthcare, TMHSS can be a cost effective intervention which promotes personal empowerment [9].

In the literature, several TMHSSs have been proposed [1] [2] [8]. Moreover, some work has been presented to provide smart home control to Brain/Neuronal Computer Interaction (BNCI) users [7] [11] [5] [6]. To our best knowledge, telemonitoring has not been integrated yet with BNCI systems but as a way to allow remote communication between therapists and users [10].

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In this paper, we present a sensor-based TMHSS, currently under development in the EU project BackHome[2]. The proposed system is aimed at supporting and assisting BNCI users and relies on intelligent techniques to provide both physical and social support in order to improve QoL of people with disabilities.

1. The Proposed Telemonitoring and Home Support System

The proposed TMHSS is aimed at helping the user to be more independent by providing smart home control, Web browsing, and e-mail services. It also increases online social inclusion ("eInclusion") thanks to the possibility to interact with the most popular social networks. The proposed system provides also QoL automated assessment based on information gathering and data mining techniques [14].

Telemonitoring and home support are carried out through two stations: the user station and the therapist station. The former is aimed at providing the services to the user and monitoring her/his activities. The latter is aimed at providing all the functionalities to the therapist and giving her/him the possibility to interact with the user, also personalizing the assigned therapy.

The sensor-based TMHSS is able to monitor the evolution of the user's daily life activity at home, once discharged from the hospital [15]. Specifically, wearable sensors allow monitoring fatigue, spasticity, stress, and further user's conditions. Environmental sensors are used to monitor –for instance– temperature and humidity, as well as the movements (motion sensors) and the physical location of the user (position sensors). Smart home devices enable physical autonomy of the user and help her/him carry out daily life activities. From the social perspective, an Internet-connected device allows the user to remotely communicate with therapists, carers, relatives, and friends through Skype, email, or social networks.

The goal of the proposed TMHSS is to continuously monitor and assist people with neurological disorders and to study and evaluate the evolution of their QoL.

2. Quality of Life Assessment

The proposed sensor-based system acquires personalized information through data coming from: (i) a BNCI system[3] that allows monitoring ElectroEncephaloGram (EEG), ElectroOculoGram (EOG), and ElectroMyoGram (EMG); (ii) wearable, physiological, and biometric sensors, such as ElectroCardioGram (ECG), heart-rate, respiration-rate, Galvanic Skin Response (GSR), EMG switches, and inertial sensors (e.g., accelerometer, gyrocompass, and magnetometer); (iii) environmental sensors (i.e. gas, smoke, luminosity, humidity, and temperature sensors); (iv) smart home devices (in the current implementation home lights, a TV, and an IP camera); and (v) devices that allow interaction activities (i.e., a desktop PC).

Using the information gathered by the sensors, the evolution of the QoL of the user is studied and evaluated. In so doing, improvement/worsening can be inferred and feedback to therapists and users can be provided [13].

[2] http://www.backhome-fp7.eu/backhome/index.php

[3] Currently, the EEG-P300-2D, a standard P300 control paradigm.

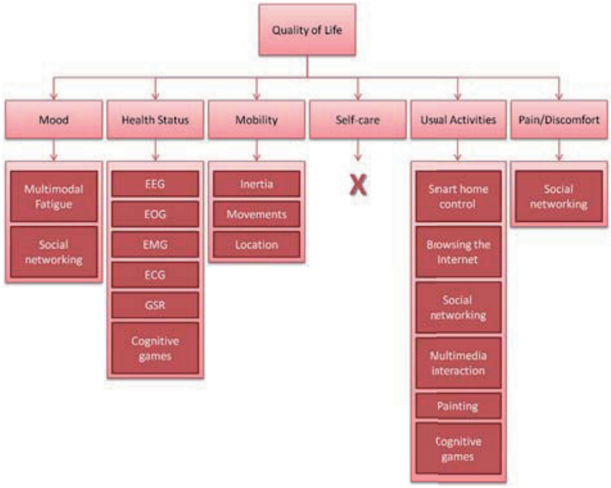

Figure 1. QoL items and the corresponding monitored data.

We defined the user's QoL as the conjunction of several items: *Mood*, *Health Status*, *Mobility*, *Self-care*, *Usual Activities*, and *Pain/Discomfort*. Figure 1 sketches the considered items together with the data monitored to gather the needed information.

Apart from *Self-care*, which we decided not to monitor for privacy issues, each item is separately studied as a machine learning problem by relying on the data gathered by the adopted sensors.

To give an example, let us briefly illustrate here how *Mobility* is monitored. Through the adoption of inertial, location, and motion sensors, the system is able to know the position of the user, at any time[4]. All information about location, performed movements, covered distance, visited rooms, time spent in the bed (and thus on the wheelchair) are used as classification features to build a multi-class k-NN [4]. The considered classes concern the user's satisfaction in her/his mobility ability (from "Very Bad" to "Very Good") and the training set is built directly asking users to assess their level of satisfaction. Once the system has been trained, we are able to infer user's satisfaction, to study the behaviour trend and to assess the improvement/worsening of the user's QoL.

We are currently performing preliminary experiments with a first group of users. Results are evaluated in terms of classical information theory measures, i.e., precision, recall, and F_1 [12].

3. Conclusions

Supporting people with disabilities is an important task, especially if the user is returning home after a discharge. In this paper, we propose a telemonitoring and home support system aimed at remotely assisting both therapists and people with severe disabilities as a result of neurological problems. The system, developed by adopting suitable sensors, provides physical and social support and is aimed at improving quality of life of peo-

[4]Users are typically on a wheelchair, thus the walking activity is not of interest. To detect the position of the wheelchair and its movements, RFID tags are embedded into the wheelchair together with following sensors.

ple with disabilities. To better illustrate the proposed approach, the current status of the implemented system has been briefly described. Moreover, to highlight the quality of life assessment task, we also present how to monitor mobility activities and infer users' satisfaction.

Acknowledgements

The research leading to these results has received funding from the European Community's, Seventh Framework Programme FP7/2007-2013, BackHome project grant agreement n. 288566.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-737

A Cost Benefit Study of Welfare Technology in Practice: Supervision with Web Camera as a Complement to Physical Visits

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Abstract. The demographic development implies that the number of older persons with care needs is increasing while it will be more difficult to recruit staff to the elderly care. In the gap arising there is a belief that welfare technology can play an important role saving time for tasks that demands human hands. The welfare technology used in this study showed that the cost could be reduced for the municipality and benefits the users. Supervision with a web camera showed to be a good complement to physical visits. Users, significant others and the staff were all positive in terms of satisfaction, sleeping quality and safety aspects.

Keywords. Welfare technology, cost /benefit, supervision.

Introduction

The demographic development implies that the number of older persons with care needs is increasing while it will be more difficult to recruit staff to the elderly care. In the gap arising there is a belief that welfare technology can play an important role saving time for tasks that demands human hands.

In the mirror of that two researchers from two different research and development units got a mission from the Swedish Institute of Assistive Technology (SIAT) to evaluate a trial using a web camera as a complement and/or alternative to supervise older people with need or extra care of supervision and safety during night time [1]. The trial was on-going from September 2011 until October 2012 in three municipalities in Sweden. Most night time supervision today takes place through physical visits of two home care staff. This is often disturbing or insufficient for care takers.

Welfare technology as an ICT application is sparsely used in elderly care in Sweden [2]. The technology used in this project "Night peace" is used only in a few municipalities in Sweden and only in small trials and as far SIAT knows not at all in Europe.

Aim: The study had three research questions.

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- How will users and their significant others perceive the use of Night peace compared to traditional supervision during the night?
- How will the home care staffs who works during the night perceive the use of Night peace compared to traditional supervision during the night?
- Which costs are related to Night peace compared to traditional supervision during the night?

1 Methods

1.1 Material

The technology used in this project is called Night peace (In Swedish Nattfrid). Night Peace is a service for users who need supervision or additional care and safety in their homes. One or several cameras, which work in complete darkness, are mounted in strategic locations in the home. Users and providers agree on how the supervision should be arranged and during which time. Normally once or twice a night and during 15-30 seconds. The home care staff can assess the situation in real time using live video and make a qualified decision on what actions are needed, such as dispatching staff for an in-home visit.

When the home care staff looks through the camera the user is notified by a small blinking light. The supervision is in real time and nothing is recorded. There is a need for either fixed, wireless or mobile broadband for the service to work.

1.2 Evaluation

The project took place in three municipalities in Sweden. In total 23 end-users were trying out the Night peace during a period of six month in mean. The trial was ongoing from September 2011 until October 2012.

Semi structured interviews were used and were conducted by researchers from two different research and development units. End-users, significant others and staff from the home care services were interviewed. The aim was to interview all end-users before and after they had got the web camera. The purpose was to compare changes in their perceptions of the supervision. Practice showed that some of the users already had the web camera before the project started. The interviews were only conducted once with those who already had the web camera.

In total 16 significant others were interviewed in one occasion. The majority of them were daughters and sons but also partners or friends were interviewed. In total 25 persons from the home care service were interviewed in five group interviews.

1.3 Cost Analyses

Costs of ordinary supervision have been calculated and compared to costs of using Night peace. The calculation is based on that 75 end-users are having the web camera during one year. The cost for home care service during night is estimated to 41 € per hour. The running costs are cost for the technical equipment, installation, service and compensations for work.

1.4 Ethical Considerations

All interviews were taped, transcribed and analysed by the researchers. The participation in the interviews was voluntary and all participants were informed that they could refuse the interview at any time without an explanation. Data were treated with high security.

2 Results

All the users of Night peace were satisfied with the alternative way of supervision. They perceived less distraction during night which was positive not at least for the sleeping quality. Even those who had a combination of personal supervision and supervision with the Night peace perceived it very positive. The majority felt safe and satisfied and wanted to continue with this new form of supervision.

All the significant others interviewed but one had a positive attitude to the web camera. In spite of some technical problems with the technique the majority felt safe and satisfied. Some of the significant others also perceived a positive effect of their own sleeping quality because of the feeling of safety for their close relative. The staff had a positive experience of working with Night peace. All pointed out that supervision with a web camera would be especially beneficial for persons with dementia or other kind of cognitive impairment. This working method could support a more individual and flexible supervision based on the person's demands. For example persons with dementia only got personal indoor visits when they really needed and not unnecessary visits when they just waked up or got scared. For the care provider the service means more time and resources to provide quality care when needed.

2.1 Cost Analyses

The cost analyses showed that compared to ordinary supervision the cost can be reduced with 8 716 € per user and year (Table 1). The cost analyses is based and conducted in one of the participating municipalities (9 cameras). Net effect was in total 274 hours per user and year. Additionally the petrol cost was reduced with approximate 421 €.

3 Conclusions and Planned Activities

The study showed that the welfare technology used in this study could be a good complement of supervision for older people during night time. Night peace was positive for the users, significant others and for the staff in terms of satisfaction, sleeping quality and safety aspects. Moreover the technology used showed that the cost could be reduced for the municipality.

- SIAT will work to spread the results from this study and similar studies with the same conclusions. SIAT will do that through conferences, seminars and reports both nationally and internationally.
  - SIAT will initiate more studies in the field.

Table 1. Results of the comparison of ordinary supervision with supervision using the Night peace.

Cost effectiveness per user and year One hour of home care service during night = 41 €	**Value**	**Euro (€)***
Saved transport time		
Number of saved hours /supervision	**0.35**	
Number of supervisions/night	**1.58**	
Total saved hours/user and year	**+ 151**	**+ 6 191**
Saved timed for supervision		
Number saved hours /occasion	**0.33**	
Number of saved hours/user and year	**1.58**	
Total saved hours/user and year	**+ 171**	**+ 7 011**
Running costs		
Compensations for work (hours)	**-48**	**- 1 968**
Costs for technical equipment		**- 2 518**
Net effect (hours) /user and year	**+274**	
Net effect (Euro)/user and year		**+ 8 716**
Reduced cost for petrol. Mean 0,4 km/supervision x 1.8 € x 365 x 1.58		**421**

*1 € =8.30 SEK March 8, 2013

- SIAT will support the development of welfare technology.
- SIAT will recommend the Swedish Ministry of Social Affairs to support implementation of welfare technology in the municipalities.

4 The Impact or Contributions to the Field

In Sweden there is a slow but ongoing process to change work methods in elderly care to start using more technology as a complement for physical visits from home care service.

This paper aims to show how technology can be useful both for the elderly with high demands of care and cost effective for the municipality. During the last years SIAT has supported other projects that also showed that welfare technology both increase older people's activity, participation in society and independence and is cost effective. Examples are mobile alarms for persons with dementia, communication applications using television and electric powered wheelchairs.

More research is needed to evaluate other applications of welfare technology. Using more welfare technology in elderly care is a must in the near future if we want to continue to manage the care of older people in a proper way.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-741

Using Remote Tele-Video Technology to Provide in-Home AT Assessment and Training to Mobility-Impaired Elders and Their Caregivers

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Abstract. Relatively inexpensive remote tele-video technology offers a practical alternative to traditional in-home rehabilitation. This paper describes three studies of "hands-on" AT skills training delivered via in-home and remote tele-video technologies. Study 1 was a randomized clinical trial that demonstrated a significant change in self-efficacy ($F=6.32$, $P=.015$) in the intervention group that received a comprehensive intervention compared to a control group of mobility impaired adults, and secondarily that interventions delivered by remote tele-technology was as effective as on-site in the home. Study 2 was a pilot study of 32 caregivers (17 intervention) and (15 control) that adapted Study 1 protocols and methods to deliver an intervention targeting care dyads and to obtain data on preliminary effect sizes to power Study 3. In this study, intervention group was related to change in satisfaction with assistance skills for two of the four tasks, getting in and out of bed, ($\chi2= 6.9$, $p=.032$) and toileting ($\chi2=7.7$, $p=.020$). Study 3 will implement the Study 2 protocol as both in-home and tele-videoconferencing modalities. The study is expected to result in a more efficacious AT service delivery that will improve both caregiving and care recipient outcomes.

Keywords. Assistive Technology, Telerehabilitation, Aging, Caregiving.

Introduction

A growing number of older adults who live at home are losing the ability to fully care for themselves as they age into progressively greater levels of disability and mobility impairment. Moreover, as skills decline, these elders must increasingly rely on family members or friends for help with some of the most basic of daily activities that we take for granted, such as getting in and out bed, toileting, bathing and dressing. For seniors who can function independently as well as caregiver/care recipient (CG/CR) dyads for those who require assistance, in-home assistive technology (AT) programs is a common and effective strategy to prevent decline in activities of daily living (ADLs) [1] and facilitating recovery of ADL functioning and locomotion [2, 3].

Whereas in-home therapy provides the opportunity for assessment, provision and training to occur within the context of everyday task performance the capacity to offer

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the critically needed home-based services is often contingent on distance and the availability of personnel. In some locations, health rehabilitation providers may be scarce, and few, if any, offer consultation with an assistive technology (AT) specialist. In areas where in-home services are not feasible, relatively inexpensive remote tele-video technology offers a practical alternative to traditional home visits for successfully treating activity performance deficits or to augment home-health rehabilitation.

1 Application

Several studies have suggested that remote tele-technologies can enhance ADL function. However, no studies have examined the effectiveness of tele-video technologies for delivering a comprehensive, multifactorial intervention similar to traditional in-home rehabilitation. The purpose of the three studies (2 completed and one ongoing) reported in this paper are to demonstrate that in-home "hands on" skills training in the use of assistive technologies for older adults could be effectively delivered via remote tele-video technologies, to elders who were either independent in mobility and transfer ADLs or required assistance from an informal caregiver.

Study 1, *Virtual Therapy Using Tele-Rehabilitation* was a randomized clinical trial designed to demonstrate that a comprehensive, 4-week in-home therapy intervention could effect a change in task self-efficacy (confidence in performing routine household activities) among a group of mobility impaired adults, and secondarily to explore the effects of two different delivery modalities (i.e., remote therapist using tele-technology versus therapist on-site in the home).

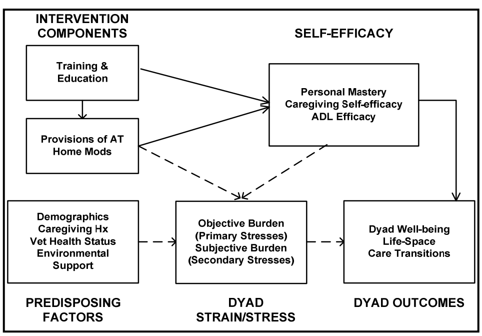

Fig. 1. Conceptual model.

Study 2, ***C**aregiver **A**ssessment of **S**kill **S**ets and **I**ndividualized **S**upport though **T**raining (CG ASSIST)* was a pilot study designed to adapt the protocols and methods from Study 1 to develop and deliver an intervention targeting CG/CR dyads and to obtain data on preliminary effect sizes to power Study 3, a Phase II study to compare a remote tele-video intervention with other intervention modalities for CG/CR dyads.

2 State of the Art

2.1 Assistive Technology Interventions

Research and practice have repeatedly demonstrated that modifying one's home through assistive technologies and environmental modifications is an important intervention strategy to help manage chronic disabling conditions and increase independence, safety, ease of use, self-efficacy, and self-esteem [4-6]. Moreover, home modifications may save money by reducing the need for, or increasing the effectiveness of caregivers and reducing health care costs [7]. Several recent studies have demonstrated the effectiveness of home assessments, small scale modifications for specific tasks, and training for individuals or caregiver/care recipient dyads [7, 8] in producing significantly lower levels of decline in IADLs and ADLs and reducing the cost of medical care and other in-home assistance services. As a result, there is increasing recognition among healthcare providers that AT/home modification is a viable strategy to permit older individuals to successfully age in place.

Although some research has examined relationships between caregiving and care recipient outcomes (e.g., functional status, mortality [9], the large majority of CG research has emphasized psychological responses to caregiving, particularly burden and depression [10, 11], rather than reducing the physical strain of caregiving that would be associated with many assistive technologies. Of particular interest are a series of studies conducted by Gitlin and colleagues [8, 12] in which caregivers who received AT interventions reported less decline in CR performance and less need for assistance.

2.2 Tele-health and Telerehabilitation Intervention Studies

With the advent of high-speed, high-bandwidth telecommunication networks, telehealth has emerged as a significant component of the health care system. Research has shown that this technology can promote community re-entry, improve quality of life, and reduce cost. A number studies have documented the effectiveness of a variety of telecommunications technologies, including low cost, commercially available two-way interactive videoconferencing, for monitoring physical condition and physiological status and for performing diagnoses and dermatological monitoring. However, few studies have evaluated these technologies for their use in delivering rehabilitation interventions to patients at home [13, 14].

3 Methods

In Study 1, independent functioning elders in two intervention groups received four home intervention visits to assess needs; deliver the AT interventions; and receive training on the appropriate and safe use of the AT compared to the Usual Care Group (UCG) that received no intervention other than what was prescribed by their physician (i.e., this varied by individual and physician) compared to those in the. All four intervention visits were done either via remote tele-video (Tele Group) or traditional in-home visit (Trad Group). In Study 2, CG/CR dyads received the same 3-visit, in-home intervention and in Study 3, dyads are receiving the 3-visit protocol developed in Study 2 either via remote tele-video (Tele Group) or traditional in-home visit (Trad Group).

3.1 Intervention

Participants received an assessment, provision of AT and a series of one-hour therapy sessions. The intervention focused on 3 transfer tasks (bed, toilet, and tub/shower) and 3 mobility tasks (locomotion throughout the home, negotiation of the entrance and doorways within the home, mobility in the kitchen). Based on the nature and number of problems identified during the baseline in-home or remote tele-visit, subjects were prescribed individualized interventions. These prescriptions included three types of interventions: adaptive techniques/methods (e.g., bed transfer training), assistive technologies designed to increase functional abilities (e.g., lift, sliding board, commode chair), and recommendations for home modifications (e.g., lighting, grab bars).

3.2 Tele-video Equipment in Study 1

In Study 1, tele-technology consisted of an "off-the-shelf" mobile, wireless tele-video system that used plain old telephones system (POTS) lines to transmit real-time, two-way audio and video between the patient's home and the therapist in a clinic. A research assistant with a similar level of technology expertise to a home health aid, who would ultimately operate the equipment, set up the equipment in the home. The videophones were "plug n' play," designed to replace standard phones without additional installation costs. To facilitate observation throughout the entire home, the system used wireless radio frequency (RF) to enable the portable, palm-sized video camera to move freely without wires and transmit real time images from anywhere in the home. Whereas Study 1 utilized traditional POTS equipment, such equipment requires wired landline telephone systems for operation. However, with the increased prevalence of cell phones, many individuals no longer have land lines. As a result, we are using a Cradlepoint to set up a WiFi hotspot in subjects' homes that will permit an iPaD to provide 2-way video and audio interaction across a secure network.

4 Results

4.1 Study 1

Sixty-two individuals (30 usual care and 32 intervention) with mobility limitations participated in the study. At baseline there were no differences in task self-efficacy scores between the usual care (UCG) and the two (Tele and Traditional) intervention groups. From baseline to post-intervention there was a significant change in self-efficacy (F=6.32, P=.015) that was manifest in an 8.7 point increase in self-efficacy scores in the IG (56.3 to 65.0), which was more than 7 times greater than the increase of 1.2 points (59.1 to 60.3) in the UCG. Further, there was a statistically significant group by time interaction (F=4.25, P=.044) suggesting that the change in self-efficacy is primarily attributable to the AT intervention.

For both Tele and the Trad groups, the intervention had a medium effect size[41] (SES 0.35 in the Tele Group and 0.54 for the Trad Group), which reached statistical significance only in the Trad group. When effect sizes were examined as a percentile standing of the average intervention participant relative to the average control participant, both methods of intervention delivery had a very large change compared to the UCG. Specifically, at 6 weeks the self-efficacy standing of the average subject in the Tele Group and the Trad Group exceeded the average percentile standing of a subject in the UCG by 64% and 71%, respectively.

Table 1. Self-Efficacy score and the standardized effect size of Tele Group and Trad Group compared to Usual Care Group on change in Self-Efficacy.

	Baseline *mean (SD)* *[95% CI]*	6 weeks *mean (SD)* *[95%CI]*	Change *mean (SD)* *[95% CI*	SES ± 95% CI	percentile
Tele (n=16)	55.2 (23.1) [42.9 – 67.5]	62.4 (20.9) (51.2-73.6]	7.2 (14.6) [-.6-14.9]	.346 [-.25-.95)	64
Trad (n=16)	57.4 (23.2) [45.0 – 69.7]	67.7 (21.8) [56.1-79.3]	10.3 (13.4) [3.2-17.5]	.540 [.06-1.14]	71

4.2 Study 2

Thirty-eight caregivers were recruited; 17 intervention and 15 control caregivers completed the 3 month follow-up assessment. During the intervention the clinical experts made a total of 729 recommendations across the four functional activity tasks. On average the experts made recommendations for 9±7 AT devices, 7±4 physical modifications, 13±11 adaptive methods and 10±10 energy conservation methods. Therapists provided between 1 and 9 new devices to each dyad, for a total of 78 devices delivered. All dyads were trained on the new devices and techniques. Intervention group was related to change in satisfaction with assistance skills for two of the four tasks, getting in and out of bed, $\chi^2(2, N=32) = 6.9$, $p=.032$, and toileting, $\chi^2(2, N=32) = 7.7$, $p=.020$, but not for dressing ($p=.44$) or bathing ($p=.41$). Intervention group was also related to change in safety concerns for getting in and out of bed, toileting and bathing.

5 Contributions and Conclusions

Study 1 not only suggests that in-home AT interventions can be effective, but also that both tele-video and traditional methods for providing the interventions are effective. While these latter findings are only exploratory due to the small sample size in each group, they nonetheless have important implications for the delivery of in-home rehabilitation. Travel time and distance pose significant challenges to provision of traditional in-home AT assessment and client training. Local specialists capable of providing in-home care may be limited, particularly in rural areas, and the cost associated with practitioners traveling large distances typically restricts the provision of these services to relatively small geographic areas. Moreover, the continuity of care from clinic to home is often compromised because the therapists providing outpatient care in the home is seldom the same individual who provided inpatient services. Tele-video may help address these problems in several ways. First, by providing clinical therapists who treated a patient in the hospital with access to the patient at home, continuity of care can be preserved. Second, it could be used in lieu of or prior to a home visit to provide a view of the patient performing activities in context, thus increasing efficiency and effectiveness of the visit; and finally it could be used for cost-effective follow-up after an in-home visit.

In Study 2, we demonstrated the feasibility and preliminary effectiveness and have substantiated a great need for in-home, hands-on AT interventions for informal caregiving. The need for informal CGs is growing in parallel to the rapidly increasing size of the population of older adults who are dependent on their CGs for help. The extensive CG research literature posits that the high levels of burden associated with caregiving can lead to relinquishing the CG role through premature institutionalization of the CR. Challenges in providing assistance with basic activities of daily living is one common and potentially modifiable problem identified by CGs that is also a direct and indirect risk factor for NH placement.

6 Planned Activities

Study 3 will implement and evaluate the effects of the Study 2 *CG ASSIST* environmental and educational in-home support program on caregivers and older veterans with dependency in mobility, transfer or positional change activities. The unique aspect of this intervention is the dynamic dyadic target and unit of analysis. Anecdotal reports from the therapists in our pilot study revealed that CRs were cognizant of the burden placed on their spouses and 'caregiver' training occurred at the dyad level with the CR actively participating. As a result, we have designed a *caregiving* versus a *caregiver* intervention and are examining effects for the dyad or in the care-partnership team. The caregiving intervention also tests a novel and less labor and time intensive approach to intervention delivery and implementation for CGs through *tele-videoconferencing*. The study is expected to result in more robust and efficacious interventions to improve CG and CR outcomes.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-748

A Multi-Modal Telerehabilitation Platform: Design and Applications

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Abstract. Telerehabilitation is a growing alternative to traditional face-to-face therapy to meet the demand in the rehabilitation field. However, because teleheath care is mostly deployed between two health care establishments, patients still need to travel to clinics to receive their treatments. To solve this specific problem, telehealth provided directly at home is an innovative solution. Because of both technological and clinical challenges surrounding in-home telehealth, the platform used must be in constant evolution. This ensures a high quality and an efficient way for rehabilitation delivery. The aim of this presentation is to present the telerehabilitation platform designed and built by our research team, "Équipe Spécialisée en TéléRéadaptation À Domicile" (ESTRAD). Based on a modular design, the generic platform integrates commercial systems and peripherals with custom software, TeRA. In addition to the video and audio components, other components are launched by TeRA (e.g. oximeter, stationary bike, speech therapy software) depending on the clinical applications. Until now, the platform has been used successfully to treat different rehabilitation populations (e.g. orthopedics, pulmonary and neurologic). ESTRAD is already working on the next generation of the platform in order to reduce its cost by using a less expensive videoconferencing solution and to provide further capabilities.

Keywords. Telehealth, Telerehabilitation, Human Computer Interface.

Introduction

Providing telehealth services is viewed as an innovative way to deal with healthcare accessibility[1]. Teleconsultation, telemonitoring and teletreatment, all applications of telehealth, have emerged in the last decade. However, most of these setups are deployed between two health care establishments because of the strong network already in place. Despite increasing in some way accessibility of services between urban and rural area, a large proportion of health care patients still have to travel to a health care center[1]. Telehealth provided directly at home from a health care center is an innovative solution to that travelling problem.

1 The State of the Art for In-home Telerehabilitation

In-home telehealth services are challenging on a technical and clinical point of view. On a technical level, many considerations need to be addressed to enable the use of such a system. Those considerations include providing video and audio communication over a standard residential high-speed Internet link, developing software to support clinical assessment and rehabilitation, and packaging software and hardware components such that in-home installation of the technology is unobtrusive as possible. On a clinical point of view, the system must be simple to use, reliable, well integrated and should bring an add value over the standard clinical approach.

ESTRAD (*Équipe Spécialisée en TéléRéadaptation À Domicile*), the team specialized in in-home telerehabilitation at the Research Center on Aging of Sherbrooke, was created specifically to address those requirements for multiple projects. In-home teletreatment for rehabilitation is defined as an application of telehealth where a professional from a clinic delivers treatment to a patient at home [2-5]. Those therapeutic interventions require repetitive sessions over several weeks including exercises, coaching, feedback and education in order to improve the physical functions of the patient. In order to achieve a successful and satisfying rehabilitation over a standard internet network, real time bidirectional audio and video interactions between the professional and his/her patient must be performed.

In this context, a telerehabilitation platform was designed and built to provide in-home telehealth services to various populations. Specifically, the system was developed to take into consideration the needs of different rehabilitation populations; orthopedics (Post Knee Arthroplasty)[6], pulmonary (Chronic Obstructive Pulmonary Disease - COPD)[7] and neurologic (post stroke condition, speech therapy)[8].

2 Platform Design

The platform was designed to be as flexible as possible to make sure it could be usable for a large range of applications. A modular approach was used, providing the capability to adapt each module with ease according to the final use. The platform consists of four principal components, as shown in Figure 1.

Audio and video, both critical components of a successful session, are recorded by the capture module (A). Transmission (B) of the captured data is done over a high-speed Internet residential connection, and thus requires compression (audio, video, data). At the remote end of the link, the received information needs to be played back and displayed (C), either to the clinician or to the patient. The required information is not the same for both sides, and thus a specific and different display interface has to be provided. Finally, interaction (D) is required on both sides, either to control the session and the cameras (clinician) or to display local data and interact with clinical software (including questions for example).

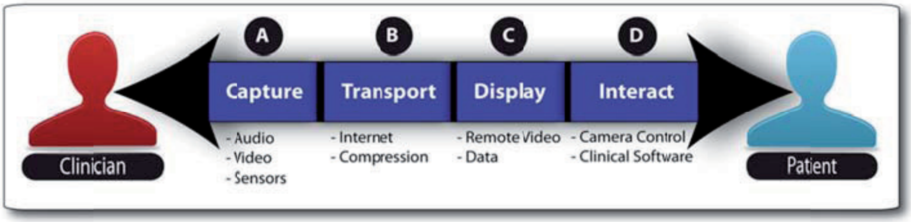

Figure 1. Major components of a multi-modal telerehabilitation system.

3 Technical System Description

Based on the modular design, a generic platform was built, integrating commercial systems and peripherals with a custom software named TeRA. Figure 2 presents the specific adaptations for each application presented here: clinician side, COPD and speech therapy. In each of those systems, a Tandberg videoconferencing unit (A) is used to provide a wide-angle pan-tilt-zoom camera, an omnidirectional microphone and an embedded codec for the audio-video compression (h.264 and G711). The videoconferencing unit also encrypts the transmitted data, providing the required security for such system. On each adaptation, an all-in-one computer (C) with a 25" touchscreen (HP Touchsmart) is used to display the remote video, and to run the application specific software (D).

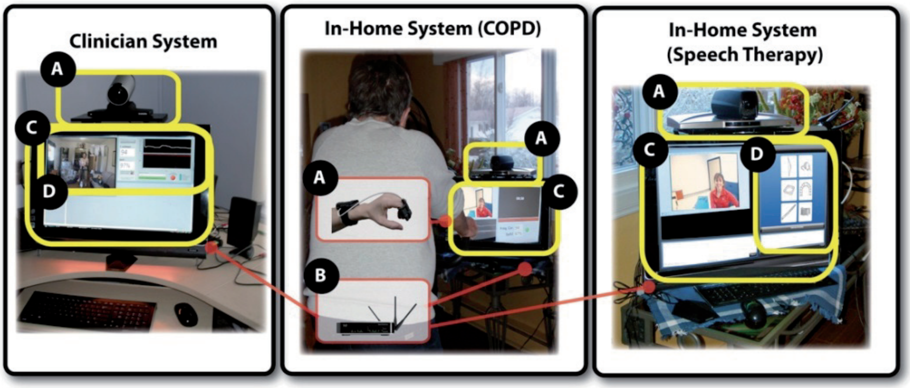

Figure 2. Telerehabilitation platform on the clinician side, and applied to COPD exercises and speech therapy. Letters refer to the design pattern used to build the platform.

On the clinician system, three software, each with a different role, are used. TeRA is the main software used by the clinician. It provides an overview of all the available patients, and eases the connection process by allowing the clinician to connect with a simple double-click. Data collected in a session is recorded in a local database. TeRA also launches specific software application according to the patient's configuration, and TeRACam. TeRACam is the software that is used to display the video feed on each side (clinician, patient), but also to control the local and the remote camera (clinician's side only). A simple point-and-click and area-zoom interface is provided to ease the control.

4 Adding Data to the Platform Synchronized with Audio/Video

Depending on the clinical application, another software is launched by TeRA. With the COPD population, a wireless pulse oximeter (A) and an exercise bike are installed at home[7]. In a session, oxygen saturation and cardiac frequency are transmitted to the clinician side, and displayed on the application specific software on the patient side. With a speech therapy population, pictures are displayed on both side, and, in turn, the users have to communicate the software selected picture to the other one using various means of communication (speech, gestures, writing, drawing). All of these data are transmitted using a standard cable or DSL connection at home. (B)

5 R & D: Improvements of the Platform

The ESTRAD team is already working on the next generation of this platform, which will be a lot cheaper by using a less expensive videoconferencing solution. The new platform will also allow telerehabilitation with multiple patients at the same time, potentially improving the efficiency of the clinician for some types of populations.

The main clinical software, TeRA, is being completely redesigned to centralize all the data on a main server. The new version of TeRA will also work as a central hub for collecting physiological sensor data (pulse oximeter, thermometer, glucometer, inertial measurement units). A new feature is also being introduced in order to record sensor data between the sessions, providing a complete follow up report of the sensor measurements that will greatly help the clinician and the patient in the rehabilitation process.

Work is also being done in testing and adapting the system to be used over a cellular network. If results are positive, this will ease the installation process, as contact with an internet service provider will not be required as long as the cellular network coverage is sufficient in the patient's area.

6 Conclusions

Currently, the platform has been used successfully for long-term teletreatment (over two months, twice a week) with various populations: 208 patients following a total knee arthroplasty, 23 patients suffering from COPD, 6 post-stroke patients with balance disability and 2 speech therapy patients. Even though most of these studies are still in progress, preliminary analyses revealed that condition of each population (i.e. function, disability, functional capacity, quality of life, gait, functional communication, denomination capacity, etc.) is enhance post-intervention compared to prior teletreatments.

Satisfaction of patients and professionals will be described in the Corriveau et al. presentation (accepted to AAAT, 2013).

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-753

Patients Satisfaction with an in-Home Telerehabilitation Exercise Program and Physiotherapists' Satisfaction toward Technology for an Acute Stroke Population: A Pilot Study

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Abstract. The purpose of this study was to investigate the satisfaction of patients and physiotherapists toward technology used during in-home teletreatment following discharge from an acute care hospital after a stroke. The teletreatment that was delivered to the patients consisted of 45-minute sessions of exercises inspired from Tai Chi movements, twice a week, over a period of 8 weeks. The health care services satisfaction questionnaire was completed by the patients at the end of the intervention. The subjective appreciation of the technical quality of the physiotherapist using the technology during the telerehabilitation treatment was noted at the end of each treatment session. The analyses for this pilot study have thus been completed on a total of 6 patients and over 96 sessions by a physiotherapist. Satisfaction towards health care services provided was high for both patients (86%) and physiotherapists (90%). While patient satisfaction is very important in maintaining treatment compliance, the satisfaction of health care professionals must be high in order for new treatments to become mainstream in clinics. Our results show that in-home telerehabilitation seems to be a promising alternative to traditional face-to-face treatments.

Keywords. Telerehabilitation, Satisfaction, Ageing, Professionnal.

Introduction

In-home telerehabilitation, defined as the provision of remote rehabilitation services to individuals with disabilities using information technologies and telecommunications in their home[1], is growing as a complementary intervention to traditional face-to-face therapy for stroke patients[2-4]. Satisfaction is an important indicator of the degree of efficacy of an intervention. Telerehabilitation have demonstrated good levels of satisfaction with a chronic post-stroke population but not with acute stroke.[5]

1 Purpose

In this context, the purpose of this study was to investigate the satisfaction of patients and health professionals with in-home teletreatment as an alternative to face-to-face therapy for individuals following discharge from an acute care after a stroke.

2 Methodology

2.1 Design and Data Collection Procedure

This study was embedded in a pilot study on the feasibility of in-home teletreatement following a stroke. The design used a pre/post-intervention measurement (T1, T2) with a 2-month follow-up (T3) without a control group. The patients' satisfaction with health care services was collected at the end of the intervention (T2). Health care professionals' satisfaction was measured at the end of each treatment session during the intervention period.

2.2 Participants (Patients and Physiotherapists)

Inclusion criteria for stroke patients were: 1) returning home after discharge from the acute hospital and not having received intensive rehabilitation; 2) presenting mild to moderate balance problems; 3) having someone available during telerehabilitation session and 4) having an access to a high speed internet connection at home. Patients with severe heminegligence and visual impairment were excluded. Physiotherapists had to be specialized in neurology.

2.3 Technological Platform

Treatments were provided over a high-speed Internet connection at home. On the patient's side, a screen, speakers and a commercial videoconferencing system (Tandberg 550MXP) with a pan-tilt-zoom camera was installed to provide the required audio and video communication. Data was bandwidth limited to 512 kbps to stay under the upload limit of residential Internet connection. On the clinician's side, a similar system was installed. However, on the therapist's side, a computer running custom software (TeRA) replaces the screen that is used at home. This software allows the clinician to easily establish a session and control the local and remote camera.

2.4 Teletreatment Intervention

The intervention consisted of an exercise program based on Tai Chi dispensed by in-home telerehabilitation as used in a previous study[6]. Recent studies have demonstrated that a re-education balance program based on Tai Chi movements improve balance in people at risk of falls[7] . Each session was planned to last 45 minutes twice a week for 8 weeks.

2.5 Patients' Satisfaction with Health Care Services Received

Patients' satisfaction with health care services was assessed with the French version of the "Health Care Satisfaction Questionnaire"[8]. This questionnaire showed a good internal consistency (Cronbach's alpha coefficient of the overall scale = 0.92)[8]. The multidimensional nature of the concept of satisfaction is analyzed by the presence of three factors: satisfaction with regards to the relationship with the health care professional, satisfaction with the services delivered and satisfaction with the general health care organization. The questionnaire contains 26 questions, which are separated into two sections. The first section aims to verify the satisfaction level related to the received health services in different situations and the second section evaluates the importance given to these situations when consulting within the general health organization. Patients were asked to answer on a four-point Likert scale where (1) represents “not at all satisfied” or “not at all important” and (4) represent “highly satisfied” or “highly important”.

Health Professionals’ Satisfaction with the Technology

Satisfaction with the quality and performance of the technological platform was assessed with the “Technical quality subjective appreciation questionnaire”, which was created by our research team. This questionnaire was built using the quality attributes for telemedicine success determined by Lerouge’s team[9]. Physiotherapists completed this questionnaire at the end of each treatment session. The questionnaire is divided in two sections: 1) the first section consists of five items focusing on the technical quality of teletreatment sessions (audio, video), and 2) the second section includes three questions on the clinical objectives, relationship with the patient and overall satisfaction. In the first section, the score varied from 0 to 3, with 3 being the highest level of satisfaction (“Good”), while 0 was the lowest (“Bad”). The score is computed as the sum of all the answers and then adjusted to a percentage. The last three questions of the questionnaire are answered on a scale of 0 to 10, with 10 being the highest level of satisfaction.

2.6 Results

For this pilot study, six post-stroke participants (3 women and 3 men) aged between 67 and 92 who suffered a mild to moderate stroke (MRS= 2 or 3) with balance impairment were recruited. Two women physiotherapists gave the telerehabilitation: one had 20 years of experience while the other had one year. Patients showed improvements for all fall-related variables: balance and gait, motor function, and lower limb strength[6] (see Table 1).

Table 1. Efficacy of teletreatments.

Variable	Measured instrument	Pre-Treatment	Post-treatment	2-month follow-up
Balance	Berg scale (/56)	49.3	53.3	52.4
Functional Gait	Timed Up and Go (s)	15.9	12.5	12.1
Motor function	Chedoke McMaster (leg) (s)	5.2	6.0	6.4
Motor function	Chedoke McMaster (postural control) (s)	5.2	6.2	6.4
Lower Limb Strength	Sit to Stand (s)	26.5	18.7	18.4

2.7 Patients’ Health Care Satisfaction

Patient’s health care questionnaire results showed a high level of satisfaction for the global score (86 ± 5%). Mean score of the three factors measured (i.e. relationship with the health care professional, satisfaction with the services delivered, satisfaction with the general health care organization) were between 79% and 95% (see table 2). Furthermore, comments from the patients confirmed their satisfaction regarding their experience with the telerehabilitation: “It was easy [to use the technology]. Actually, it was fun!” “There weren’t a lot of problems [with the Internet connection]. A few times we lost it for a few minutes, but it really gave us the advantage of not having to leave the home and to have a personalized intervention.”

Table 2. Patients’ satisfaction toward received care.

	Part. 1	Part. 2	Part. 3	Part. 4	Part. 5	Part. 6	Mean ± SD
Global score (%)	82	80	84	91	85	93	86 ± 5
Factor 1 score: Satisfaction with regards to the relationship with the health care professional (%)	82	79	85	95	90	92	87 ± 6
Factor 2 score: Satisfaction with the services delivered (%)	75	76	74	85	67	94	79 ± 10
Factor 3 score: Satisfaction with the general health care organization (%)	91	96	97	97	91	99	95 ± 3

2.8 Physiotherapists’ Satisfaction with the Technology

The quality and performance of the technological platform perceived by the professionals was calculated using the average of the ratings obtained for all the telerehabilitation sessions (see table 3). Moreover, the therapist found that the clinical assessment of the session according to treatment goal was achieved at 92 % and 95 % of the relationship quality was reached. Finally, the overall satisfaction with the treatment sessions was 90 %.

Table 3. Physiotherapists’ satisfaction with the technology.

Variable	Bad (0)	Insufficient (1)	Satisfactory (2)	Good (3)
Reliability of the technological environment	0%	5%	27%	68%
Voice/image synchronization	0%	4%	28%	68%
Refresh rate of the images	0%	2%	13%	84%
Sound quality	1%	5%	32%	62%
Operability of the peripherals	1%	6%	26%	65%

3 The Impact to the Field

After minimal training, all participants were able to function independently with the technology. The high scores on the satisfaction questionnaire showed that these elderly patients with impairment appeared to have accepted this new service delivery method. Furthermore, all therapists were satisfied with the treatment session. These results agreed with the ones obtained in a previous study that aimed to measure the satisfaction of patients and health care professionnals with the technology and services provided during in-home rehabilitation after discharge from total knee arthroplasty surgery.

This novel intervention method has the advantage of providing intervention to patients in their living environment without having to travel. However, this pilot study has some limitations. The participants were not randomly recruited and it is possible that the participants included in the study were more enthusiastic and positive about modern technology. Thus, a randomized study will be required to be able to generalize these results.

4 Conclusions and Planned Activities

Both participants and therapists showed a high satisfaction with telerehabilitation. As a patient satisfaction is associated to treatment compliance and professionnal satisfaction to treatments usage in clinics, these preliminary results demonstrated that in-home telerehabilitation seems to be a promising alternative to face-to-face intervention.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-758

Exploring the Acceptance of a Monitoring-based Telecare Service

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Abstract. This study aims at defining and evaluating new monitoring-based services where telecare and smart home approaches are combined to support the well-being of the aging population. The evaluation was carried out by means of envisioning scenarios discussed with older adults and telecare operators. The basic assumption of the envisaged service was to increase the efficiency of the actual telecare service by providing the telecare operators with a detailed profile of the telecare users built on the automatic collection of data in their home. Results of the evaluation showed that such a system would be appreciated by telecare operators, but acceptance considerations should be taken into account in order to meet also the older adults' consensus. We finally discuss specific factors that can be implemented in order to improve the quality of traditional telecare services respecting both older adults' domestic environment and telecare operators' work practices.

Keywords. Telecare, Smart homes, Independent Living, Scenario-based Evaluation.

Introduction

The supply of care at home is one of the promising strategies to cope with the several social and economic challenges posed by the demographic changes that are affecting the European countries (European Commission Report, 2010). The integration of telecare and smart home technologies represents a big opportunity to strengthen the impact of telecare, not only by making it more efficient in terms of costs and treatment, but also by offering solutions that encourage independent living and enhanced quality of life (Tang and Venables, 2000).

The origins of telecare and home sensors can be dated back to the 70's when the first generation of wired alarm systems emerged and were deployed within elderly care homes. These integrated systems have evolved during the years from a mere emergency bottom assistance service towards the so-called third generation telecare systems able to alert the operators without the need for the user to explicitly call for help. Particularly the third generation telecare services leverages the potentialities of low intrusive and highly smart technology solutions aimed at monitoring and interpreting the behavior of users within their home, in order to identify trends of changes in the habits of users and prevent from undesirable consequences (Stowe and Harding, 2010).

This usually implies the installation of unknown devices in the home that are likely to change the familiar environment, raising acceptance problems and leading older

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people to reject new technology, especially when its benefits are not clear (Melenhorst et al, 2001). Similarly, on the service provider side, the technology deployed needs to integrate smoothly with the established practices and do not disrupt them. These issues can be addressed through the understanding of user's needs and by implementing services and functionalities based on familiar and well-established technology such as telephone and television (Daniel et al, 2009). Although the design of the technology devices has been developed making them less intrusive and easier to install, the feasibility of such system's evaluation is still low and few studies have been run in a real environment (see for example Conci et al. 2010). In the literature, older adults' adoption of monitoring services is mostly investigated by means of scenario-based focus groups (Steele et al, 2009), that has been widely accepted in preliminary phases of innovation design helping to give a future image of the evaluated service and uncover hidden challenges (Röcker, 2010).

This study aims at defining and evaluating with users new monitoring-based services where telecare and smart home approaches are combined to support the independent living of the aging population. By involving in the study both the service providers (telecare operators) and service users (older adults), we wanted to identify factors related to the delivery of telecare services with the final goal of: i) improving the quality of existing services; ii) supporting telecare operators; iii) increasing the satisfaction of older adults.

1 Service Concept: The Good Morning Mirror

The concept of the new telecare services was based on data gathered by means of contextual inquiries (Beyer, H. and Holtzblatt, 1997) of telecare centers, and focus groups with older adults carried on within the NETCARITY European Project (Bierhoff et al., 2008). We called the envisaged monitoring-based telecare service: Good Morning Mirror.

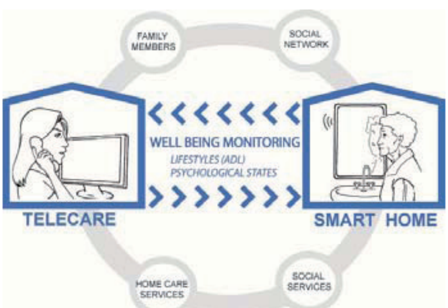

Fig. 1. General concept of the monitoring-based telecare service.

The Good Morning Mirror is based on advanced monitoring technology aimed on one side at providing telecare operators with detailed information about the telecare users' in-home status; on the other side assessing and improving the telecare users' well-being. One of the main problems that telecare operators actually encounter is to have a well-defined description of the users status's trend and therefore prioritizing their daily calls to the telecare users. This might be possible if the system could build a person's lifestyle pattern on the basis of a regular collection of daily life data, recognize and manage any unusual change over time. As showed in Figure 1, the envisaged monitoring-based service exploits data automatically collected by means of sensors and smart-objects (in our case a mirror) installed in telecare users' home. The data is consequently aggregated and made available to telecare operators. The data does not only provide an image of the health status but attempts also to assess the well-being of older adults.

We conceptualized the well-being of a person as the measure derived from the analysis of Activities of Daily Living (ADL) and Mood monitoring. Both these measures have been used in automatic monitoring of health status and recognized as important indicator to assess the autonomy of older people (Celler et al., 1995), and psychological and physical status (Reijula, 2010).

Finally, as showed in (Leonardi et al., 2009) the adoption of such technologies and services depends on their low intrusiveness in the user's environment. The Good Morning Mirror was designed taking into account both the work and domestic contexts. On the telecare operators side we focused more on integrating the service into their work practices without overloading the telecare operators; while as regards the older adults we faced the adoption issue by augmenting existing domestic objects, rather than introducing novel artifacts into the domestic environment.

2 Methods

The evaluation of the Good Morning Mirror service was done by means of envisioning scenarios (Carroll, 1995). *Scenarios* are stories that describe activities of people in relation to a specific system or service. They include a setting, a plot, sequences of actions and changes in the circumstances of the setting. Characters of a scenario are the *personas*: rich descriptions of archetypal users meant to draw attention on users' goals and motivations. The objective of scenario discussion is to make explicit the use of a system or service and stimulate the generation of ideas about it.

Four scenarios have been developed. Each scenario highlighted a particular issue related to the service and was discussed with either telecare operators, older adults or both the groups (Table 1).

Table 1. Scenarios' title and their main explored variable.

Scenario's Title	Target Group	Main issues
Understanding before calling	Telecare operators	Acceptance of the monitoring-based system.
Looking inside Antonio's home	Telecare operators and Older adults	Acceptance aspects related to using cameras to look into a user's home in case of need.
The Good Morning Mirror	Telecare operators and Older adults	Acceptance of the service and interaction with a virtual agent
Installing sensors into Maria's home	Older adults	Acceptance of sensors and criticalities experienced by older adults.

A focus group with 8 telecare operators selected from two different telecare centers was organized. They were all female operators with more than 2 years of experience in the telecare sector. A second focus group was organized with 6 older adults (mean age: 71 years). They were recruited in a recreation center and voluntarily participated in the study. We chose people with a self-reported high level of autonomy and an active social life. Telecare users were deliberately discharged to avoided biased answers due to their personal experience with the telecare service.

3 Results

Data of the focus groups were collected and analyzed on the basis of our research questions which were slightly different depending on each participants' group (telecare operators vs. older adults). In general, we wanted to explore the attitude of users towards the Good Morning Mirror service; specifically, with telecare operators we focused on the practical aspects of introducing new technology in their usual work setting (usefulness of ICT, control over data, information management); with older adults we focused on their motivations to adopt such a system (e.g. usefulness, perceived intrusiveness of the system, privacy). We report here the main investigated issues and a summary of the answers by telecare operators and older adults.

3.1 Focus Groups with Telecare Operators

Attitude Towards a Monitoring-based Telecare System. Telecare operators were generally positive towards the system. Every information about the user's situation was considered useful, especially when the number of telecare users is high respect to the number of telecare operators. Although, every piece of information has to integrate automatically in the user profile without overloading the operator.

Understanding User Wellbeing. Telecare operators call daily the telecare users and attempt to understand the user's status by means of informal conversations. In the focus group, telecare operators pointed out the lack of an objective source of information about the user's in-home situation. For this reason, they positively evaluated the Good Morning Mirror's feature of an automatic (and objective) user's data collection.

Information Presentation and Management. A system that automatically presents the relevant information about the telecare user and also prioritize the telecare operator's calls is considered useful. Information should be presented in a synthetic format linked with extra data on the user's status.

Cameras Monitoring. Telecare operators reported that cameras would not be easily accepted by users and should be adopted only for specific cases (e.g. Alzheimer). They thought that users should be provided with the possibility to decide when (dis)activate it. Furthermore, they agreed that using camera could also raise problems in terms of privacy violation: telecare operators would not feel entitled to use it in any case.

3.2 Focus Groups with Older Adults

Attitude Towards a Monitoring-based Telecare System. Older adults were aware of the usefulness of such a service for everyone who cannot live autonomously anymore, but they still highlighted the importance of a human-based service.

Acceptance of Monitoring Devices. Older adults were generally skeptical about the usage of monitoring devices (both cameras and sensors) that could threaten their privacy. Nevertheless, they were more likely to accept them if they were proposed on the actual needs and desires of the user, beyond the "same package to everyone" concept.

Acceptance of Devices for Behavior and Psychological Monitoring. Sensors that recognize behavior and psychological states were not perceived as useful as the emergency sensors that instead contribute to increase the sense of security.

Attitude to a Virtual Agent that Interacts with Users on a Mirror. Older adults reported that a virtual agent could particularly be well accepted by those suffering from loneliness. The virtual agent could stimulate people to smile and to ameliorate their mood. A virtual agent should also actively interact with people by changing its status depending on the user's mood.

4 Discussion

Results of the evaluation showed that a monitoring-based service can really be supportive to telecare operators by providing them with aggregated, useful and informative data about the older adults and their in-home situation. Less consensus was expressed by older adults that did not seem particularly enthusiastic towards a highly monitoring service. Nevertheless, operators and older adults agree on some factors characterizing future monitoring-based services: *Usefulness*. Users recognize the usefulness of the system especially when people do not have any other support at home. *Contextualization*. Data should be integrated with other information about the user that trace an history of his/her status. *Personalization*. The intervention in the house should be designed around the specific psycho-physical characteristics of the users. *Modularity*. The infrastructure of the system should be modular and scalable so that it can be integrated into the home only if relevant for that specific user. *Human presence*. Both operators and older adults agree on the necessary presence of a human trained operator, that interprets the data gathered by the system and decide how to deploy it.

5 Conclusions

This paper reports on main results gathered from the formative evaluation of monitoring-based services. The evaluation was conducted by discussing scenarios with telecare operators and older adults. We wanted to identify specific factors that might be implemented in order to improve the quality of existing telecare services. Particularly, we wanted to shed light on some aspects that affect the attitude towards monitoring-based services from the perspective of both service providers and service users.

The envisioned monitoring-based service aims at supporting telecare operators by providing them with an updated profile of the current situation of each telecare user and of his/her environment. This profile is expected to improve existing telecare services because: i) it allows a more flexible scheduling of the calls and other forms of intervention; ii) operators can adapt their timing to the dynamically varying needs; iii) the availability of information about current (and past) status of the user allow telecare operators to properly intervene on emergencies. From this perspective, it becomes of crucial importance for the effectiveness of these new services the presence of a specifically trained human telecare operator adequately educated to interpret simple environmental events, behavior and cognitive states of the user, and their modifications over time.

Concerning older adults, the main issue is to understand their attitude towards new services and technology. Our study confirmed the fact that acceptance of monitoring devices depends mainly on variables related with technology itself such as intrusiveness, position in the house, intelligibility; and variables related with the person: perceived frailty, perceived loneliness, support and social network.

In conclusion, we argue that monitoring-based telecare services should be seen as a technological ecosystem in which both telecare users and telecare operators collaborates in the assessment, maintenance and improvement of telecare users' well-being. The system should be designed as a support for the exchange of information and it should adapt to the user, find meaningful ways of interaction and proactively stimulate new behaviors oriented to well-being.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-764

Experiences of Older People using Videoconferencing in Home Care – A Case Study of Telecare from Finland

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Abstract. The objective of this qualitative case study is to explore home care patients' perceptions of a videoconference system as part of their home care. The study also aims to examine how the possibility to form a video connection with nursing staff affects home care patients' feelings of loneliness and security. Seven home care patients' perceptions of the used videoconference system were surveyed using semi-structured interviews with themes based on technology acceptance literature. The gathered research material was analyzed thematically. The study is part of a larger KOVI project. The interviewed home care patients felt they had a natural conversation through the videoconference device. The individuals' views of the usefulness of videoconference technology seemed to be an essential factor in the acceptance and use of technology. The use of the videoconference device was not considered particularly challenging, so the ease of the use of technology and learning to use the device were not considered a major challenge, not even for the elderly. The customers were worried about the privacy because of the installed cameras, but considered the safety the system brings more important. The lack of previous knowledge concerning technology, however, was noted in situations that deviated from common usage of the equipment. Guidance and instructions in difficult situations and maintenance of the device were deemed important.

Keywords. Telecare, older people, videoconferencing, technology acceptance.

Introduction

There is an urge to develop new methods to cope with the increasing amount of aging people needing medical and home care. In Finland in 2010, the cost of home care services increased by 24 million euro (3.3%) compared with the previous year, totaling 756 million euro [1]. Similarly, there has been growth of people needing home care on a regular basis; the amount of clients has increased 5.1% between the years 2010 and 2011 exceeding 71600 people [2]. This trend sets challenges for the society to tackle its responsibility to take care of patients. The ever growing amount of aging people cannot be institutionalized, but more and more health care services must be provided at home and one solution is to use telemedicine and telecare applications [3].

The European Commission recognizes two essential areas for telemedicine: home care and medical co-operation [4]. However, the model of a digital video-based home telecare system defines six different types of service: medication services, treatment follow-up services, home monitoring, automatic home equipment, rehabilitation services and communication services [5].

In the context of health care, technology acceptance and use have often been studied using familiar acceptance models and theories. However, for instance, TAM model [6] is used as such or it has been modified or expanded to fit the health care sector better [7, 8, 9, 10, 11]. The hindering or blocking factors impacting the acceptance of technology has been studied as well [12, 11].

Older people living alone may feel comfortable when a nurse or home care visit them, as they have company for a while and may feel safer. The feelings of insecurity are quite common among older people [13]. Similarly feelings of loneliness tend to increase when children move away, or when their spouse or friends pass away [14]. These negative feelings are examples of a range of triggers, which can also promote the use of telecare [15].

This qualitative study reports experiences of seven older users using videoconferencing as part of their home care. The study was carried out within a larger pilot project called 'KOVI', (Kotihoidon virtuaaliteknologia) i.e. virtual technology for home care. This research focuses on two main questions:

- How do the clients of home care experience videoconferencing and accept it as part of their home care services?
- How does videoconferencing service impact the feelings of loneliness and safety of the home care patients?

This last question was studied earlier in the context of CareTV, where teleconferencing was arranged between older people's relatives and friends [16].

1. Methodology

1.1. Technical Environment and Functionality

The project was executed in cooperation with the Center for Knowledge and Innovation Research at Aalto University, a home care unit in the City of Helsinki, Palmia and Forum Virium Helsinki. The latter two of the companies involved in the project (Palmia and Forum Virium Helsinki) are owned by the City of Helsinki. The telecare videoconference equipment was provided by Arctic Connect and Tunstall.

The system consisted of a touch screen computer, a panic alarm phone, a microphone, a loudspeaker and two cameras; one attached to the screen pointing towards the user sitting in front of the computer, and the other with possibility to angle and zoom in the premises of the home care patient. For instance, the virtual nurse was able to follow how the patients walk. The equipment was connected in clients' homes to internet using H.323 videoconferencing protocol. The system is shown in Figure 1.

The initiation of videoconference session could occur in three different ways. The home care employee could call the client who then accepts or rejects the call by touching the green or red icon on the screen. Alternatively, the home care patient could call home care and the nurse was able to accept the call in a similar manner. If the employee of home care was not available at a certain moment, the system left a notification for the nurse, who then called the patient back. The patient was also able to make an alarm by the panic alarm phone attached to her wrist, in which case the nurse could open the video connection without approval from the patient. However, this third alternative was not in the scope of the pilot project.

Figure 1. Videoconference system installed in the premises of client.

1.2. Semi-structured Interviews

The data was collected with semi-structured interviews, which were done during spring 2012 in the homes of the elderly taking part in the pilot project. At that time, these home care patients had used the videoconferencing system for approximately five months. The participants in the pilot project were selected by the unit of home care to involve customers with different needs of care in order to test the suitability of videoconferencing in various contexts. The home care staff used videoconferencing to follow the welfare and health of the patients, to assure compliance with the treatments and to remind customers about medication and meals, equally not ignoring the aspect of informal social interaction. Seven home care clients were interviewed for the study, of which two were women and five men. The mean age of participants was 75.6 years, varying from 60 to 92. Naturally, the small amount of participant is a limitation for this study.

The recorded interviews were transcribed and analyzed thematically. Topics were extracted from the discussions to the themes presented in the theoretical framework of the study. The mapping of the themes of the interviews for the framework of the study is presented in Figure 2 in the next section.

2. Results and Discussion

The themes which emerged from the interviews were divided into four different categories: technology, individual, social environment and service related (illustrated in Figure 2). Each theme had several subthemes, which are listed under each theme. The subthemes, which the home care patients highlighted, are discussed further.

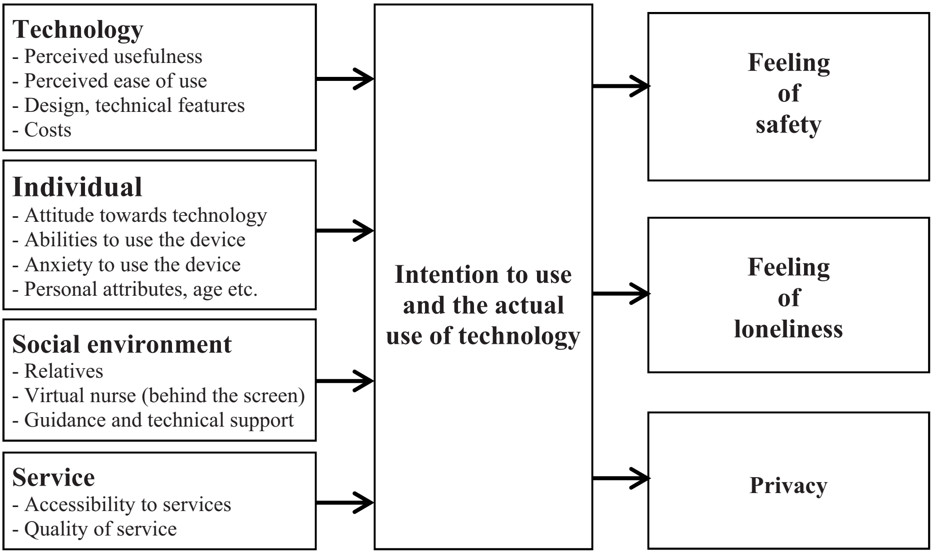

Figure 2. Interview themes mapped to the framework of the study.

In the interviews, the patients highlighted that the perceived, subjective usefulness was an important factor. The utilitarian use of services seems to apply in this context as it does in mobile services [17, 18]. Patients said that the videoconferencing system increases the feeling of safety as well as decreases the feeling of loneliness, because it was possible to talk to someone about problems and worries if needed. It also brought the peace of mind not only to patients but to family and relatives, too. One home care patient felt that the system better suited people living alone or people who did not have many visitors:

> *"Well, not in this situation, because we are two people, but let's say that the situation is totally different when there is only one person left, and that will eventually happen."*

The use of the system was considered easy, but there were problems with the touch screen, as the interviewees were used to push buttons when using technical devices. In general, the majority of the interviewees thought that the use of the system does not require any special computer skills, as two interviewees stated:

> *"The machine is so easy, simple thing, a simple job for a simple man."*

> *"I did not even think that I would not learn to use it. I was thinking that what is given, it will be used."*

However, if the user was not capable of using the system e.g. due to physical impairment, the system caused anxiety and frustration. The maintenance and cleaning of the device caused anxiety as well. The users wanted clear instructions and guidance on how to use the system in exceptional situations, and how to clean the system without breaking it. The role of technical support was regarded essential. In general, the attitudes toward the used videoconferencing system devices and the received service were positive among the interviewees, because the patients understood that the use of the system assists the work of home care.

Nevertheless, traditional home visits cannot be replaced completely with videoconferencing. Some patients wanted the virtual nurse answering or calling to always be the same person, as this would help create a trust relationship and increase the feeling of safety. One problem was that the virtual nurse worked only during office hours and was not available in the night or late in the evening meaning that the phone calls were relayed to other home care employees or nurses outside office hours. The patients experienced the discussion with nurses natural even though it happened via video. The interviewees liked the social interaction the device enabled, and users hoped that they could meet other peers or family members via the use of the system, which technically was possible, but was not implemented in this pilot project.

Generally speaking, the patients thought that privacy related aspects had been taken into consideration quite well. A couple of users wondered if the visual connection was always open, which made it important to explain them that the visual connection was open only when the user had accepted the video call. Furthermore, the placement of the rotating camera was considered an important issue; blind spots were regarded as favorable:

> *"It is nice that the camera does not reach the balcony. There it cannot see me, you see, so I can smoke a cigarette, because here inside I don't smoke… but there, well… they don't know that I smoke."*

One interviewee also mentioned that she enjoyed being able to take a nap without worrying that home care staff would come into her apartment and interrupt her sleep. Thus, she said that the videoconferencing system increased her privacy.

3. Conclusion

In this qualitative research, experiences of a videoconferencing system of seven older people were studied. The research found that the use of videoconferencing can increase the feeling of safety and decrease home care patients' loneliness, which is a finding supported by earlier research [15, 16]. In addition, the perceived usefulness was an important factor in the use of the system. The elderly involved also suggested that it could be convenient to use systems which make it possible to connect with multiple friends and relatives at the same time, i.e. creating a virtual coffee table. The use of the videoconferencing system was considered easy by the interviewees. Problems in the physical and functional capabilities of the users were more significant than cognitive problems.

Privacy is an important issue in all use of information technology. Therefore creating blind spots for the cameras should be considered, so that the customer knows there is a possibility to escape out of range of the camera, despite the fact that the visual connection is fully managed by the patients themselves. Communication through videoconference was regarded natural. However, a familiar virtual nurse was considered better to gain a confidential and trustful relationship by some interviewees.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-770

GPS-Tracking Devices in Dementia Care: New Tasks, Responsibilities and Competencies

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Abstract. This paper addresses the use of GPS-tracking devices in dementia care in a Norwegian context. The paper is based on empirical data drawn from two sources: the "EFORTT" project and the ongoing "Safe Tracks" research project. The results show that the use of GPS-tracking has important implications for the actors involved. Both the persons with dementia and family carers report on improved safety and increased independence. These findings are in accordance with the expectations expressed in current policy documents, which opens up for increased use of GPS and other telecare technologies in a dementia care setting. The focus of this paper is on the key role of family carers in relation to the implementation of the GPS-tracking device. The research findings show that in order to make the new technologies work, family carers are assigned new tasks and responsibilities. The critical issue raised in this paper is that many family carers do not have the necessary capacity, skills and competencies needed in order to take on these tasks. And in addition, not all persons suffering from dementia have someone to do the tasks for them. In this is the acknowledgement that the introduction of GPS-tracking devices in dementia care is not a trivial matter, which calls for a more nuanced understanding of the challenges posed by the introduction of new technologies to dementia care.

Keywords. Dementia Care, GPS-tracking, New Tasks/Responsibilities, Competence.

Introduction

Dementia is a progressive disorder that affects all aspects of cognitive functioning, including memory and orientation, and has profound effects on the ability to perform activities of daily living. In Norway today, most people suffering from dementia live at home during the early stages of the illness, and then, as their condition deteriorates, they move to a nursing home. The move from the home to an institution is often necessary because of concern for the person's safety and security.

A major risk-factor related to dementia is wandering. As the illness progresses, many suffer from memory-lapse or disorientation, and may have problems finding their way back home when outdoors. There are therefore a number of searches for people with dementia every year in Norway, and not all have a happy ending. Therefore, wanderers who are considered at risk of getting lost are often moved to the sheltered (locked) units of the nursing home. However, for many, this is not a wanted solution. Being outdoors, using the body and experiencing nature may be one of very few

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activities left for those in the middle or more advanced stages of the illness. On the other hand, institutional care is also very expensive, and requires a lot of personnel-resources.

Currently, the Norwegian health authorities are in the process of allowing the use of GPS-tracking devices in dementia care. A GPS-tracking device consists of a small device which the person suffering from dementia is to wear while being outdoors. The device is linked to a satellite positioning system[1], which makes it possible for persons with approved access to a digital map, to locate the whereabouts of the person wearing the device.

The GPS-tracking device is only one example of new technologies targeted at the frail elderly in Norway these days. Other examples are automatic door alarms, fall detectors and other forms of automatic monitoring that will send an alarm to a call center or family carers in the case of an emergency situation. These technologies are often referred to as 'telecare technologies', and in Norway they are introduced as a part of a State-financed plan for dealing with the consequences of the ageing of society.[2] The overall aim of the investment in telecare technologies is to enable more cost- and labour efficient health- and care services, which, it is argued, will be necessary in order to meet the expected high increase in demands for services. In the public rhetoric about the advantages of telecare technologies, the focus is often on an expected 'win-win' outcome: not only will the new technologies provide more efficient services, but also contribute to more safety and independence for its users, and in this way result in better services.

1 Background and State of the Art

The focus on new technology in care is a part of a broad international trend. In a number of countries public plan documents and deliberations refer to the demographic and economic challenges that western society is facing, with the increasing number of old people, expected lack of care personnel and projected higher costs of public health and welfare services. Examples are the report "Building Telecare in England" (2005), the OECD-report "Long-term Care for Older people" (2005), the ISTAG-report Report on "Strategic Orientations for Information and Communication Technologies Research in Europe" (2004) and the Norwegian Government Commission report "Innovation in care" (NOU 11: 2011). The research activity in this field has also been high and in particular over the past decade (Thygesen, 2009). In Norway as in many other countries there are currently a number of studies under way with focus on GPS-tracking devices in dementia care.[3]

1.1 The Empirical Basis of This Paper

The paper is based on empirical data from two projects: the EU-funded EFORTT project[4], where the use of GPS in dementia care was one of several case studies, and the current "Safe Tracks" project[4] which involves the collaboration between five Norwegian municipalities and the independent research organization SINTEF. This project is funded by Norwegian Regional Research Funds.

For the EFORTT-project case-study family carers who had experience with GPS-tracking devices were interviewed. In the "Safe Tracks" study GPS-tracking devices has been implemented as a part of formal care provision in the five municipalities in

2012. In this period a total of fifty-five persons with dementia and their family carers have been involved in the study.

2 Methods

The research has been based on a qualitative design in order to gain the necessary in-depth knowledge. Thus semi-structured interviews, focus group interviews and questionnaires were used for systematic data collection. The interviews were both targeted at the person suffering from dementia (when possible) and on family- and formal carers. Focus group interviews were used to supplement individual interviews, and for purposes of discussing and exchanging information between the actors involved. All interviews were audiotaped, given an informed consent from the participants.

3 Results

> *"My husband got his [dementia diagnosis] nearly five years ago. He has always been going for long walks. The problems came after a while. There were some episodes when he got lost, and once he nearly froze to death. (...) After a while he started to wander also at night, and for a period I was out looking for him almost every night. It was a nightmare for both him and for me. (...) This was when I got this GPS, and I have to say that it was like getting a new life for us both. All the suddenly I could join the choir again and start going to the gym. And my husband started to go to the dances regularly, which he had not done in many years."*[5]

This quote, which is taken from one of the interviews with a family carer, shows the impact of the use of the GPS device on her and her husband's lives. Clearly, through the use of the GPS a new way of life is made possible, as both of them can resume leisure activities. For the family carer, using the GPS-tracking device means that she does not have to be present, together with her husband at all times, as the GPS makes it possible for her to locate his whereabouts at any time. Increased independence and possibility of living a more active lifestyle are effects reported by many people with dementia and their family carers participating in the "Safe Tracks" study.

In the following we will however go beyond these results and focus on one aspect of GPS-tracking implementation that in our experience get little attention in the public debate about the advantages of telecare technologies: the work and skills required to make these technologies work (Moser and Thygesen, forthcoming). And as stated in the introduction to this paper we will focus our attention of this paper on the role of family carers. In order to do so we will introduce more quotes taken from interviews with family carers.

3.1 New Tasks

> *"It was a challenge to get him to take it [the GPS device] with him. I found a small pouch for a mobile phone with a key-ring. He still remembers to lock the door. It was a routine I knew he still had. And he takes it [the GPS device] with*

him 80% of the time. But then the pouch was too thin I found. Because when he had it in his pocket he pressed the button by accident, so it switched itself off. So I bought a new pouch with a key ring."

This quote, which is taken from another interview with a family carer, shows some of the complexity related to making the GPS device work for her husband. Her situation is that she is working and away from home for parts of the day, and therefore has to find creative ways of ensuring that her husband takes the GPS with him on his long daily walks, and that the device does not accidently switch itself off. However, these are only two of several tasks involved. For the GPS device to work the batteries needs to be charged. And someone also needs to log into the computer or smart-phone in order to locate her husband's whereabouts. These are all tasks that need to be done on a regular or even daily interval, because otherwise the GPS device will not work as intended. And all of these are examples of tasks that usually are performed by family carers.

3.2 New Responsibilities

"By using the GPS I am given more responsibilities. I am responsible for the GPS being charged, because if it is not, and he goes for his walks and the battery goes flat, it is my fault if something happens. And it is up to me to find a solution that ensures that he takes it with him. So it is not just about the GPS device itself. There are problems with pockets, zips and jackets. And this is supposed to function together with the equipment [the GPS]."

In this quote the family carer reflects on the implications of the use of the GPS device. Clearly, if the tasks involved in making the GPS work are not met, the technology will not work, which means that it will not offer any protection or safety for the person suffering from dementia. The consequence is that new forms of responsibilities are put on family carers.

3.3 The Requirement of New Skills and Competencies

Following on from this, it is clear that the new tasks and responsibilities require certain skills and competencies. For example, competencies are needed in handling the GPS equipment. Charging batteries, switching the device on, and logging on to internet to locate the person who wears the GPS device are tasks that require basic computer-skills. Many family carers have very limited experience in using computers, so although the technology may be simple and user friendly, it may still prove to be a barrier. And importantly, also other skills and competencies are needed that relate to the physical and mental capacity of the family carers involved. The establishments of routines for charging batteries, or ensuring that the person wears the GPS while outdoors require a good memory, the capacity to plan and the ability for creative problemsolving.

Our research shows that many family carers do not have these skills and competencies. And for many, the requirements of the new technology, such as the GPS-tracking device, come on top of an already heavy care-burden.

4 Conclusions

In concluding, we will like to emphasize the positive potential of new technologies, such as GPS-tracking devices in dementia care. In this paper, which is based on empirical research studying the implementation and use of GPS devices in dementia care in Norway, we have focused especially on the role of family carers in making the new technologies work as intended. Drawing on excerpts from interviews with family carers we have shown that although the use of GPS-tracking devices gives both the person with dementia and family carers opportunities for more independence and increased safety, there are also certain requirements that have to be in place. Family carers play a key role in performing the tasks required in order to make the technology work. These tasks involve the establishing of routines for charging the batteries and for ensuring that the person brings the GPS device when outdoors. In the delegation of these tasks to family carers there are also new forms of responsibilities involved, because if the technology does not work, it will not offer the necessary protection and safety for the person suffering from dementia.

In practice this means that telecare solutions, such as GPS-tracking devices, also have its limitations. The technology does not work on its own. Many tasks and functions cannot be delegated to the technology alone. And as we have shown, someone must therefore take on these tasks that make up the preconditions for the technology to work. Many of these tasks are left for formal carers to do. The bottom line of our argument is that many family carers do not have the skills and competencies needed in order to take on these tasks and responsibilities. And not all persons suffering from dementia have someone who can take on the tasks and responsibilities. These are implications that healthcare works and policy makers need to be aware of, as the focus of today's debate is one-sidedly on the advantages of telecare technologies, including the use of GPS-tracking devices in dementia care.

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1) GPS is an abbreviation for Global Positioning System. This is a satellite navigation system which was originally developed for military purposes. Today this is a commercial product used for a variety of purposes.

2) Three reports form the platform for the Norwegian Governments plan for implementation of telecare technologies: "Innovasjon i omsorg" (Innovation in care), NOU 11-2011, "Velferdsteknologi. Fagrapport om implementering av velferdsteknologi i de kommunale helse- og omsorgstjenestene 2013-2003" (welfare technology: report on the implementation of welfare technology in municipal health- and care services 2013-2030), Helsedirektoratet (2012) and "Morgendagens omsorg"(Tomorrows care), Stortingsmelding 29 (2012-2013).

3) There is no complete overview of all ongoing projects in this area. In Norway for example, research on the implementation or testing of telecare technologies is a target area for funding by the Norwegian Research Council and Regional research funds. This is also the case in the other Scandinavian countries. In Denmark a large GPS trial involving five municipalities and 180 persons with dementia was done in the period 2009 until 2011 (for evaluation report see www.safecall.dk/mediafiles/safelink/PDFfiler/Slutevaluering-GPS-til-demente.pdf). In the UK there are a number of different studies in this field, such as the KITE-project (Keeping In Touch Everyday), where technology and dementia care issues are addressed, including the use of tracking devices. The project is hosted by the Centre of Excellence for Life Sciences in North East England. Other research projects specifically addressing the issue of GPS-tracking in dementia care is Pot et al's pilot study (Pot et al, 2011).

4) EFORTT is an abbreviation for "Ethical Framework For Telecare Technologies." The focus of the project was old people living at home, and involved a collaboration of researchers from the Netherlands, Spain, the UK and Norway and was completed in 2011. One of the Norwegian case-studies involved the use of GPS-tracking devices in dementia care. For more information about the EFORTT project please see http://www.lancs.ac.uk/efortt/

5) All personal details of the interviews used in this paper have been changed in accordance with research-ethical guidelines.

Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-776

Exploring the Use of GPS for Locating Persons with Dementia

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Abstract. The study "Trygge spor" [2] is exploring the use of Global Positioning System (GPS) technology to locate persons with dementia. The overall objectives have been to assess the deployment of technology and services facilitating safety and security for people with dementia, family caregivers and professional caregivers. 55 persons with dementia and their caregivers participated in the impact study, and have been using GPS when performing outdoor activities as part of their daily activities during the evaluation period of eleven months. A commercially available GPS [3] was provided to the participants. This paper describes the study design and discusses the findings with reference to persons with dementia and their caregivers. The study reveals that using GPS for locating persons with dementia provided increased safety for all stakeholders, including persons with dementia, family caregivers and professional caregivers. Persons with dementia might maintain their autonomy and continuing their outdoor activities despite the progression of the disease and they could enjoy their freedom. A precondition for successful implementation of GPS locating persons with dementia is to properly assess the user needs, identify appropriate technical solutions and discuss the ethical dilemmas in order to select the least intrusive intervention. Furthermore it was experienced that collaboration between persons with dementia, family caregivers and professional caregivers are important for successful implementation of GPS for locating persons with dementia. It is advisable to further include persons with dementia and their caregivers in the process of developing appropriate devices and services for persons with dementia. More research is needed in order to evaluate the long term impacts and how to implement technology and services for locating persons with dementia as part of the regular services provided by public health care providers.

Keywords: Dementia, GPS, locating persons, participatory design

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[2] "Trygge spor"; English translation "Safe Tracking"

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Introduction

The number of people living with dementia worldwide is currently estimated to be 35.6 million, and this number is expected to double by 2030 and more than triple by 2050 [1]. Dementia is a syndrome that can be caused by a number of progressive disorders that affect memory, thinking, orientation, behaviour, speech and the ability to perform everyday activities. Alzheimer's disease is the most common cause of dementia.

Dementia is a global public health challenge and is one of the major causes of disability and dependency among older people [1]. In Norway dementia is the disorder that require most resources of the health care services in the local communities [2]. Dementia also has a significant impact on the lives of each individual person affected and might causes additional burden of care on their families [2]. Wandering and getting lost is common among people with dementia and can happen during any stage of the disease [3]. Wandering of persons with dementia in the domestic settings is often what leads to institutionalisation, which is costly and not necessarily what the people involved would wish [4]. Advances in mobile technology are opening up new means of tracking outdoor activities using Global Positioning System (GPS), and various projects have focused on recognizing wandering behaviours supporting persons with reduced cognitive abilities [4,9,15]. Our study would like to explore if the use of GPS could enable persons with dementia to maintain their autonomy and keep up their normal outdoor activities as long as possible.

Kitwood [5,6] followed by others [7,8] have been focusing on the personhood of the affected individual and emphasising his or her perspectives and subjectively defined experiences and needs. Kitwood's paradigm of person-centered care has had a major impact on modern dementia care. The core values of the new paradigm in professional dementia care are independence, wellbeing, and empowerment of individuals and their families which is also reflected in the study.

The extent to which the use of GPS for locating persons with dementia actually contributes to the values of person-centered care has been a matter of debate. Some people regard electronic tracking as means of maintaining the autonomy of patients, since it potentially enables them to perform outdoor activities on their own. Others regard GPS as monitoring equipment which deprives privacy and autonomy, and as a threat to human dignity.

We identified two systematic reviews of wandering behaviour [4,9], but did not find any randomised controlled trails of electronic tracking [11]. There are some intervention studies about locating persons with dementia [10,11,13,14], but it is a lack of research about the ethical issues and the impact that is grounded in the actual experiences of usage [11], and the majority of the studies includes only a limited number of participants with dementia using GPS in their daily activities.

Support for this study was provided by Regional Research Fund Oslofjordfondet, Oslo, Norway, the Norwegian Research Council and Fylkesmannen i Sør-Trøndelag, Norway. We are grateful for the major contributions from persons with dementia together with their family caregivers and the professional caregivers from the respective municipalities.

1. Objectives

The objective of the "Trygge Spor" study has been to explore and assess the use of GPS technology and services locating persons with dementia. The target groups have been persons with dementia, family caregivers and professional caregivers. The objective of this paper is to assess the impact of using GPS for locating persons with dementia with respect to the person with dementia and their caregivers, and to describe the design of the impact study.

2. Method

This is an empirical research study and a qualitative research design was considered most appropriate providing in depth information and detailed understanding of how people with dementia and their family caregivers experience using GPS as part of their daily life. The study also aimed to explore how the professional caregivers experienced using GPS for locating persons with dementia as part of their services. Understanding the implication on and the involvements of the professional caregivers were also of major interest.

The impact study included 55 persons with dementia or reduced cognitive function and their family caregivers (50). The participants with dementia were identified and requited by professional caregivers in five different municipalities in Norway (Drammen, Bærum, Trondheim, Bjugn and Åfjord) following the selection criteria. In Norway 50% of persons suffering from dementia are living at home [2]. Furthermore 80% of residents living at nursing homes are suffering from dementia, but only 50% have been diagnosed [2]. Based on these findings, persons with dementia either living at home together with their next of kin (14) or alone (16), or at residential care or at nursing homes were included in the study. Participants living at home include two groups, one group receiving health care services, the other did not. Both male (28) and female (27) were included.

The persons with dementia and their caregivers had no prior experience with using GPS for locating persons with dementia. A commercial available GPS system for locating persons with dementia from Safecall[3] was provided to the participants. The professional caregivers from public health care sector were trained in how to use the GPS and they carried out the individual assessment of all participants and provided the necessary follow up. The participants used the GPS regularly when performing outdoor activities during a period from one month up to almost one year. One person was included in the study, but he never used the GPS for outdoor activities, because his health conditions deteriorated and he was no longer able to perform outdoor activities.

Informed consent was signed by the participants, or by proxy from their caregivers. Ethical clearance was approved by the Regional Committees for Medical and Health Research Ethics.

For this study semi-structured interviews, focus group interviews and questionnaires were used for systematic data collection. Interview guides were worked out for the different target groups; one interview guide for persons with dementia and their family caregivers and another guide for professional caregivers. The person with dementia and their caregivers were interviewed three times during the study; when they started to use GPS, after 4-6 weeks and at the end of the study. If possible both the person with dementia and the family career were interviewed. If the person with dementia did not have next of kin, a professional caregiver who knew the participant well was interviewed instead. Additional questionnaires reporting on the use of GPS were filled out by participants with dementia (if possible), by family caregivers and by professional caregivers at the beginning of the study and at the end of the study. Measuring health outcomes was conducted by filling in the EQ-5D questionnaire. The professional caregivers were also attending focus group interviews and project meetings discussing and exchanging information.

All individual interviews and focus group interviews were audio-taped. Data analyses started together with the data collection, being an iterative process. The data was coded into given categories in a hierarchic structure and analysed.

3. Results

The study provides research based findings on the impact of using GPS for locating persons with dementia, realised through the intersection of multiple scientific disciplines, perspectives and methodologies.

3.1. Safety, freedom and independence

All stakeholders highlighted improved safety and reduced anxiety as some of the main achievements. Some persons with dementia stated that they felt safe because they were looked after and they did not feel that they were monitored or kept under surveillance. Others were not fully aware of the functioning of the GPS, but accepted to carry the GPS, because this would help their caregivers feel less anxious and safer. One of the participants refused to use the GPS when first introduced. According to himself "he did not have a problem with orientation". His wife informed about the GPS, and left the device at home. After some few days her husband asked if he might bring the GPS with him, and since then he was carrying the GPS when biking or walking.

It was experienced to be important to start using the GPS at an early stage and find appropriate ways of motivating, and also providing enough time for consideration, in order for the participants to be confident. Some of the family caregivers, that were still working stated that because of the GPS they were able to continue working, while still caring for their spouses that could maintain their freedom and autonomy.

A male informant used to walk together with his wife, but because of his physical condition he was no longer able to join her whenever she would go out for a walk. Sometimes she had difficulties finding her way back home, and the husband worried that she might get lost or hurt. Using the GPS enabled him to locate his wife on his iPad, and he could meet her if she did not find her way back home without any further problems. He felt safe and relaxed, and could perform his daily activities without being too anxious; while she maintained her freedom to walk and their quality of life were increased for the coouple4.

A female participant was living at a residential home, and she had the experience of being lost and spending one night outdoor during the cold season, before the rescue team found her. She loved walking in the neighboring forest and did not want anyone to accompany her during her afternoon walks. After the dramatic incident both she and her caregivers became anxious and the caregivers did not like the idea of her walking alone. She, her relatives and the professional caregivers agreed to try the GPS. This provided her with the freedom to walk and the caregivers with the safety they needed.

If she was not yet home within a certain time the caregivers could locate her and identify if she was on her way. If she was stuck, they could meet her and escort her home. When asking the professional caregivers about their experience with using the GPS they answered; "Safety, safety and safety". Furthermore they stated that the GPS provided the lady with "the freedom to walk, as she always loved".

Both family caregivers and professional caregivers reported that using GPS reduce their anxiety and they felt safe when they could locate the person with dementia, and the persons with dementia could maintain their autonomy and enjoy their freedom continuing their outdoor activities despite the progression of the disease.

3.2. Transfer to institutional care might be postponed

Some families reported that using GPS for localisation postpone the transfer of their next of kin to institutional care. Because of the GPS the wife and the professional caregivers could locate her husband with dementia, and she could call for assistance, when he was not able to return back home. Using the GPS with assistance from the professional caregivers from the municipality, made the wife cope with the situation and her husband could remain at home, as they both wanted. The husband maintained his freedom, while the wife felt safe and could ask for assistance when needed. Close collaboration between the family caregivers and professional caregivers was reported to be of major importance for the success of using GPS.

3.3. "Reduced restraint"

Family caregivers and professional caregivers reported that current methods like physical or chemical restraint might have serious adverse effects, and GPS was experienced to be the least intrusive intervention preventing people with dementia getting lost. The caregivers experienced less arguing and conflicts, and for one case the use of drugs could be reduced. Professional caregivers reported that using GPS locating persons with dementia improved quality of life and was experienced as" reduced restraint".

3.4. Individual assessment, collaboration and technical imitations

The use of GPS was based on individual assessment of user needs, including the family resources and the local environment, followed by thorough discussions about ethical dilemmas in order to select the least intrusive intervention for each individual person. Infringement of privacy and dignity were part of the ethical discussion. Traffic safety, was also addressed, and all participants were considered by their caregivers be able to act safe and adequate in the traffic. It was experienced that close collaboration and fruitful interaction between persons with dementia, family caregivers and professional caregivers were one of the key factors for successful implementation of GPS.

Using GPS was not considered to be an "easy solution" or viewed as a way of reducing personal care. It was rather viewed as a way to provide autonomy and enable persons with dementia to continue their daily outdoor activities and improve quality of life.

For some participants it could be a challenge to ensure that they always carried their GPS outdoor and that the GPS was charged and switched on. After carefully assessing each individual participant, it was possible to find a solution for most cases.

Technical challenges were reported, if GPS signals, internet or telecommunication were not available and sometimes when changing batteries. It is important to be aware of possible technical limitations, if not the GPS might provide false safety. Appropriate training of caregivers was experienced to reduce technical problems and false safety.

3.5. Person-centered design

As part of the study design persons with early stage dementia were involved throughout the study and their input and experiences were documented. For those participants suffering from severe dementia, experiences were collected from the caregivers. It was experienced that including persons with early stage dementia and family caregivers in the process of evaluating and developing devices and services for persons with dementia was highly valuable. This will be described in separate publications.

4. Discussion

Locating persons with dementia has been a controversial issue. Among the major concerns reported in relevant studies are infringement of privacy and human dignity [12]. For this study many family caregivers and persons with mild dementia reported that safety was more important than privacy, like [11]. Professional caregivers were more likely to value privacy more than family caregivers, and these findings are also confirmed in other studies [16]. Family and professional caregivers experienced that using GPS might provide human dignity or even avoid humiliating situations like initiating a rescue operation, not being able to find to the toilet in time or just expose themselves being confused in public spaces.

To allow the person with dementia to maintain their freedom and independence was often explained as the motivating factor for using GPS. The caregiver felt safe and the person with dementia might still maintain their independence and enjoy outdoor activities. Freedom and independence was associated with quality of life. For this study freedom was highly valued, while other studies have valued safety [11].

The fair of reduced personal contact by using GPS has been brought forward, but for this study rather the contrary was reported. Instead of spending time at home, the participants felt free to go for their daily walks or visiting the local café, meeting other people. Relatives also felt more confident to let their next of kin join others for various activities, if they could be located in case they got lost.

Ethical dilemmas were discussed throughout the study. It was experienced that the professional caregivers demonstrated a very high standard when considering ethical dilemmas. The ethical discussions were continuously repeated reflecting the disease and the situation. Almost all informants highlight the importance of early intervention, and persons with dementia could benefit from the GPS for a longer period of time.

The study experienced very few dropouts, and most informants used the GPS, until their health condition limited their physical activities. This high compliance could be explained by the fact that the professional caregivers assessed the need and was following up on the family caregivers if needed. Close collaboration between family and professional caregivers and continued support from a trusted professional caregiver was experienced to be of major importance for successful implementation of GPS supporting people with dementia.

5. Conclusions

Using GPS for localisation provided safety, autonomy and freedom for persons with dementia to continue their outdoor activities. Persons with dementia and their caregivers experienced increased quality of life. GPS was also considered being a less intrusive intervention than physical restrictions or drugs by the caregivers. Both family caregivers and professional caregivers experienced that being able to locate persons with dementia made daily life easier; they were less anxious, more secure and felt they could better cope with the situation, and it was not experienced to reduce personal contact. Using GPS for localisation might also postpone transfer of person with dementia to institutional care.

However, a thorough user needs analysis is required, as well as ethical considerations, the skills to identify the appropriate technical solution and to establish appropriate services and procedures.

It was experienced that early intervention and close collaboration between persons with dementia, family caregivers and professional caregivers are important for successful implementation of GPS providing safety and enabling persons with dementia to continue their daily outdoor activities.

Persons with early stage dementia might be involved in the design and evaluation process, and it is advisable to further include persons with dementia and caregivers in the process of developing appropriate devices and services.

More research is needed in order to evaluate the long term impacts and how to implement technology, services and procedures for locating persons with dementia as part of the regular services provided by public health care providers.

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User Perspective

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-787

Young Practitioners' Challenges, Experience and Strategies in Usability Testing with Older Adults

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Abstract. Literature on usability practice suggests that, despite recommendations for user research and usability testing with younger or older adults being similar, practitioners working with older adults as a target audience should take special care in following the recommendations. Nevertheless, there are not many studies describing the experience of practitioners with this particular audience. Our study shares the findings obtained from semi-structured interviews with six young practitioners who have had all their practical experience with no other group beyond the older adult population. The analysis to the insights of these young practitioners 1) shows that they have learned through their own experience what are written in the literature as recommendations and guidelines, 2) confirm existing guidelines and 3) might potentially contribute to existing best practices in user research and usability testing with older adults.

Keywords. Usability testing, practitioners, older adults, interview, recommendations, mobile devices.

Introduction

As the World population ages, there is an urgent call to action to prevent exclusion and provide older adults access to information and communication technologies (ICT). This need is grounded on the benefits of ICT for bio-psycho-social well-being, on the emergence of disruptive social and healthcare services, on equal opportunities for the whole population and on the renowned demands of the baby-boomer generation.

Despite being rather recent a phenomenon, the use of mobile devices by the older adult population is gaining ever more attention as these devices increase their proliferation around the globe and are considered to be a privileged means to respond to the ICT benefits mentioned above. This widespread use has led to the settling of best practices and guidelines for mobile User Interfaces (UIs) [1], patterns [2] and features targeted at older adults [3], which are often based on usability testing with this particular target audience.

Studies point towards the need to take special attention in user research and usability testing with the older adult population [4]. Nowadays, Human-Computer Interaction (HCI) specialists have guidelines at their disposal to conduct usability tests

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with older adults [4, 5, 6], although some authors find these to still be scarce [6]. These guidelines go beyond providing advice regarding test protocols to include recommendations for the entire planning of usability tests, such as participant recruitment [7], tailoring facilities for older adults' specific needs, adapting language or even choosing the best time of day to conduct usability tests with older adults [5].

Despite existing guidelines, some studies have suggested that, in practice, procedures are not followed to the dot [8] and that real-life usability testing is likely to present challenges and unexpected events with which practitioners must deal in the moment.

Research into practitioners' experience has a tradition of some decades in HCI [9] and it is, on the one hand, one possible way to assess whether or not guidelines and recommendations are making their way through to practitioners and, on the other hand, a possible way to, in itself, deliver new insights and provide guidelines and recommendations for other researchers and practitioners.

This paper fits into the latter category by presenting the procedures, analysis and outcomes of an exploratory study into young practitioners' challenges and experience in conducting usability tests with older adults. Previous work has focused on guidelines to conduct usability tests with older adults [6]. This previous work was based on personal experience in conducting thorough usability testing sessions with older adults for a period of 13 weeks within one research project. Our study focuses on the experience of 6 practitioners and adopted an exploratory approach into the whole experience of these young researchers. This study has enabled us to confirm some of Silva and Nunes' guidelines and some guidelines from other sources in the literature as well (e.g., [4, 5]). Notwithstanding, we believe our study has 1) added to these existing guidelines, 2) might inform the HCI practitioner's roles in configuring the older adult user [10] and 3) might contribute to help other researchers make the best out of usability testing with older adults.

1. Methods

The interviews conducted within the scope of this study were mainly concerned with gaining new insights on the knowledge of young practitioners with experience in usability testing and identifying their major challenges. Despite adopting an exploratory approach, the research questions for this particular study can be summarized as follows:

RQ1: What are practitioners' main challenges in conducting usability tests with older adults?

RQ2: What is the practitioners' experience with user research and usability testing methods with older adults?

RQ3: How does the experience of young practitioners inform practice?

For the purpose of answering the above stated questions, a semi-structured script was prepared. The interviews were structured into two main blocks: 1) researchers' overall difficulties and 2) experience in test preparation, conduction, evaluation and reporting.

1.1. Sample

The participants were 6 young researchers from a research centre with experience in usability testing with older adults. Researchers' roles in the organization focus on applied research and all of the researchers' professional experience was gained in projects targeting older people.

The sample was one female and five male participants with ages ranging from 24 to 30 years old. Participants' experience in usability testing with older adults ranged from over 2 years to less than 1 year.

Participants' background was in software engineering, communication design, industrial design and multimedia. None of the participants had any professional experience in usability testing and user research methods prior to joining the research centre. As a whole, participants' experience in usability testing was gathered in internal, national and international R&D or industry contract projects relating to health and wellbeing. Together, all interviewees had taken part in a total of 178 usability tests.

1.2. Analysis

Analysis of the interviews followed Grounded Theory [11] methods and was conducted by both interviewers, using open, axial and selective coding [12, 13]. After the first individual analyses, the interviewers would go through these together to seek agreement. The first analysis retrieved a list of raw codes which was then grouped into a table. Each code in the table was accompanied by 1) a name, 2) number of entries according to each interview, 3) percentage of occurrences within the whole set of codes, 4) an explanation of the code, 5) references to comments, and 6) illustrative transcriptions.

These codes were screened for inconsistencies or repetitions in order to reduce the number of codes and avoid duplicate entries. As the codes were often attributed within a group, these groups of codes were analysed and their nodes were illustrated into visual format, with the objective of more easily unveiling the hidden connections between codes.

After having documented all the existing connections between codes, a second filtering was performed in order to eliminate irrelevant connections and thus leave only the most important relationships. This allowed for the process of axial coding, in which the researchers tried to unveil the main phenomena, along with their causes, context, actions and consequences [12]. The researchers then proceeded to analyse the codes with the most entries through selective coding, thus identifying the core categories in the transcripts.

2. Results and Findings

The final analysis revealed 16 main codes showing relationships of dependence by cause, consequence or belonging amongst them: Difficulty, Researcher's experience, Strategy, Planning, Bias, User Management, Learning, Time, Comfort, Feelings, Valuing, Documenting, Ideas, Test effect, Team and Real context.

The analysis found three major categories: Researchers' difficulties, Researchers' experience and Researchers' main strategies. The first revealed 4 sub-categories: Difficulties in user management, Difficulties in introducing the test sessions, Difficulties in conducting the test, and Difficulties in test planning. Within the second we found major references to relevant experience regarding: Older adults' behaviour, Bias, Time and First few minutes of the test protocol. The third and last major category refers to researchers' main strategies, usually developed on their own throughout their professional experience. This includes: Time-sparing strategies and Results-improving strategies.

Regarding difficulties young researchers experience in dealing with older adults, our study findings might be summarized in three items:

1. Unless supported by user management, finding and recruiting participants to take part in user research or usability testing (particularly user with specific medical conditions) is a cumbersome and difficult process for researchers.

2. Language has to be adapted to talk to older adults in two ways: 1) in general terms, if one is not used to engaging in conversations with the older population, and 2) in order to translate technical terms into terms which older and non-technologically proficient adults are able to understand. This has been widely mentioned as being fundamental; nevertheless, practitioners/researchers should take care not to fall into the unadvisable use of elderspeak [6]. Communication problems may not be specific to usability testing, as they are reported to emerge in intergenerational communication in both Eastern and Western cultures, although more pronounced in the former [14].

3. During the tests most challenges are related to older adult participants talking excessively and researchers not knowing how or when they may be allowed to interrupt without being inconvenient and without influencing the test results.

Our analysis enabled us to identify two main categories from which it is possible to begin to draw best practices for usability testing and user research with older adults: researchers' experience and researchers' main strategies. The first category mostly pertains to patterns of older adults' behaviour identified by young researchers and the latter to ways researchers have found to cope with these. Bringing these categories together, it is possible to link main challenges of conducting usability tests with older adults to main courses of action pointed out by researchers to tackle them.

1. Older adults tend to be suspicious of scams [4]. Therefore, it is important to learn how to gain older adults' trust. This is done through paying attention to language, explaining what the purpose of the test session is and, sometimes, engaging in activities outside the scope of research in order to adequately manage the relationship.

2. Dealing with older adults poses many chances for bias in the results and it is likely much more time consuming than conducting tests with the general population. In order to reduce these and to make the best out of the test, researchers should place effort into the first few minutes of interacting with older adults. The first few minutes have been found as crucial to establish trust and make participants comfortable.

3. The way in which questions are posed (i.e. open vs. closed) is not the only important detail one must bear in mind in order to keep older adults from talking beyond what is desired. In order to reduce the time it takes to conduct tests with older adults, the interviewed researchers sometimes create diversions to get back on track or place themselves in strategic positions to avoid distractions or overly lengthy conversations. The number of researchers facing the same person and the way in which they position themselves in regard to the participant both have an influence on older adults' behaviour.

5. Dealing with older adults during the test might be hard because they compete amongst each other, they want to do well and lack confidence in their capabilities, or because they worry about not being helpful if they are not able to perform the activities. Furthermore, if not assessed properly prior to the test, older adults' mental and physical issues might only show during the test itself. All of these require prior preparation and sensitivity to deal with older adults' psychological frailties.

6. If confronted with the need to choose between too long a time spent and older adults' well-being, the researchers interviewed in this study went with the latter option.

3. Conclusions

Our study is particularly valuable in regard to what Gregor and Newell have defined as User Sensitive Inclusive Design, in that this particular approach calls for a "different attitude of mind of the designer" [15]. The contribution of this study to practice is made not only by sharing common practices which were deemed as suitable by the researchers to use with older adults, but also through pointing out researchers' challenges which, if tackled, might help organizations in conducting usability testing to improve their internal procedures regarding user research and usability testing with older adults.

As a final remark, we conclude that, despite having reached two main categories informing young researchers' practices in usability testing with older adults (researchers' experience and researchers' main strategies), we highlight that these are fundamentally built upon what these young researchers have learned and understood about older adults' behaviour through direct contact. This was the category which accumulated the most information about the researchers' experience, and it was based on this personal contact that young researchers have devised strategies which try to balance the quality of the test results with older adults' wellbeing. Therefore, in the light of this fact, our results seem to reinforce the idea for the need to invest in the practice of User Sensitive Inclusive Design [15] with older adults.

Acknowledgements

This study was conducted in the scope of the project 'Smartphones for Seniors (S4S)', a QREN initiative, co-funded by the European Union/FEDER, through program COMPETE – Programa Operacional Factores de Competitividade. The authors would like to thank Fraunhofer's researchers who kindly agreed to take part in the study and share their experience. The authors would also like to thank the three anonymous reviewers for their valuable comments, suggestions and insights.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-793

Devising Participatory Design Workshops for Individuals with Diverse Disabilities

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Abstract. Effective user participation during the creation of new assistive products can help to identify design criteria which may not be otherwise evident to product developers. This paper describes the formulation of a series of participatory design workshops which are currently underway in the Republic of Ireland. It focuses on the development of a plan to both foster participant empowerment while generating actionable results, along with the activities, games and structure that constituted the primary workshop. The need for flexible methods and challenges regarding recruitment and communication are also discussed.

Keywords. User-centered design, computer access, mass customization, assistive technology, mobility and dexterity, communication, product development.

Introduction

This paper presents one stage of an ongoing research project aiming to generate a framework for involving a variety of AT users in the design process of new customizable devices. Pragmatism underpins the research so the framework is under development through the practical design of a new computer input device. The first stage engaged professionals working in the field of AT prescription, provision and training and established consensus on a range of specific design criteria and clinician needs. This paper focuses on the formulation of the second stage which involves users with motor disabilities that necessitate the use of assistive computer input devices.

1 Participatory Design and Assistive Technology

Participatory Design (PD) is the name given to certain design principles and practices which aim to create products and systems that are more receptive to human needs [1]. Sanders [2] differentiates it from the more commonly used term "user-centered design" (UCD) by describing UCD as design *for* users and PD as design *with* users. PD methods include design workshops, brainstorms, role-play scenarios, storyboard and prototype development and ethnographic research techniques. Sanders et al [3] propose the organization of PD tools and techniques into groups related to "talking, telling and explaining", "acting, enacting and playing", and "making tangible things". The use of PD in the area of AT development is a contemporary phenomenon and all relevant studies found in the literature took place in the last decade. PD, in the development of medical and assistive technologies appears to be most commonly used for the domain of human-computer interaction, but there are few studies about the PD of hardware-based AT products. There is also ambiguity in the discipline, with little instruction available about how a designer should evaluate, analyze, interpret and implement the outcomes of PD in practical product design processes. Though beyond the scope of this paper, the larger research project aims to address this gap and develop a method for the translation of PD outcomes to technical design practice.

2 Methodology

This section describes the first of four PD workshops which was devised principally to initiate concept generation with participants with disabilities. It also aimed to help ascertain the perceived validity of some of the ideas garnered during the first phase of the project, which involved professional and clinical AT users.

2.1 Participants

Purposive sampling was used to recruit AT users who had diverse disabilities and experience with different types of AT Computer Input Devices (ATCIDs). For the purpose of this research, ATCIDs are defined as hardware-based input devices used by individuals for whom standard mice and keyboards are inaccessible. Examples include switches, joysticks and touch panels. A set of inclusion criteria was developed and provided to a manager of an AT service provision organization. This manager acted as gatekeeper and instigated participant recruitment, helping to prevent the risk of coercion by the researcher while protecting the anonymity of individuals' who did not wish to take part. The literature posits that between three and six individuals make up an optimum PD team [4] but because the pace of communication among the cohort was likely to be varied due to the use of augmentative and alternative communication (AAC) aids, a smaller sample of three to four was proposed to allow adequate time for individuals to contribute.

2.2 Workshop Activities

The workshop was structured in three parts: an initial introduction, a design session, and an evaluation. First, confidentiality agreements and consent forms were completed, participants introduced themselves and there was a short presentation about the research. The design session then aimed to generate ideas about current devices. A question guide steered the group through an exploration of relevant experiences, likes, dislikes and hopes pertaining to ATCIDs. A flip chart was used to document the responses and create mind-maps around these. Brainstorms based on the stimulus questions aimed to build a set of criteria for product development. After this, a variety of 2D and 3D materials were presented as generative tools [5] and participants were asked to pick and choose elements they believed represented something positive about ATCIDs. This idea evolved from design consultancy IDEO's "tech box", whereby designers collectively add to and use a locker of various toys, materials, gadgets and fabrics to inspire creative thought and develop product concepts. It was also inspired by the use of design cards in software PD [6]. The PD exercise described here amalgamates these two tools to make one which is appropriate for different participants with diverse disabilities. Essentially, the hypothesis is that particular items which appeal to a participant ought to inform the design process of customizable AT products. For example, if an individual has a visual impairment, they might choose certain tactile artifacts whereas someone with a motor impairment might choose something that is easy for them to grasp. Materials presented should be relevant for the AT product under development, so in this case, as seen in Figure 1, objects and materials included various non-toxic materials like memory foam, silicone, plastics and metals, assorted toys, color swatches, a selection of forms made by the researcher from extruded polystyrene foam and sets of images of familiar electronic devices. At the end of this exercise, each participant had created a "design dish" containing images, textures and representations of things they associate with a successful ATCID. Choices were then discussed and, finally, during the evaluation session, the results of the day were summarized and presented to confirm participant agreement. A short evaluation questionnaire was then used to ascertain the participants' views about the day.

Figure 1. "Design Dish" Materials.

3 Findings

The purpose of this short paper is to give an account of the PD workshop activities, rather than to detail the design related outcomes for ATCID development. Briefly, all data collection media - MP4 files, photographs and flip chart transcripts - were laid out for comparison and synthesis. The Framework Analysis [7] technique was then used to create a hierarchical thematic framework and organize the qualitative data. The findings support the proposed benefits of customizable ATCIDs as product-related needs, desires and use patterns differed greatly between the participants. Various aesthetic and functional features emerged as important and these were listed and defined in order to inform the development of the ATCID prototype.

In addition to data gathered about the product design process, substantive findings related to the practical facilitation of a PD workshop were;

1. Participants tended to defend devices that currently work for them;
2. AT abandonment came about due to changes in both product availability and user needs;
3. Participants tended to have low expectations for AT.

4 Conclusions

A number of challenges emerged during the workshop. Participant recruitment was an issue as only two participants could take part on the day due to sudden commitments. The activities were still useful, though it is unclear if a richer dialogue would have resulted from a lager team dynamic. Also evident was the issue of tunnel vision [8], a theory that proposes product-users create ideas related only to patterns of activity they are accustomed to. Consequently, resulting designs may just be solutions to perceived problems, rather than real problems. Here, participants tended to respond generously with information about themselves and their ATCIDs, but engaged less in dialogue about concepts or ideas that were not linked with their current AT.

The experiences described in this paper advocate flexible workshop formats involving activities that can be used with different sized PD teams. This has the potential to help overcome participant recruitment and attrition issues. Flexibility is also important so participants with various levels of ability can contribute fully. Workshop developers should also ensure adequate time is allowed for communication and rest. Distribution of question guides and information packs prior to the workshop allows AAC users to prepare answers if they like and also provides participants with extra time for reflection. This paper posits that PD workshops should facilitate a positive and fun environment; although the facilitator will attempt to identify unmet needs, they must avoid probing in a negative way that could lead to participants feeling disappointed with their current devices. In essence, there needs to be a balance between constructive criticism of AT and positivity about the opportunities it offers. Critically, an omnidirectional system of teaching and learning between the facilitator and individual participants should be fostered in order to promote participant empowerment.

The aims of this initial workshop were to investigate and generate conceptual solutions for customizable ATCID development and also to inform the preparation of subsequent workshops. As the workshop series continues, the materials used to drive the PD process forward and generate feedback will evolve. Generative tools, as described in this paper, will be replaced with basic product models, then with more functional prototypes and finally, the last workshop will serve to evaluate a works-like/looks-like prototype [9] which realistically represents the look, feel and behavior of a mass-produced computer input device.

In conclusion, the PD process to date supports the idea that generative tools and questionnaires, used in a flexible workshop format, can offer opportunities for individuals with diverse disabilities to participate in the design process of AT hardware.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-798

Thinking through Design and Rehabilitation

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Abstract. The initiative described in this paper explores how the concept of 'design thinking' can be introduced to people with spinal cord injuries (SCI) as a route to improved independence, resourcefulness and personal control. The underpinning premise of the study is that design thinking offers a kind of resourcefulness and the ability to think laterally about problems.

The overall aim of this study was to investigate what design thinking might offer to people living with a spinal cord injury. In a controlled healthcare environment design thinking strategies were introduced as a way of supporting self-efficacy and cognition of perceived manageability, which has been shown to be positively associated with constructive health behaviour and adjustment to life changes, including a spinal cord injury (Bandura, 2004. Cicerone, Azulay, 2007. Dohnke, et al, 2007. Hampton, 2004).

Potential intended outcomes were driven by the ideas that by introducing the concept of design thinking to people with SCI it would help build self-efficacy and offer people the confidence to make positive changes in the context of their own lives, experience and self-esteem. Two of the main factors in developing self-efficacy being experience in overcoming obstacles and persevering to obtain a goal, and observing peers succeed in a similar way (Bandura, 2004. Dohnke, et al, 2007).

This paper presents work undertaken by the Art and Design Research Centre at Sheffield Hallam University as part of a project relating to Design & Rehabilitation, an initiative instigated and co-ordinated by the Royal Society of Art (RSA).

Keywords. Design Thinking, Inclusive Design, Rehabilitation, Spinal Cord Injury.

Introduction

In November 2010, the RSA's Design & Rehabilitation project led by Dr Campbell the then director of design was unique in piloting a series of workshops with spinal cord injuries. These small-scale workshops (for 8 people) were aimed at testing the effective potential and attendant operational issues of introducing design training in developing resourcefulness and self-reliance. The project was based on Campbell's premise that if people in general (not just designers) have tools available (cognitive and physical) to be more resourceful, then changes may be seen in their self-management ability (2009). The workshops anticipated that design thinking would foster independence by addressing the loss of confidence and motivation that often results from a sudden physical impairment, by developing methodological and practical skills for problem solving (Campbell, 2011).

Other examples of the use of design thinking in a general Health Care environment include the work undertaken at the Mayo Clinic, North America, where physicians and designers have tested hypotheses about ways in which providers and patients interact (Yale School of Management 2012). Tim Brown of IDEO describes being involved in teaching design thinking to nurses, doctors and administrators in the hope of inspiring practitioners to contribute new ideas to innovative changes within clinical practice (Brown, 2008). However, there has been little documented use of the use of design thinking in the UK or internationally that specifically applies design thinking in the context of teaching SCI patients and the skills involved in design thinking, besides the work that was conducted by the RSA and partners mentioned above.

Anecdotally, some rehabilitation specialists have recognised there are many inpatient SCI patients who struggle with boredom and monotony of inpatient life, which can reinforce depression (Campbell 2011). It was intended that having a design workshop that compliments existing rehabilitation might help stimulate patients who are mentally and to some extent physically active even possibly physically independent to some degree. Currently, published NICE guidelines do not exist for the rehabilitation of SCI patients. However, the National Spinal Cord Injury Strategy Board, led by Dr Fiona Barr is working towards developing SCI care pathways, consequently it is a pertinent time to be evaluating the design thinking workshop and its impact on SCI patients.

1 Methodology

The project described here was divided into a number of phases. In the initial phase of the work, three universities took up the challenge of the RSA objective to devise and test design-training/design thinking models for people with a spinal cord injury. Each university worked closely with one of the UK's eleven specialist units for SCI. Partnerships were formed as follows:

- Bucks New University and the National Spinal Injuries Centre at Stoke Mandeville
- Glasgow School of Art/University of Strathclyde with Glasgow Queen Elizabeth National Spinal Injuries Unit
- Sheffield Hallam University and Sheffield Princess Royal Spinal Injuries Centre

These partnership activities expanded on the design workshop prototyped by the RSA and Back-Up, the national charity for spinal cord injury and while the initial RSA/ Back-Up workshop was instrumental in testing the concept, each subsequent partnership was able to provide a new perspective on the research activity. The methodology for teaching/implementing designerly thinking and practices to people with SCI remained open to definition but in each partnership this was fundamentally based on the use of design activities and theories introduced in participatory workshops, run in a healthcare and wellbeing/design education context and or location. Each of the three universities proposed individual approaches, which reflected the work of the design faculties in their universities, with the common criteria that within each individual approach, the SCI participants were to be considered as potential designers and/or active design thinkers. Sheffield Hallam University's Art and Design Research Centre worked with the Princess Royal Spinal Injury Unit at Sheffield's Northern General Hospital. This paper presents and reflects on: the research that was undertaken with participants from these two institutions; the methodology developed; work and results followed by the research; conclusions and the direction the work has since taken. Representing Sheffield Hallam University was a team of designer/researchers from

Lab4Living [1]. The teams approach was to establish shared ownership of the project with the SCI participants from the Princess Royal unit. It was made explicit in their methodology, to the SCI participants and healthcare staff at the Princess Royal, that this was a joint enquiry, and an opportunity for shared learning. This was done in an attempt to disarm the stereotypical view of the designer's role as the 'expert', drafted in to solve functional problems identified by the users and to utilise the idea of 'Inclusive Design' as a fundamental part of the theoretical framework of the workshop. The strategy of Inclusive Design is recognised as an approach that encourages designers to design for social inclusion in collaboration with users or communities, in which the output is not associated with negative perceptions of age or disability (Coleman 2004).

The aims and objectives in the project were summarized as:

- to challenge the perceptions of design amongst non-designers
- to investigate how design can support self-efficacy
- to understand the opportunities that the development of design/design thinking skills might present to individuals living with long term disabilities
- to further Lab4Living's work and help define the role and value of co-design and participatory design
- to encourage the transferability of skills and knowledge

The Sheffield based project took the form of a series of 6 connected workshops with the overarching concept of introducing design as a way of thinking, which might be interwoven with practical actions to resolve problems that anyone could face in everyday life. The team attempted to steer clear of specific challenges or issues that might be faced by an individual participant (while being sensitive to commonly held problems), as it was feared that this might potentially narrow down the focus of design experience. The workshops were loosely based around the following themes and activities:

1. What is Design? - case study, which potato peeler is best?
2. Prototyping - iterative trial and error - making towers out of spaghetti and marshmallows.
3. Design Encounters: 'sensing' the world differently - sounds, textures, barriers, light, order and nature.
4. Mapping and Contextualising - mapping the design encounters onto hospital plans.
5. Design Questions and Lateral Thinking - what is the problem?
6. Design Activity

The research was strongly supported by a team of students from the MDes and MA Design courses at the Sheffield Institute of Art at Sheffield Hallam University, who committed their time to this project in addition to the demands and requirements of their course. The feedback from all the students was overwhelmingly positive with reference to the impact of this project on their own design practice and more widely on their lives.

The workshops were delivered to a number of SCI in-patients at the Princess Royal Spinal Injury Unit site. The number of patients at each workshop varied from between

[1]Lab4Living (www.lab4living.org.uk) is a collaboration between the Art and Design and Health and Social Care Research Centres at Sheffield Hallam University, clinicians and users. This partnership brings together research expertise spanning the fields of health, rehabilitation, design, engineering, ergonomics and user led design.

4 – 12, depending on people's physical ability to attend, and timing with other commitments such as treatments and consultations but there was a core group of around 5 patients who attended the majority of the workshops. The patients ranged significantly in physical ability, some being able to walk with the assistance of crutches, many in wheelchairs with limited upper body strength, dexterity and range of movement and one patient in a bed. This range of ability presented many challenges in terms of delivering the workshops. The workshops were 3 hours in duration (with tea breaks), and delivered once a week on a Wednesday afternoon over a period of 6 weeks.

Typically a workshop session would start with an introductory talk that would cover a number of things including:

- A recap on the previous weeks activities
- A review of what stage we were at in the overall trajectory of the workshop
- Set out the agenda for that days activities
- Introduce the main topics and activities of the day
- Provide a forum for discussing any questions or problems regarding the days events

In general terms the mode of delivery included: presentations; discussions; scene-setting exercises; and design making/thinking exercises. The workshop contents were comprised of a mix of: 'ice breaker' activities, all based on problem solving, practical 'prototyping' activities; observational activities using all senses; lateral thinking exercises; grouping and classifying exercises; and included the use of visual and video clips showing examples of 'good' and 'bad' design; and a range of introductory and briefing talks. As the workshops were activity based the design students participated as a resource, working alongside workshop participants to discuss ideas and assist in the design process.

This phase of the Design and Rehabilitation project concluded with a seminar hosted by the RSA, at which clinicians, designers and SCI patients from the three different teams from Glasgow, Sheffield and Buckinghamshire came together to share their experiences.

2 Findings

The feedback from the patient participants and the healthcare professionals that observed this pilot was very positive. Patients made efforts to attend despite the voluntary nature of the workshops and occasional clashes with scheduled therapies, with the overwhelming response at the end of the course of workshops being a request for more workshops. Feedback on the experience gathered at the last workshop from the SCI participants who had been active in designing and taking part in hands-on, practical tasks and imaginative challenges included comments like:

> *'Design is about everyday'.*
> *'Design is a...'Way of thinking. How things work and make people feel'.*
> *'Depends what kind of design. Yes, now I think change can happen through design – now I can see problems that need addressing'.*
> *'I've been thinking a lot about design. It's been good to have a focus'.*
> *'Everyone is always telling you – that's not the way you do it. But I want to do it my way!! It drives you mad sometimes'.*

There were a number of issues encountered during the running of the workshops and some good practices that emerged through the experience. One of these was recognition for the importance of careful planning and structuring of the workshop activity. The weekly plan was discussed with the workshop co-ordination team in a meeting preceding the day of each workshop. This enabled the team to flag up any potential problems and assign any specific roles and responsibilities for the day. These briefing sessions became an important part of the research as they orientated the students, design staff, OTs and supporters etc. to the direction and planned activities of the following workshop. However, it became increasingly clear as the workshops progressed that the implementation of the planned events had to be extremely flexible to accommodate the physiological needs of the participants. In real terms this meant that the delivery of content and participation in design activities had to be carefully timed in terms of duration and sequence. The use of data-projectors and other visual aids also needed to be carefully managed and monitored, so as not to exclude members in the group who could not easily see material or might be adversely affected by looking at digitally projected content for a long period of time. Participants' attention spans and physical capacity, often influenced by pain management needs also played an important part in the ordering and duration of activities within the workshop session. In addition environmental issues were found to be extremely impactful on the success of the workshop, such as the ability to work around tables (sketching ideas etc.) when confined to a wheelchair, the location and amount of furniture in a room (if this could be easily rearranged) door access and lighting. It was found that the amount of consumable and other resources should also not be underestimated. The workshop team provided a number of digital and analog resources including: laptop computers and a data projector, used for presentations and showing movies; digital cameras and a photo printer, used for documentation and participant content generation; drawing and note making materials – flip charts post-it notes etc., used to generate and present ideas by and to participants.

From a clinicians viewpoint comments were made on the ability of the design focused workshops to allow the patients to consider a different perspective (not medical based) on their condition and to have the opportunity to talk about nonmedical things with a range of other people. The workshops provided a contextual space that linked concerns, needs and possibilities between the immediate environment within the hospital and with external domestic and personal spaces.

3 Conclusions - Next Steps

The project has since engaged support from the Service Improvement Team at Sheffield Teaching Hospitals (parent hospital of the Princess Royal Spinal Injury Unit) and has successfully secured funding from the Health Foundation to run a trial in which the workshops are modified to fit within a standard rehabilitation service delivery model and delivered to all the patients meeting the inclusion/exclusion criteria that pass through the rehabilitation ward at the Princess Royal Unit over a 6 month period.

The Service Improvement Team will be monitoring the project, with a time series analysis of standard measures and of patient feedback via questionnaires and in-depth interviews before, during and after the workshops, with 3 and 6 month follow-up interviews scheduled after discharge from the ward during which it is anticipated that evidence of sustained retention and use of the design knowledge or lack of retention will be found. They will 'measure' perceived manageability parameters (sustainability of the intervention) along with some standard SCI patient metrics such as Spinal Cord Independence Measure (SCIM), Length of Stay (LoS) and readmission rates.

The intention is to gather evidence to support the hypothesis that design training can develop resourcefulness and self-reliance for SCI patients and hence potentially reduce length of stay, readmission rates and self-reliance out in the community. Should this trial provide this evidence, the work will be put forward to inform the NICE guidelines and further funding will be sought to conduct a more controlled multi-site study. It is appreciated that within this study there is no control group and therefore improvements might be due to other factors such as simply the focused time spent with a willing therapist (the design teacher) or other on-going service improvements with the Unit. With the numbers of people going through the unit being insufficient to conduct a full randomised control trial, it is not possible to assess against a control group. The structure of the time series analysis is such that the researchers are merely looking for a step change against previous base line data of LoS, perceived self-manageability and re-admission rates. If this step change is detected, the project will be in a position to argue the case for a more controlled, larger, multi-site trial and hence address these issues.

In the medium term we also need to begin to make some important preparations if this type of research is to be sustainable and taken seriously from a health and wellbeing perspective. We need to be developing preparatory workshops for designers working within health care communities, to help educate and prepare designers to understand medical conditions and attendant physical and mental issues, involve the community in the co-development of workshops and explore strategies to better set up the experience for the participants.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-804

Power to the People: An Exploration of Participatory Research and Development in Disability Practice

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Abstract. Aim: this paper aims to briefly describe some current approaches to participative research and technological development with people with disability in the Republic of Ireland (Roi).
Methods: Two aspects of a shared approach are used to highlight lessons learnt from participative research and development.
Findings: Ethical issues that emerge with research and development are highlighted. It also demonstrates the potential for service user empowerment, arising out of participative approaches.
Discussion: Issues arising from service user participation in research reveal it to be a powerful tool for sharing a vision across both disability and mainstream education and employment services in the ROI. Future research is required in the area, in addition to local and national guidelines to foster more extensive educational/community participatory research ventures. Funding support for expert AT Users, for community partners and an increased recognition for non-traditional research is also required.

Keywords. Design, Participation, Disability, Empowerment, Participatory Research**.**

Introduction

One 3rd Level Institute in the Republic of Ireland (ROI) has pioneered an innovative research and development (R &D) programme as a key component of an *Applied Medical Design* module; within which there is a particular focus on educating engineering students about assistive technology (AT). Students learn about AT in an experiential manner by exposure to real life engagement with people with disability. This paper aims to briefly describe a secondary analysis of the effect of these participative R&D approaches. Two examples will be used to highlighted lessons learnt from these participative processes that highlight both the arising ethical issues and service user empowerment that emerged.

1 Literature Review

1.1. Ethical Issues

Although not specifically related to AT devices or participative research and development, discussions of ethical issues permeate the literature. All research needs to conform to ethical principles to ensure that it is of some perceived benefit for participants (beneficence). It should also do no harm to participants (nonmalificence) [1]. These are well understood constructs in modern research, and great care is taken to ensure that there are appropriate conditions for research and development to take place [1]. The right to choose whether or not to partake is fundamental to these principles (self-determination), and consent is usual. The potential vulnerability of all service users [2] needs to be borne in mind when using research and development approaches, and those with disability could be considered a particularly vulnerable group [1]. As a result communications need to be clear in terms of expectations, including the risk of raising expectations [of the outcomes] that are too high, which could be disappointing for users.

While there is discussion and debate in the literature about whether or not service users should partake in research, there is overwhelming public enthusiasm to take part in health related research even in the context of risk [1,2,3,4,5]. Research can also be seen as therapeutic [6]. However there is also a risk of coercion/persuasion if “the stakes are high” [1] and support for a less voluntary inclusion in medical research [7]; i.e. that medical research ought to be a natural part of a service users’ experience. These debates indicate some of the overarching issues with “power and control” [8 p.363,9] that arise in research, and highlight that it can be a “disempowering process for people who are used merely as passive objects of …research” [8 p.363]. Conversely participative approaches aim to be more all-inclusive and sensitive to individual needs, and evidence among marginalized groups indicates that under certain conditions it can result in empowerment.

1.2 Personal Empowerment

Participative Design (PD) is an umbrella term for principles and practices which aim to create products and systems that are more receptive to human needs [10]. It advocates that users are involved throughout the whole design process. However there is little discussion in the literature related specifically to the empowerment of disabled people who have taken part in participative engineering design research.

Participants generally like to know about the results of research [3,4], and this is something that is reported anecdotally among this cohort. Interestingly a lack of feedback about results [and lack of participation when developing the research] created barriers to performing research within other marginalized groups [indigenous Australian populations] [11]. Furthermore this lack of involvement led these groups to perceive themselves as passive objects of curiosity for researchers, who were perhaps working out of a sense of academic curiosity or civic duty [11]. A similar situation exists, at least anecdotally, among disabled populations in the ROI prompting them to desire a more active engagement in all levels of research. Indeed contemporary good practice among researchers of marginalized groups [indigenous American populations] [12]; propose that active engagement at *all* stages of the process a key to success.

Success involves moving beyond participation to *ownership* with “participants” becoming co-authors and co-researchers [9,12]. Clear boundaries regarding of ownership of data [including informal conversations] [12] is required, with ownership seen as the service users [or joint], rather than solely belonging to the researchers.

Importantly the emerging key elements of successful participative involvement of marginalized groups are: self-determination (control over involvement in R &D); mediation of socioeconomic impediments (that the R&D would improve their social/economic disadvantage) and a collective vision (a shared vision for change among participants and researchers that strives to make a difference) [12]. Additionally there needs to be equitable involvement of all partners in all phases of the research; mutual benefit of all partners and promotion of co-learning and empowering processes that seek to address social inequalities [13].

A reflective analysis of the effect of these participative R&D approaches that highlight both the arising ethical issues and the unplanned outcomes of service user empowerment now follows. This approach was adopted as the collaboration partners had not designed a research approach in advance of their engagement with one another, but as a consequence of the experience, they identified the need to undertake a retrospective analysis of the outcomes of the experiences.

2 Materials and Methods

2.1 Student Engagement in Critical AT Design

The fundamental concepts of AT design are delivered over a six week period at the 3rd level institute (i.e: Dublin Institute of Technology at undergraduate degree level) comprising six hours of small group teaching delivered to engineering students. The learning outcome for this portion of the module is the development of an AT device concept through engagement with front line disability service providers and individuals using those services. The availability of small student groups permitted a manageable site visit to *Enable Ireland*. Enable Ireland supports individuals with physical and multiple disabilities. Its AT training service aims to match clients to appropriate AT products and it also provide a training service to staff to assist them in supporting, developing and modifying AT devices to meet end users’ needs.

The student cohort (n=30) engage in a two-hour site visit to *Enable Ireland*’s AT training service in Dublin. AT Users make summary presentations of what they perceive to be ‘the good, the bad and the ugly’ regarding their current and past assistive technology experiences. Gaps are jointly identified [by students and service users] with a view to developing new product design concepts, which are later outlined and developed by the students and subsequently presented back to the group at the end of the semester. AT users are active participants in the evaluation committee which reviews each student project presentation. To date a total of over 120 AT Product Design concepts have been generated via this collaborative process, and range from: a text to speech smart phone app to enable an individual with a visual impairment to have food product ingredients read aloud; an accessible pill dispenser, an alternative mouse which moulds its shape to the user’s hand and a device to enable a wheelchair user to push a baby buggy independently.

2.2 Designing a Framework for User Involvement in AT Product Design

Arising from these aforementioned initiatives, Engineering Academic staff developed a proposal that ultimately formed the basis of PhD study. This concerns the generation of a framework for user-centred assistive technology (AT) hardware design through the development of a computer input device. Adults with physical disabilities (motor-impairments) are involved in participatory design workshops as part of this study. All participants use assistive devices for computer access. So far, participants have included service users of two AT service provider organisations. Four workshops were planned to facilitate different stages involved in the product design process: concept generation, concept development, prototype development and prototype evaluation. Each design workshop was structured as three sessions: an initial introduction, a design session, and an evaluation.

3 Findings

3.1 Self-Determination

Both facets of this initiative described above required ethical approval and/or relevant access permission. All elements of the participatory research approaches complied with specific ethical principles of consent. Participants in both aspects of this user-driven initiative were actively involved in the concept development and design process. They reported feeling empowered, felt part of the research and believed that they were able to provide a meaningful contribution that would ultimately make a difference in practice. This feedback was gathered during annual focus group meetings at the end of each academic year, which consisted of 3 young adults with disabilities offering summary reports of their experience collaborating with product design students. The data was not gathered formally during the first three years, but simply noted anecdotally. During the academic year 2012-2013, the following findings were reported and collated:

2 of the 3 students involved reported that as a result of their collaboration, they had revised their Person Centred Plans to accommodate a new personal goal of pursuing further education. The word ‘empowered’ was used by one to describe the positive nature of her experience, being consulted as an ‘expert AT user’, and how this had led her to revise her own view of her skill sets. She reported that previously she would not have considered her AT user experience to be particularly valid, but that now, she saw that it represented a unique skill set which could be further harnessed to enable her to access further education. Another participant reported that this collaboration raised his confidence in his own training abilities and he has subsequently actively pursued further AT training opportunities both within Enable Ireland and with other educational partners. A third participant reported particular satisfaction that her ideas regarding new AT product development were being taken seriously and were not considered by the students to be ‘hare brained’. She appreciated being taken seriously, and reported that she appreciated being treated as a peer, and understood in a holistic sense rather than being treated simply as an AT user. In summary, this third participant reported that she felt this collaboration with product design students became a springboard to acceptance of difference, which went beyond the original aim of the project. She also reported that she felt she was not just consulted, but that she ‘led’ the process. She initiated many

questions with the students and recognised her teaching role with them. Finally, she also reported that she felt the experience further strengthened her own resolve to pursue a career opportunity in Assistive Technology. (She was already enrolled in a Social Science degree programme prior to her collaboration with the Product Design Students.)

Limitations of this research centre on the relatively small cohort of AT users involved (on average 3 per year, over 4 years), and the close working relationship established between the users and service provider, which may have led participants to feel that they should report positively on the experience. Increasing the cohort in both size and diversity (eg: inviting individuals without any service provider affiliation to participate) in future years will also assist in gathering more comprehensive data on the impact of this kind of collaborative research.

Notwithstanding the limited cohort of AT users, this project reflects positive outcomes which extended beyond what was anticipated at the start of the process. It will be necessary to address our data gathering approaches in more detail for future participants so that we can learn further from both a qualitative and quantitative analysis of their views both pre-and post-collaboration.

3.2 Co-Learning and Empowering Process That Attends to Social Inequalities

In, *Designing a framework for user involvement in AT Product Design* information leaflets and presentations have been provided indicating provisional findings. Both of these reflected the results of shared learning and shared goals and aspirations of both students and service users. Given the engineering design nature of both aspects of this collaborative initiative, and the fact that participants had an active input to designs [by virtue of the participative approach], the ultimate emerging designs serve to challenge disadvantage as they developed a collective vision of future designs that will not only help with day-to-day living, but will ultimately empower people with disabilities to overcome structural disadvantages in the environment.

4 Conclusions

Participative designs R&D are powerful tools for engaging positively with individuals with disability. While researchers and those working and researching in disability services are mindful of ethical issues; tokenistic approaches to R&D are common. Parallels with research in indigenous communities would suggest that the aforementioned approach may potentially result in opposition to the conduct of research. It is clear that an awareness of the potential power differential between researchers and service users is required, and that participative research should seek to address these differences. Disability R &D can be improved and enhanced by greater service user self-determination in research (including involvement in design and dissemination) and the development of projects that focus on a shared vision for disability (one that empowers service users and serves to address social exclusion).

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-810

What can we learn from Ankle Foot Orthosis users Satisfaction?

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Abstract. The purpose of this study was to answer the question what influences consumer satisfaction and how satisfaction is associated with use or non-use of the Ankle Foot Orthosis (AFO). For this goal an specially designed “Design in Orthopaedic Engineering Questionnaire for Usability Evaluation of Orthoses” (DOE-quest) was used to answer whether the results of a subjective device evaluation correlates with or rules out the person’s expectations of this device. The questionnaire was sent to 500 AFO users (consumers), randomly selected by choosing an AFO user name every 10 subsequent names from the database of five participating Prosthetics and Orthotics companies, (P&O). The five P&O companies were selected from all over the Netherlands. Descriptive statistics were used to describe the consumer characteristics. Chi-square tests were used to describe the association between safety, durability, ease of use, comfort and effectiveness and variables of process satisfaction (delivery, maintenance, professionalism, delivery follow up, services in general).T- tests were performed to indicate whether variables met the Pareto principle. To determine the strength of linear dependence between satisfaction on the one hand and health related characteristics and AFO use on the other hand, Pearson product-moment correlation coefficients were calculated. In total 123 males and 87 females, a 44% response rate, who have a prescribed AFO for three months or longer completed the questionnaire. The distribution in types of orthosis was in favour of custom made, 85.1% and 14.9% off the shelf. EQ-5D scores (N=190) were between 0 and 1 (M= .71; SD= .22) reflecting a representative group of the whole range of the client population with light to severe health problems. Diagnoses leading to the AFO prescription were widespread. In general, 74.8% of prescribed OD’s were considered satisfactory. Some personal characteristics appeared to be of great importance to AFO satisfaction and use. The delivery process was the only variable that met the 80% Pareto principle on all personal characteristics. In general, orthosis safety and comfort did not meet the Pareto principle of satisfaction. Females were less satisfied on orthosis comfort (p= .0001) and professionalism (p= .012) compared to males. Innovative insights were gained related to off the shelf and custom made orthosis. The numerous additional comments made in the questionnaire indicate that improvements in AFO design and evaluation process start with a better evaluation and check of the fitting and comfort of the AFO. If the fitting and comfort of the AFO is optimal, the use of the AFO can be expected to be highly frequent as well. The results of this study can be used to pinpoint aspects which are important in the design process of OD’s: -Standard AFO evaluation after a week, three months and a year follow up, -More attention in training new prosthetic and orthotic staff regarding the evaluation process in enlarging awareness of the importance in querying the consumer.

Keywords. Ankle Foot Orthosis, Orthopaedic Device, Assistive Technology, Satisfaction, Personal Characteristics, Questionnaire.

Introduction, R &D Idea: Research Objectives

Although several instruments currently exist to measure consumer satisfaction and

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acceptance of rehabilitation aids or pain associated with the orthopaedic devices (OD), none of the questionnaires quantifies consumer satisfaction, satisfaction about the delivery process and use or non-use together.

The purpose of this study was to answer the question: what influences consumer satisfaction and how does satisfaction predict use or non-use of the Ankle Foot Orthosis (AFO)?

1 State of the Art in this Area

Non-use of prescribed assistive aids leads to a decrease in quality of life by a decrease in activities and participation [1-2]. Recent studies on the use and non-use of orthoses show differences between different types of orthoses. Where a large percentage of non-use varying from 8 to 75% was seen by Jannink [3] in relation to orthopaedic custom shoes, the usage of functional wrist orthoses in patients with rheumatoid arthritis was only 48% [4]. Although an overall rating of 8.1 (scale 0-10, higher figure indicating better satisfaction) satisfaction on orthoses was measured, a number of serious deficiencies in worker performance was reported. Bosman et al. therefore recommended to continue the focus on consumer satisfaction to improve the quality of P&O services in daily practice [5-6].

Satisfaction is a subjective concept and very much depends on the user. It can be defined as the experienced comfort and acceptation of the use of the AFO. Satisfaction can be measured with respect to orthosis characteristics but is also related to the process of design and delivery of an orthosis [5,7].

A specially designed "Design in Orthopaedic Engineering Questionnaire for Usability Evaluation of Orthoses" (DOE-quest) for this goal was used to answer whether the results of a subjective device evaluation correlates with or rules out the persons expectations of this device [8].

2 Methodology Used

2.1 Participants

A DOE-quest questionnaire was sent to 500 AFO users, randomly selected by choosing an AFO user name from every 10 subsequent names out of the database of five participating orthopaedic companies [8]. The five P&O companies were selected from all over the Netherlands.

2.2 Material / Questionnaire

A 83 items DOE-questionnaire [8] consisting five scales was developed (for this purpose?) (a) Consumer related characteristics (32 items); (b) Characteristics of the orthoses (55 items); (c) Environmental characteristics (6 items); (d) Delivery process (2 items) and (e) General health (The EQ-5D), 5 items. Items consist of two or more applicable options (categorical variables) or a five point Likert scale. Ten items representing the severity and importance of limitations were scored on a 10 cm visual analogue scale. Participants were able to provide additional information with respect to the AFO in a blank comment field. Respondents were asked to name 3 items of which they think that improvements could be made on the AFO.

2.3 Data Analysis

I) Personal Characteristics and Satisfaction. Descriptive statistics were performed to describe the consumer characteristics. Chi-square tests were used to describe the relation between (safety, durability, ease of use, comfort and effectiveness) and variables of process satisfaction (delivery, maintenance, professionalism, delivery follow up, services in general).T tests were performed to indicate whether variables met the Pareto principle.

II) Bivariate Correlations. To determine the strength of linear dependence between satisfaction on the one hand and health related characteristics and AFO use on the other hand, Pearson product-moment correlation coefficients were calculated.

III) Factor Analysis. To describe the variability among observed, correlated variables in terms of a potentially lower number of unobserved factors, a factor analysis was performed to search for joint variations in response to unobserved latent variables. The information gained about the interdependencies between observed variables will be used to reduce the set of predictive variables to satisfaction.

IV) Collection of Additional Comments. Comments made by the AFO users in the blank fields were used to describe additional requirements and recommendations of interest in AFO design.

3 Results

3.1 Participants

I a: General characteristics. In total 123 males and 87 females,(44% response rate)with a prescribed OD for three months or longer, completed the questionnaire (mean age 48.8; SD 25.0). The distribution in types of orthosis was in favour of custom made, 131 (85.1%) custom made and 23 (14.9%) off the shelf. EQ5D scores (N=190) were between 0 and 1 (mean score .71; SD .22) reflecting group representative for the range of the client population with light to severe health problems. Diagnoses resulting in AFO prescription were widespread, e.g. cerebro vascular accident, cerebral palsy, multiple sclerosis, hernia, bone spur, et cetera. In general, 74.8% of prescribed OD's led to satisfaction. Some personal characteristics appeared to be of great importance to AFO satisfaction and use.

I b: Satisfaction. The delivery process was the only variable that met the 80% Pareto principle on all personal characteristics. In general, orthosis safety and comfort did not meet the Pareto principle of satisfaction. Females were less satisfied on orthosis comfort ($p= .0001$) and professionalism ($p= .012$) compared to males. Innovative insights were gained related to off the shelf and custom made orthosis.

II: Bivariate correlations. The non-use of the AFO was positively correlated to AFO dissatisfaction in general (p .001 ; $r = .229$). Further detailed results on the effect of pain and stability while wearing the AFO will be presented in the presentation.

III: Factor analysis. At the moment of writing this abstract the factor analysis data is not fully completed. Two factors that predict satisfaction and AFO use will be presented in the presentation.

IV: Additional comments. Remarks mentioned in the blank fields of the questionnaire, in order of frequency, indicated that improvement of fitting and fitting of the orthosis in the shoe, looks, comfort, lacing, transpiration, used material, evaluation, dimensions, weight, adjustment possibilities, functionality, chafing, hygiene, don-doffing, damage to clothing, visibility need more attention according to AFO users.

4 Impact or Contributions to the Field, Discussion

In this abstract satisfaction of the OD users and factors influencing product satisfaction and manufacturing process they are not satisfied about are addressed. In general 74.8% of OD users claims to be satisfied about their OD. Although this is a high percentage 25.2% is not or not fully/ sufficiently satisfied about the OD, the manufacturing and delivery process. Consequences of dissatisfaction in functioning of patients are large, beceause it means extra financial costs or non-use of the OD. Dissatisfaction in custom made OD is considerably higher compared to the of the shelf product. This can be explained due to the fact that custom made OD's are used in special conditions and or severe cases.

The numerous additional comments (161) made in the questionnaire indicate that improvements in AFO design and evaluation process starts with a better evaluation and check of the fitting and comfort of the AFO. If the fitting and comfort of the AFO is optimal the use of the AFO can be expected to be highly frequent as well.

5 Conclusions and Planned Activities

The purpose of this study was to answer the question: How do personal or device related characteristics influence consumer satisfaction and use of an AFO? Based on our results the percentage of use is rather high. However still 1 out of 10 is not using their AFO. The percentage of dissatisfied AFO users is 25.2%. Further factor analysis will be performed to identify correlated variables. Consumer participation in the fitting process and evaluation process can increase AFO satisfaction. The results of this study can be used to pinpoint aspects which are important in the design process of OD's:

- Standard AFO evaluation after a week, there months and a year follow up,
- More attention in training new prosthetic and orthotic staff regarding the evaluation process in enlarging awareness of the importance in querying questioning the consumer.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-815

User Centered Design in Practice – Developing Software with/ for People with Cognitive and Intellectual Disabilities

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Abstract. This paper describes a formative evaluation conducted during the Knoffit software project with people with intellectual and cognitive impairments. Within the project, a User Centered Design is not only used as research method but it is also connected to be the project's central aim: People with intellectual and cognitive disabilities as the main future users of the software are included in the project as testers for evaluating the currently available software prototype. Based on their feedback on the prototype the software will be re-designed and again tested iteratively. In addition to the evaluation description the paper presents gained results.

Keywords. User Centered Design, Software development, Intellectual and Cognitive Disability.

1 Background

Web content is regularly not accessible respectively understandable to people with intellectual or cognitive disabilities. Typical accessibility problems are hard words, abstract writing, complex sentences and long and nested paragraphs.

The project "Knoffit" proposes a new approach to encounter these understandability problems in web content. It is based on user generated content appearing as multimedia explanations or easier to understand alternative content for complex words or sentences. The approach is described in more detail in [1].

The existing prototype is tested with potential future users to fulfill the project's central approach that is a "User Centered Design" as it is described in [2]. This method ensures that the developed software's functionality meets the users' requirements. Within the dialogue between developers and future users the product is iteratively improved until a sufficient result is achieved. This paper describes on the one hand how this procedure is applied among the project's target group of people with cognitive and intellectual disabilities. On the other hand first results of the software evaluation are presented and a short outlook is given.

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2 The Evaluation Process

2.1 Motivation

A central research approach of the described project is to follow a User Centered Design process for the intended software product. This includes involving the glossary's potential future users with cognitive and intellectual disabilities into the software development process. Initial considerations together with professionals led to the decision to start the collaboration after a first prototype of the planned service was constructed. This approach was intended to avoid possible misunderstandings on the users' side resulting from an only abstract "idea" instead of a real existing and usable software tool.

Hence, the software development was split into two specific phases. In the first step the software prototype was created following a classic software design process [3]. After finishing this first software version it was introduced to the potential future users to let them evaluate it and show possible improvements. In an iterative dialogue between users and developers – forming an evolutionary software design [3, Kap. 20], [4, S. 45] – the software was then continuously improved.

The development of the first prototype followed known recommendations and requirements for designing content for people with cognitive and intellectual disabilities [5], [6]. These include e.g. structured Graphic User Interfaces (GUI) with only little text, easy to read language etc. Though – due to the software's overall complexity -, it could be expected that this first software solution would still contain certain usability problems and room for improvement, which could best be identified by letting the potential future users test it.

2.2 Introduction to Knoffit

The glossary "Knoffit" is designed to improve the understandability of web content. This is especially important for people with cognitive and intellectual disabilities but not limited to these groups. The glossary is based on user generated content dynamically added to the original hard to understand web content. Fig. 1 illustrates the glossary's workflow.

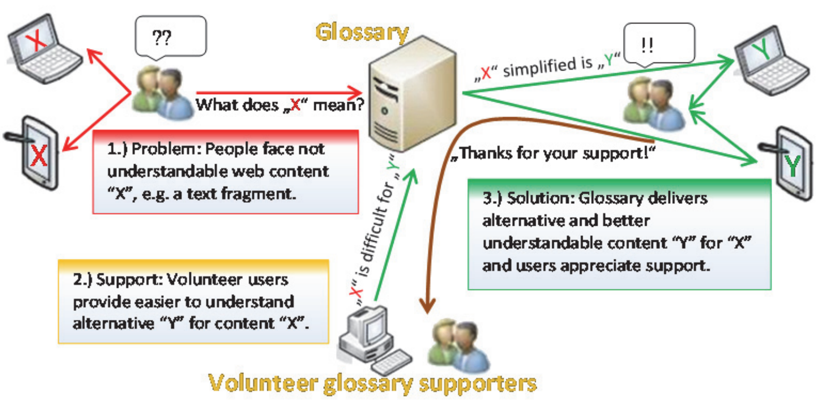

Fig. 1. Basic operation mode of glossary service Knoffit.

First, a user reports a hard to understand web content "X" (e.g. a single term, complex sentence etc.) to the glossary using the glossary add-on for the browser Firefox. Based on this report, volunteer users can react in form of providing easier to understand alternatives or explanations (named "Y" in Fig. 1) for the incomprehensible content "X". They can use different media types for this, including (hyper-) text, pictures, videos and audio recordings. These explanations are stored in the glossary repository. The next time a user accesses the website containing the previously reported hard content, the browser add-on looks up the glossary and enhances the original content with the authored data, resulting hopefully in an improved understanding of the previously incomprehensible content.

However, if the adopted content is still not completely understandable, users have the opportunity to give feedback to the authors of the explanations. For example, they could ask for further information or different media types than the one used within the explanation. In addition the feedback function allows users to thank volunteers for their efforts and to appreciate the explanations.

2.3 Design of the Evaluation

The development accompanying evaluation forming the project's User Centered Design consists of two separate steps: a list of consecutive tasks and an open interview.

The first step of the evaluation is a formative evaluation which is well suited for identifying problems regarding the usability of a product and to gain rapid feedback [7]. Hence, during this part the testers are asked to fulfill 10 different tasks building one upon another. The tasks are designed to address not only all the software components involved (two components on server side and a client application implemented as browser extension), but also the overall functionality offered by the intended glossary service. Among other activities, the testers are asked e.g. to navigate to the glossary website, to create and modify a user account, to create and rate explanations etc. While working on the task list each tester is accompanied by a member of the evaluation team. This person logs the tester's activities while she/he works on the different tasks of the list. Involved staff members are student assistants. They were trained in using the software and provided with guidelines on how to write the protocol and animate the individual partner to "think aloud". By using the "thinking aloud" approach [8] the written protocol contains both perspectives on what is happening on the screen during working on a task: On the one hand the staff member observes the tester's activities during working on a task (e.g. time until a task is completed or "mistakes" the tester makes), forming the observer's view. In addition the tester allows the staff member to log the tester's perspective, too, by verbalizing her/his intentions, feelings and problem solving strategies while working on a task.

After the testers have finished the task list, they are asked about their opinions on the software and possible improvements they can imagine. This happens as an open interview that is recorded and afterwards transliterated. This second part of the evaluation allows the testers to give general feedback about their experience when working with the software without being bounded to a certain task. Hence, issues not (completely) addressed within the previous formative evaluation respectively the 10 accomplished tasks may be discussed between testers and developers.

2.4 Conducting the Evaluation/Population

Different caring organizations were contacted for asking their clients to participate in the evaluation. These organizations include "Bethel vor Ort"[2], "Lebenshilfe"[3] and the computer lab/club "PIKSL"[4] ("person centered interaction and communication for self-determined living") in Germany and "Daelzicht"[5] in the Netherlands. They consist of different caring and education institutions for people with cognitive and intellectual disabilities, e.g. computer courses/rooms, sheltered workshops, vocational training units and residential homes.

In total 25 testers from the age of 19 till 49 were involved in testing the first prototype. The testers showed different variants of intellectual and cognitive disabilities, including autism and different degrees of learning disabilities. All testers had at least basic reading skills and they were experienced in using the Internet and the computer in general. These requirements for testers were defined prior the test and the care institutions chose the testers for the evaluation.

Though the general testing procedure with a formative evaluation and an open discussion part was identical during all performed tests, some certain aspects varied. One of these aspects is the number of people testing the software in parallel: Several testers preferred testing the software individually with only one staff member at their side; especially to avoid distraction by other testers. Other test persons rather liked the idea to test the software in a group and thus some tests were conducted in groups of two and up to seven testers in one room each accompanied by one observing staff member. In addition the test location varied: While some of the residential homes and sheltered workshops were equipped with PC work/ training rooms, others were not. Hence, where necessary, the tests were conducted in PC labs at the university or other institutions of the particular organization. Although the actual testing scenarios differed from each other, the results are yet comparable and usable to further improving the currently existing prototype.

3 Results from the Evaluation Process – Lessons Learned

As expected, interaction with potential future users showed many and various aspects of possible improvements. During the analysis of the protocols and transcripts from the audio recordings a "to do list" for the three different components of the software system could be aggregated. These three main components are 1) the glossary server component, 2) the social networking component of the website and 3) the glossary client (extension for Firefox), where actually most usability problems occurred during the testing.

3.1 Website – Glossary Server Component

Two major problem fields could be identified during testing the glossary server component: The first one – usage of incomprehensible terms and words – appeared in

[2]Homepage of Bethel: http://www.bethel.de/ (last access: 2013-03-27)
[3]Homepage of Lebenshilfe: http://www.lebenshilfe.de (last access: 2013-03-27)
[4]Homepage of PIKSL: http://www.piksl.net (last access: 2013-03-27)
[5]Homepage of Daelzicht: http://www.daelzicht.nl (last access: 2013-03-27)

all analyzed software components, not only in the glossary server component. The other identified problem was the usage of unclear icons/symbols. Especially during the process of explanation authoring the testers were regularly irritated by the icons used (see Fig. 2). The applied arrow icons were intended to support authors during the three steps of creating an explanation analog to comparable software assistants (right arrow: forward/next step, left arrow: backward/previous step). The testers remarkably often had no imagination of the arrows' meaning and expected ordinary "submit" buttons instead.

Fig. 2. Arrow icons during the process of explanation authoring.

Apart from this fact, the authoring process for creating explanations was understandable and usable for most of the testers. Most subjects simply tried to write an explanation. But a few of the testers also wanted to create multimedia metadata, e.g. by recording themselves speaking an explanation aloud, linking a YouTube video or by uploading a descriptive image. Independently of the used media type the testers were able to operate the particular implemented software (e.g. Flash Plugin for recording audio explanations) without any or major help by their observing partner.

In addition the testers had no remarkable problems in navigating the website with its different sections and the glossary with its three elements (glossary start page with a list of recently received requests and added explanations (1), list of difficult words (2) and the list of available explanations in the glossary (3)). Almost all testers were able to navigate on the service's website autonomously without external help.

3.2 Website – Social Network

Certain words and expressions were unclear to the testers in all of the investigated software components. This includes the social networking component on the service's website as well. Especially the registration process showed some hard to understand vocabulary and hence, the testers were unsure what information they were asked to give. Most of the testers had problems to differentiate between "Name" and "Username". Regularly they did not know what a "username" may be and needed help to fill in the information.

In addition some users had problems to understand the difference between login and registration: Many users immediately tried to provide their account data when they saw the login field on the website, though they had no account at that point of the software test and had no login data (neither username nor password). When their observing partners explained them the necessity of register first, most of the testers had problems to find the registration dialogue. Due to their limited speed in filling in the required data into the registration form, the session of some testers expired. Hence, they had to fill in the information again, which was frustrating for them. Summarized, it could be observed that most of the testers would not be able to create an account for the glossary platform without external help and that there is need for significant modifications in the registration process.

Fig. 3. Social network homepage.

Once the testers had created an account most of them had no major problems in operating the social networking functions. They were asked to friend up with different other users, provide a profile picture, to write and send each other messages etc. Most of the testers were able to fulfill these tasks without external help and effort because they were already familiar with this functionality from other comparable networks (especially Facebook). Some of the testers expressed that they like the idea of a social network that addresses the specific needs of people with intellectual and cognitive disability. The network was also noticed as "valuable extension" of the basic glossary service and it "was fun to use it".

3.3 Glossary Firefox Extension

The final group of usability problems is located in the glossary client, implemented as extension for the browser Firefox. In addition to unclear wording the browser plugin showed several further problems for the testers. First of all the users had problems with downloading and installing the software. Many users could not find the download link (button in top right corner of Fig. 3) or felt insecure by the various warning and information messages appearing in Firefox when installing the add-on.

Even when the installation was successful, the testers faced further problems with the software. Several glossary functions are only available for authenticated users to avoid abuse and spam. The glossary client therefore consists of a settings dialogue (see Fig. 4) where users can set certain preferences, e.g. their login data, the media types of explanations etc. When the testers were asked to modify these settings, most of them were confused. They were not familiar with modifying any software settings and could not find the preferences dialogue.

In addition it was quite hard for the users to find the glossary client's control elements and to notice modifications applied to the website when an explanation is embedded into it. Many testers did not perceive the inserted hyperlinks at all, though they were indicated by a leading Knoffit icon and a formatting typically for hyperlinks (bold and underlined).

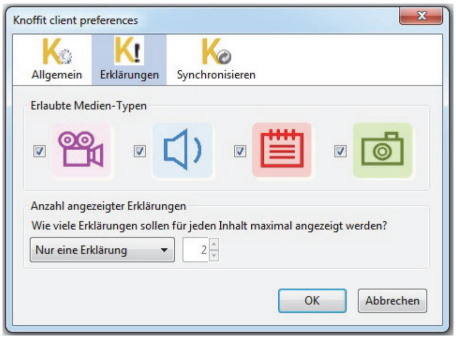

Fig. 4. Knoffit Client preferences dialogue.

However, most of the users who noticed the inserted links, intuitively interpreted them as such, and hence used them in the familiar way. When clicking the link they were able to let the explanation(s) appear respectively disappear. The functionality and dialogue for rating an explanation was usable and understandable for the testers as well.

3.4 Discussion

The evaluation showed several problems regarding the usability and understandability of each of the individual software components. Most of the identified problems can be solved with only moderate effort, e.g. dialogue messages with unclear words. On the other hand some problems require more research to apply appropriate solutions. This includes for example an easier to find registration dialogue and a clearer communication to the user that something has changed on the website when explanations have been embedded. Some of the testers proposed help videos (screencasts) visualizing how to use the software.

An interesting fact is, that the glossary client (Firefox plugin) appeared to be the most difficult to use part of all involved software components. However, the client's development followed the same recommendations for designing accessible (web) applications as for the website components (glossary server and social network). It may be argued that this is a consequence of the testers' profound experience in using a browser (navigating on websites) and their limited experience in using other standalone software on their PC. There is the need for further investigation to support this assumption.

4 Conclusions and Outlook

The User Centered Design approach is a source for valuable information of how to iteratively design a final product. The project shows that this approach is applicable to the specific target user group of people with cognitive and intellectual disabilities. However, a major issue of this approach is the time that needs to be invested to receive the users' feedback by tests. This includes not only conducting the user test itself, which demanded in average approximately 2.5 hours per tester in this project. In addition the protocols and audio recordings need to be analyzed and aggregated afterwards, which again lasted several hours per tester within this project. The involved testers formed a heterogeneous group: While some of them were very experienced in using the computer and surfing the internet others were not and therefore needed support from their partners more often. In addition the testers “thought aloud with different degrees of loudness”: Most of the testers had no problem with thinking aloud and to verbalize their thoughts, feelings and intentions. A few testers, though, needed to be remembered to talk to their test staff partner regularly.

Despite these efforts, the evaluation showed the value of user integration during the development of a product. It was impressive how many different and creative solutions were proposed by the testers and discussed with the test staff members. These ideas include optical design issues, proposals to improve the software’s usability etc. In the next development iteration these ideas and the identified problems will be addressed and another test will be conducted to evaluate the resulting software version.

After finishing the software development, a final evaluation will be conducted to analyze the glossary’s impact on the users’ text understanding. The concrete evaluation method is part of further research activities and not yet available.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-823

Attachment to Assistive Technology: A New Conceptualisation

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Abstract. How people use assistive technologies depends on how they relate to them. As technologies such as assistive robots are developed—that have a physical presence, some autonomy, and the ability to adapt and communicate—the relationships that people have with them will become more complex and may take on some of the characteristics of the social relationships that we have with each other. In this paper, we compare the relationships that people form with assistive devices to the bonds we develop with people, pets, and objects. Building on conceptual frameworks provided by social psychology we aim to develop a taxonomy that can provide a consistent framework with which to describe and analyse human-other relationships, hopefully leading to improved design of assistive technologies.

Keywords. Assistive Robot, Attachment Theory, Affective Response, User Perspective.

Introduction

People form relationships with assistive technology that are complex and multi-faceted, with the potential to be either beneficial or harmful to their long-term welfare. Here we focus on assistive robots—devices with some autonomy and physical presence that are capable of interacting socially with people, and therefore can be expected to elicit significant emotional responses. Using ideas from social psychology, particularly "attachment theory" [1], we aim to develop a taxonomy with which to describe and analyse the bonds people form with technologies such as assistive robots, hopefully leading to more user-appropriate design of these devices. We also intend this taxonomy to support the development of objective measures for describing human-robot (HR) interactions and for estimating the nature and strength of HR affective relationships.

This paper marks the beginning of a three-year research project which seeks to develop an objectively measureable taxonomy of HR bonds. One practical application driving the project is how the taxonomy will be implemented to address the, as yet unclear, question of what levels of attachment/social bonds between people and robots might be optimal in different contexts. To illustrate the application of our taxonomy to such a question, consider the following two problems.

Firstly, in an educational setting, what is the optimal level of attachment that a child might require of the robot 'half' of its learning dyad from which to learn most effectively? In drawing from attachment theory, [1, 2], we can begin to tackle this problem by understanding that in order for an individual's capacity for exploration and mastery of their environment to be activated, their attachment needs must be satisfied.

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As learning is more than providing instruction but also taking care of a social environment where peers can instruct each other [3], care must be taken that robotic teaching interventions promote social bonding between actors, or at least do not break them. Given the likely novelty of the robot to the participants who will interact with it, an educational robotic assistive device must be designed with the capacity to facilitate felt security, for instance by being non-threatening, friendly, and quickly resolving its inherent strangeness (for example, by addressing and joking about being a robot) in order to maximise participants' capacity to explore and to learn. Clearly, if the nature of attachment within such a dyad is to be managed, a set of tools for characterising HR attachment are a requirement – our taxonomy is intended to provide this.

Secondly in the context of a care setting we might ask, what optimal social bond between a human and a robotic assistant would lead to the most favourable rehabilitative outcome? In order to address such a question it is, again, self-evident that tools for the analysis of HR bonds are a necessity. To motivate the development of our taxonomy in this setting consider the common problem of loneliness amongst elderly residents in long-term care facilities (LTCF). One approach to this problem has been to investigate whether social robots could provide an 'easy-care' version of animal therapy which would not require attendance to the biological needs of a living animal [4]. For instance, Banks et al. [4] compared a robot dog (the AIBO) with a real live dog and found that both robot and dog interactions significantly reduced loneliness levels in LTCF residents. Further, scores of "general attachment" on the Lexington Attachment to Pets Scale did not differ between the dog and AIBO groups (*Dog: 25.5 ± 1.4, AIBO: 23.1 ± 1.6, maximal score 30*). Banks et al. concluded that future widespread use of robotics in geriatric facilities is feasible. However, this raises the question of whether it is it desirable for bonding to occur between people and robots, and, if it is, what is the appropriate level of bonding in any given context? Answering such questions, we believe, requires a new conceptualisation of HR relationships.

Robots are not alive as humans and animals are, and yet they have capacities for interaction and appearing 'alive' far beyond those of inanimate objects. As such, our proposed conceptualisation of HR bonds draws from three distinct bodies of literature: the bonds humans have with humans; the bonds humans have with animals; and the bonds humans feel towards objects.

1 Human-other Bonds

Human-human Bonds. Psychologists have identified a variety of forms of affective human-human bonds [5]. An important example class of these are the long-standing close emotional ties, known as "attachments", that have been analysed by attachment theory [1]. Attachments are thought to be driven by a behavioral system that is common across all mammals, and evolutionarily programmed to keep infants close to their caregivers and safe from harm. As assistive technology and social robots become more advanced, the likelihood becomes greater that people will form attachment-like bonds to those technologies which provide care. Recent developments that aim to place robots in caregiving and educational tasks, in particular amongst elderly and child populations, have therefore led ethicists to highlight potential issues with humans becoming attached to robots [6]. But what would complete attachment to a robot constitute? Hazan & Zeifman [5] identify four hallmarks of human-human attachment relationships:

i) Proximity seeking – the attached individual preferentially seeks out proximity to the attachment figure, and where possible, will choose to spend time with them.
ii) Separation distress – the attached individual is distressed at the prospect of, or in the event of, prolonged or permanent separation from their attachment figure.
iii) Safe haven – the attached individual turns to the attachment figure for comfort or support in times of stress, for example when threatened.
iv) Secure base – the attached individual's knowledge that their attachment figure is available (if needed) enables them to explore and master their environment.

It is difficult to imagine a bond with a robot fulfilling these criteria today, mainly because the state of the art in social robotics is not yet up to the challenge of producing a sufficiently convincing personality with which to have this kind of relationship. But perhaps robots could partially fulfill these criteria. For example, research into autism therapy has shown that interactive robots can mimic interaction games between infants and caretakers [7] that play an important role in the development of human social cognition and communication, and could thus elicit some attachment-like responses. Hazan & Zeifman's hallmarks could therefore provide a useful touchstone for social robotics to calibrate itself against even if designing robots to meet all four criteria would currently be problematic.

Human-animal Bonds. In analysing assistive robots, drawing on the human-animal bond literature is perhaps more helpful than drawing on studies of human-human relationships since animals and robots share some interesting similarities. For instance, animals, like assistive robots, are often owned by humans, and yet are also more interactive than most possessions.

Human-animal bonds have been examined as attachments, utilising attachment theory to explore human relationships with pets, although these relationships tend to be based on different working models to those with humans [8]. Other researchers have discussed "attachments" to pets, but without using the term "attachment" in the technical sense defined by attachment theory (i.e. as an evolutionarily-driven emotional tie to a caregiver) [9]. This inconsistent use of "attachment" within the bonding literature is potentially confusing and HR relationships might be misconstrued if the term "attachment" is applied loosely. Here, therefore we reserve this term for relationships which feature all of Hazan & Zeifman's four hallmarks.

Human-object Bonds. The emotional ties that people have with favourite or sentimental items, is another area in which the word "attachment" is often used in a non-technical and potentially confusing way. Strictly speaking, bonds to objects cannot feature the four hallmarks of attachment since, as defined in the literature at least, attachment is a tie that exists between two minds.

In practical terms some researchers of human-object bonds have overcome this issue of whether the object, or animal, to which a person has an attachment must also have feelings if the relationship is to emulate a human-human attachment style interaction, by re-interpreting classic attachment theory within human-non-human bonding interactions. For example, by using adult attachment style to predict levels of attachment feeling towards possessions, as in [10], or, in the case of human-animal attachment research, by proposing models of attachment which feature some – but not all - of the classic hallmarks of human-human attachment [11]. However, with respect to translating this literature to human-robot bonds it is important to note the existence of a further issue, discussed by Sparrow & Sparrow [12], as to whether it is ethical to simulate human-like responses and bonding in a robot companion, which is not simply an inanimate object (specifically, would such a simulation represent an unethical deceit of a human user?). Addressing this question will be an important consideration over the course of our research project, however, for now, the development of our taxonomy will follow an approach similar to that of Carr et al. [11] who discuss attachment theory as it relates to human-animal bonds. They consider such bonds as unable to feature all the hallmarks of classic attachment as defined by Hazan & Zeifman [5]. We agree that this is also true in a discussion of human-object bonds, and in turn human-robot bonds. Our aim here is rather to draw on the existing literature to expand a model of where along a spectrum of bonds various human-robot interactions may lie, and in relation to those bonds formed between humans and other agents of interaction. With this in mind we can see that the literature on object ownership does indeed offer an interesting insight into the nature of bonds that people might form with assistive devices, positing, for instance, that bonding with an object serves functions related to extension of the self, and coherence in self-narrative [13, 14].

It is also worth noting that bonds to objects are often linked to attachment relationships with other people, and can therefore become imbued with attachment-like qualities. Weller et al. [15] utilise attachment theory to discuss a person's strength of bond to a mobile phone as a predictor of phone use while driving. Here the phone represents access to attachment figures, and as such may fall within a grey area between attachment relationships and object bonding. This highlights the difference between the attachment that an individual has to the people they access via their phone, and the relationship that the individual has *with* their phone (as the facilitator of their attachment behaviour). Arguably, the object's role in the attachment relationship is integral to the individual's feelings towards that object. This is also seen in behaviours such as the holding on to personal mementos when displaced—facilitating continuity of life despite the loss of a home [16]; or the use of inanimate objects to represent an extension of self-personality [17].

Studies of human-object bonds are particularly interesting for the study of HR relationships because of the insight they offer into what we might term *quasi-attachment*—bonding to an object which is associated with an attachment relationship—either through function (the phone enables communication with loved ones) or reminiscence (the object is a memento of an attachment relationship). Social robots may feature both aspects. For example, social care robots might facilitate frail and vulnerable people's contact and communication with their loved ones, whilst endowing a robot with given features of their loved ones could aid smooth interaction (for instance, robots playing recordings of loved ones' voices as reminders/warnings/comfort).

2 Towards a Taxonomy

Drawing from the literature briefly summarised above, we propose that HR bonds could be analysed in terms of their similarities to different types of existing bond with other human, animals, and objects (See Figure 1). Current relationships between humans and assistive robots perhaps have most in common with human-animal bonds, but commonalities with human-object bonds should not be overlooked, and there is the potential to at least mimic some of the features of human-human bonds. For any given device, its exact location within this relational space will depend to a large extent on the context in which it is to be used. In comparison to this framework, recent research in Human-Robot Interaction has tended to occupy one of two extremes. At one end, is the idea of robots as objects towards which attachment and love should be directed, with the possibility that such HR love could be bi-directional [18], and at the other, sits the view that we should see our assistive devices as mere objects of ownership, things with the potential to facilitate human-human social bonds but not to be bonded with [19]. However, as technology, and robot capabilities advance, devices could be developed across the full spectrum outlined here, our framework thus has the potential to underpin the full range of assistive robotic technologies we might expect to encounter in the coming decades.

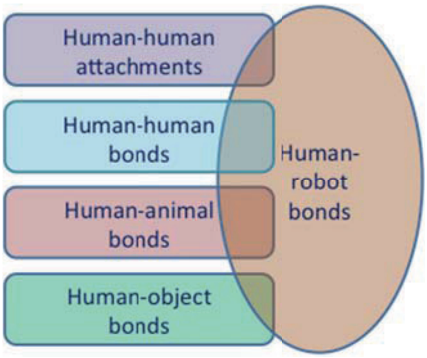

Fig. 1. Proposed model of human-robot bonding.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-829

Frontiers in Context Modelling to Enhance Personalisation of Assistive Technologies

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Abstract. The concept of frontiers as a way to complement the research on user needs and preferences with context-aware capabilities is presented. A frontier is then the fringe of space between two access modes. Several components were implemented in an Android testbed to check the usefulness of the concept in the selection of Assistive Technology enriched with environmental and device related information, that in the coarse grain are able to suggest a change in the access mode that improve the users' performance on their tasks using a smartphone.

Keywords. e-Inclusion, Information on AT, selection of AT, Context-Awareness.

Introduction

Daily live in urban environments tends to force the user to interact with a plethora of machines, everyone with its own User Interface (UI). Most probably even getting into the workplace will involve checking the smartphone in the morning for email and ToDo lists, getting a ticket to the metro or bus in a Ticket Vending Machine (TVM), reading on a tablet while in transit and finally opening the desktop computer when arrived. These tasks have different noise and light conditions, happen in a different moment of time and in a different place with or without people surrounding the user.

Several approaches [2, 3, 4, 5] have addressed the task of improving the interaction between a user and a computer by means of adding knowledge about the surrounding environment. This discipline is usually referred to as Context-Awareness. Every approach use its own definition of context , and though they all agree on using the previous characteristics, not all of them employ the user needs and preferences about the HCI as a source of data on its own. That hinders the possibility of generating personalised UIs. This personalisation is especially important for people with disabilities, as it involves autoactivating Assistive Technologies (AT). A good universal design [1] on the server side plus the correct AT on the client side will allow completing those tasks without the intervention of third persons, providing full accessibility in environments that are not owned by the user.

On the other hand, other approaches [6,7,8,9] have produced fruitful results when adapting the UI to the user needs, whether in automatic or semi-automatic fashion, Nevertheless, in these cases the adaptation of the UI is so focused on the user needs

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[2] Results presented in this paper have been researched within the Cloud4all project. Cloud4all is an R&D project that receives funding from the European Commission under the Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 289016.

that is not uncommon to leave the context reduced to the device that the user is employing, so in some cases the user gets an lesser correct adaptation of the UI if we take into account the environment, e.g.: a user who is partially sighted in a train station purchasing a trip ticket from a TVM with an auditory UI. The high noise power makes it difficult to hear the menu. In this case a visual-magnified GUI with high contrast would work better. The present research aims to bridge the gap between these two approaches, employing the context as part of the sources of data to select the most appropriate AT with the values in its settings that guarantees that the user can interact with the interactive system.

1 Related Work

The research in context-awareness ranges from definitions of concepts to frameworks to applications. This search is focused on the latter, including prototypes. Among the projects coming from the context-awareness discipline Dey [2] assembles all of the previous knowledge on the matter and defines context as "*any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves*". Early prototypes add context into office [3] include detecting who is on the building to send context-aware mail thus avoiding spurious mail in a mailing list and sending automatically the notes of a meeting and the pictures made in the whiteboard to the attendees of that meeting. These research applications are intended to show how context-awareness can be made easier to build, hence not addressing user needs.

In [4] a categorization for context is added, stating that the categories are *individuality, activity, location, time and relations*. It shows a high-order relationship model between entities where a formal 'relation' is defined between two entities sharing time and location. In more general scenarios this modelling allows to talk about 'shared contexts' via 'shift of attention'. On their context-aware applications the problem of not addressing user needs as part of the interaction arises. The Intelligent Advertisement Board [5] consists on a digital signage system installed in e.g.: a train station that thanks to the context-awareness features can display next train departures alongside with time-based advertisements. It shows the special offer for lunch near noon and the dinner options in the late afternoon, or the spectacles for this evening. It also detects the presence of passengers so it changes to a passive mode when nobody is watching. Its narrowcasting mechanism provides value both for the audience and the advertisers. But the totem doesn't know important abilities of the audience currently watching the ads, as the language they speak or their personal needs and preferences about the type of UI. In that case, hardware capable of transmitting both visual and auditory messages exists, but with no mechanism to adapt the content to the current audience.

On the other hand, there are projects that address the personalisation of UI based on needs and preferences, such as [6], but in this case neither the ambient nor the device are the context is not employed as a source of data, so the adaptations are performed on the assumption that the device is under control of the user, not a feasible assumption for public terminals. Some other projects do address the problem of devices, such as [7] where cost functions are used to enhance the UI. The authors define a feature vector that can be optimized according to device capabilities (mobile phone, regular PC...) or personal needs (present all of the options in the same window, use sliders for numerical decisors...) in a cost function. But they don't tackle the part of the context that deals with the environment, namely noise or bad light conditions, so optimisation can be performed on wrong variables in many situations. The INREDIS project [8] changed the approach to the problem of making all the devices accessible into making one device accessible (e.g. a mobile device) and connect it with every other device in the world. It was firstly based upon the Universal Remote Console [9], and lastly upon web services, and made a reasoning system based on ontologies [10] that adapts the UI taking into consideration the user device. This approach also lacked of a complete way to adapt the UI under inconvenient environment conditions.

Context-aware projects are more prone to trigger actions -such as sending an email or recording audio- automatically, while Adaptation to needs projects usually perform only changes to the UI. An ongoing project is a promising solution to solve both problems: The SERENOA project [11] tackles both context-awareness and adaptations to people with disabilities. Their proposal [12] employs Service Front-ends as the controllers to access to many services in the cloud. A future extension of this concept to real-world devices could be extremely useful to enhance device personalisation. Currently, their CARFO ontology deals with context, and they take advantage of designing UIs using a modelling language to have deeper ontological reasoning, with interface abstractions and reifications [13] but it is not oriented towards every device in users' daily lives. SERENOA can be extremely useful for web applications but the extension to any technology seems also necessary. At this point the CLOUD4all approach [14] , focused on taking advantage of embedded ATs, complements the efforts to improve universal personalisation in any device.

2 Definition of Frontiers

Environmental and device data are a source of information to filter the set of feasible UIs before applying a decision. Every UI employs a physical channel and an access mode to transmit a signal in order to send the information to the user. If the channel is jammed with interferences, the signal to noise ratio of the main UI decreases and the user stops receiving information. When a filter is applied to the selection of UIs, the interference and noise [15] may cause that the original information switches its access mode thanks to the selection of the correct AT so the user is still able to receive it. According to [16] access modes are visual, auditory, olfactory, textual and tactile, but the current marketplace of ATs makes unlikely to count on channels different from visual/textual, auditory and haptic/tactile, so those are employed for this proposal.

In order to get the most adequate AT installed and configured in the device the user is interacting with, there is the need of a AT taxonomy according to the access mode the AT employs to deliver the information to the user. A solution is a combination of the AT employed with the settings defined to configure it. Many AT suites aggregate more than one AT (e.g.: zoomtext[3] is both a magnifier and text-to-speech software). In those cases, the AT appears in both access modes but the settings are different hence they appear as two solutions. The starting point for classification is the access mode, so the space of solutions is organized in regions according to the access mode, and the fringe in the space between two different access modes is what we call the frontier between them.

[3] http://www.aisquared.com/zoomtext/more/zoomtext_magnifier_reader/

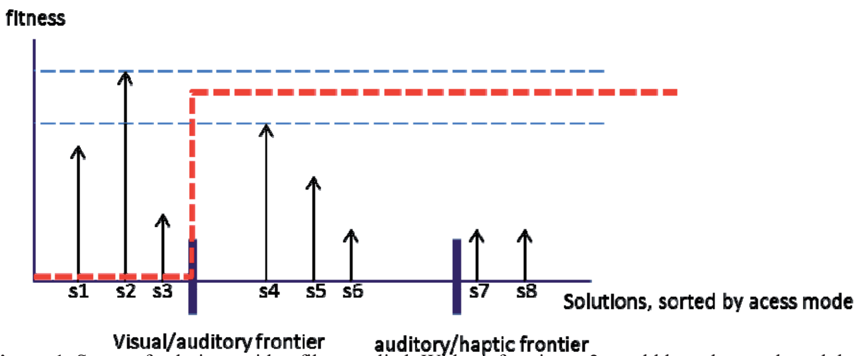

Figure 1. Space of solutions with a filter applied. With no frontiers, s2 would have been selected, but with a filter on the visual/auditory frontier s4 is the final candidate

But every user has a different sensibility to noise and interferences, so the frontiers differ among different users. This is the proposed definition of frontier: a fringe between two clusters in the solutions space of ATs moveable according to the needs and preferences of the user employing a device with different sensibilities to different interference and noise conditions on the access mode.

The way to define the frontiers for every user is twofold: by direct asking (whether filling an online questionnaire or emulating this noise conditions with an installed component) and by inference from settings the user has decided (e.g.: if the user settings include a font size greater than 18pt and high contrast, move the frontier visual/auditory to make the visual cluster smaller and the auditory one bigger). The way to use them is having a component inside the user device that decides the frontiers from the environmental noise, the device capabilities and the current configuration and then sends them to a component in the cloud that uses these frontiers for not exploring the solution space falling outside the frontiers, so despite the fitness of a specific solution this would not be applied. For Figure1, s2 could be the auditory UI in the aforementioned TVM and s4 the magnified GUI.

3 Methodology

To check the usefulness of our concepts, we have created a testbed in Android 4.1. The software components implied on the testing are:

- Matchmaker (MM): takes the user's preferences, the list of AT's sorted by access mode and the filter on frontiers, and produces a recommendation of a solution in the form of AT and settings. Since it can be the first time that an AT is employed by the current user, it infers the settings of this AT from the ones stated in the previous ATs that the user employed.
- EnvironmentalReporter[4](ER): checks the sensors of the mobile device and sends these data in a format understandable by the rest of the components.
- DeviceReporter [5](DR): checks the capabilities of the device as well as the values of configurable parameters of the device. The static values are checked just once and stored on the memory card.

4 https://github.com/JChaconTechnosite/Cloud4ALL-Enviromental-reporter

- MiniMatchmaker [6](MMM): in order to save network resources and cloud computing time, it receives the data from ER and only sends them to the MM if the difference between the last sent value and the current is greater than a certain threshold. It also defines the sampling periods for the ER with and without noise. If the source of interference still sends the noise it is treated as stationary and the period is stretched again.

The current sensors employed are luminance (dedicated) and acoustic noise (from the microphone). The current capabilities employed for the decision are the size of the screen and the values of brightness and contrast, while the DR sends them all. Our inspiration and future linkage is the CLOUD4all project where the Matchmaker concept is explained thoroughly, both the rule based and the statistical based versions[7]. Our version is a naïve approach integrated into the MMM that recommends the change in visual/auditory frontier without applying cloud computing.

Thanks to being a special employment centre[8] these lab tests were made with users that could employ the prototype as soon as it is delivered. The lab tests had the following setup: 1) two separate devices were held by the user's assistant, one configured with a visual-magnified UI and the other one with an auditory UI. 2) the auditory one was given to the user, and he starts an interaction to get a trip ticket from the UI. 3) the observer switches on a music player with loud volume; when the MMM receives this noise, it produces a speech "switching to visual UI". 4) the assistant switches the mobile with the user, and the user ends the ticket purchase.

The test comprised a generic concept validation questionnaire and specific questions about the perceived usefulness of the solution and the level of satisfaction of the user. One of our main concerns is to make sure that the adaptation capabilities of the system developed does not conflict with Nielsen's first usability heuristic (the user has to be always in control of the interaction), specific questions were asked regarding this issue. One out of three expressed their concern that the system autoadapting without their permission may be annoying, and that changes in the UI should be configured by users.Nevertheless, three users considered the autoadaptation capabilities as useful (mean 4 in a 5-point Likert scale) and considered that, if they can configure the adaptations they may use it in the long term (mean 3.67 in a 5-point Likert scale).

4 Conclusions and Future Work

Whilst the motivation of this research is the CLOUD4all Project, we strongly believe that these components fit on every software system dealing with improving the selection of the UI thanks to information coming from sensors. The concept of frontiers can be employed to treat dimensionality in a problem to find the most appropriate solution, adding user needs for providing the best UI given some sensor values, in that case knowing that the user is blind is the context that helps us not to provide a GUI even if the luminance conditions were indicating that this was the better option [17]. When we connect the testbed to the real CLOUD4all architecture, we will have conditional settings based on environment, delivered from the MM and stored in the

5 https://github.com/JChaconTechnosite/Cloud4All-Device-reporter
6 https://github.com/JChaconTechnosite/Cloud4ALL-MiniMatchMaker
7 http://wiki.gpii.net/index.php/Matchmaking
8 A 70% of us have a disability, http://www.ine.es/en/metodologia/t15/t1530418_en.pdf section 8.12

MMM, and will improve the UI for changes in the environment that don't cross a frontier, as they express rules to react to environment e.g.: when noise power raises by 10% increase speakers volume by 5%. We will also have the opportunity to validate our approach, switching on/off the context modules and comparing user's satisfaction on both options. As an ongoing work some of the authors are involved in the creation of a Context-Aware Server that allows us to have motes as a source of data, adding context information regardless of the hardware of the device the user is employing.

Currently multimodality is assumed to happen as one channel auxiliary to another, but we don't have a solution to recommend a hop from a region to another when the starting region had two channels and the ending region just one. Finally, CLOUD4all shares interest in context-awareness with the SERENOA project, so as long as the CARFO module is delivered some adaptations will be made to the concept of frontier. From the studied approaches we can affirm that the inclusion of context-awareness improves the selection of the best UI for a given interaction. This paper proposes frontiers as an artifact to reduce the complexity of joining both user needs and preferences with context-awareness worlds. At least in the coarse grain the test are promising when switching between access modes, and the nature of ongoing work permits to evolve this concept into a more fine-grained frontier to address the preferences inside the same access mode region.

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Posters

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-837

Touchscreen Interaction of Older Adults: A Literature Review

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Abstract. Several studies investigated different interaction techniques and input devices for older adults using touchscreen. This literature review analyses the population involved, the kind of tasks that were executed, the apparatus, the input techniques, the provided feedback, the collected data and author's findings and their recommendations. As conclusion, this review shows that age-related changes, previous experience with technologies, characteristics of handheld devices and use situations need to be studied.

Keywords. Touchscreen Interaction, Older Adults, Usability, Accessibility.

Introduction

Touchscreen interaction occurs when direct contact is detected on the display screen and the interface can be adapted according to the user's needs[1][26]. It has been used for assistive technologies, healthcare systems, rehabilitation tools and assisted ambient living.

Many studies have been made to increase usability and accessibility of touchscreens for users with disabilities and older adults. Design guidelines and recommendations take into account button size and spacing[11], single-touch or multi-touch[14], interaction with pen or fingers[16], text entry[18], digit input[2], different kinds of feedback[9][27] etc. Clinical-social applications have been developed to help cognitive impaired users and caregivers[10][20]. Additional features have been studied to compensate the lack of tactile feedback helping motor impaired users[3] [31].

The aim of this paper is to review studies about touchscreen interaction of older people in order to identify current state of the art and to point out the limitations of these studies.

1 State of the Art

Literature reviews about touchscreen and older users take into account the advantages and disadvantages of this human-computer interaction (HCI) technique as well as the variety of characteristics of this population[1][26]. Some studies of older adults bring out the evolution of their technology experience and social habits[6][32]. It has also been discussed the difficulties of representing disabilities on HCI research[22] as well as average older individual[32].

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2 Methodology

20 studies about touchscreen interaction of older adults from different authors have been chosen. They were published between 2000 and 2013:

- 7 studies came from the field of HCI (CHI[5][8][31], Int. Journal of HCI[9], BCS-HCI[7], INTERACT[12], GW[25]),
- 4 from accessibility (UAHCI[11][27][29], Univ. Access. Inf. Soc.[28]),
- 4 from handicap (MSIADU[10], ICCHP[14], ACM ASSETS[16][18],
- 2 from ergonomics(Journal of Ergonomics[2], Ergonomics[34]),
- 1 from usability(USAB[19]),
- 1 from computer's science (EICS[15]) and
- 1 from gerontology (The journal of applied gerontology[33]).

Older people interaction with new technologies is becoming a major topic on different fields and the subject of real research of multidisciplinary studies.

All the chosen studies analyse touchscreen interaction on flat touch sensitive display screens. We will describe the population involved, the apparatus, the interaction techniques employed and the tasks.

3 Results

3.1 Population

Older adults from North America, European countries and Asia are represented. There is a big variation in the number of subjects and their ages: from 3 to 85 participants; older adults age 50 to 91 years old.

Users' skills or impairment have been identified before experiment tasks trough questionnaires or measures: vision (8 studies), hearing (3 studies), cognition (4), and hand motor function (7). Different methods were used to measure user's disabilities, as Purdue Pegboard test for manual dexterity[11][16][33], Archimedes spiral drawing[23][31] or 9 holes steadiness test for tremor[16]. Pointing performances were also used to differentiate inter-groups during the experiments[9]. Cognitive skills were evaluated with computer assisted tests[27] or standardized measures[34].

Some aspects of subjects' background were taken into consideration as predictors of performance on interaction tasks and subject's attitudes towards new technologies. Subjects were interviewed about years of education, reading skills, professional activities and attitudes towards computers[5][28]. Some studies take into account the incidence of other health problems in older adult's population, including chronic diseases as diabetes [19] or arthritis[33].

Previous experience with touchscreen devices, computer or mobile phone use was an important factor for recruiting subjects. 11 studies questioned the participants about the frequency of use of computer, mobile phones or touchscreen devices. Having previous experience with computers was inclusion criteria for only one study[12] and exclusion for 2 others[15][28]. Having previous experience of touchscreen was inclusion criteria for one study[5] and exclusion for 3 others[16][31][33]. One study about digit-input recruited subjects with regular use of automated teller machines[2] and one study about smartphones recruited subjects who didn't use a mobile phone[9].

One study recruited participants with different previous experience with technologies[34].

10 studies compared the interaction task results between younger and older participants. 5 studies made the comparison between groups with different levels of motor[9][11][31][33][9] or cognitive skills[27]. Table 1 and 2 synthetize the characteristic of older user's recruited for these studies.

Table 1. Recruiting criteria and subjects' impairments.

Recruiting criteria/ Subjects' impairments	Visual disabilities	Motor disabilities	Hearing disabilities	Cognitive impairment
Subjects with some kind of impairment were included on the study	2 studies [10][12]	5 studies [10][11][15] [18][31]	3 studies [10][12][8]	2 studies [10][27]
Only body abled subjects participated of the study	12 studies [2][5][7][9][8][14][16] [18][19][25][27][33]	10 studies [5][7][9][14][16] [25][25][27][31][33]	2 studies [5][9]	5 studies [5][2][14][16] [33][27]

Table 2. Recruiting criteria and subjects' previous experience with technologies (n.a.: not applied).

Recruiting criteria / ICT	Computers	Mobile phone	ATM	Touchscreen
Subjects with previous experience of use	4 studies [5][7][9][12]	4 studies [2][12][18]	2 studies [2][9]	2 studies [5][12]
Subjects without previous experience of use	1 study [28]	2 studies [8][9]	n.a.	8 studies [8][9][14][15] [9][16][18][31][31]

3.2 Apparatus

Three kinds of tactile devices were used in these studies: monitors, tablets and mobile phones/smartphones. They had different screen sizes, from 3.5 to 42 inches. Some studies compared tactile devices to other input device as keypad[2], keyboard[28][34], mouse[5][33] and RFID based panel[10]. Table 3 synthesizes the devices that were used and their screen sizes. All studies provided visual feedback. Table 4 shows the kinds of feedback that were provided during the interaction tasks.

Table 3. Devices and screen sizes (in inches). ATM: Automated teller machine (n.a.: not applied).

Device/ Screen size	Monitor on vertical position	Monitor or surface on horizontal position	Tablet	Mobile or Smartphone
Smaller than 7'	n.a.	n.a.	n.a.	6 studies [8][9][12] [18][19][27]
Between 7 and 12'	n.a.	n.a.	9 studies [5][9][12][14][15] [18][27][31][34]	n.a.
Bigger than 12'	4 studies [2][7][11][28]	5 studies [8][16][25][29][33]	n.a.	n.a.

Table 4. Provided feedback (no studies about audio or tactile feedback only were found).

Visual	Visual and audio	Visual and tactile	Visual, audio and tactile
18 studies [5][7][8][9][10][11][12][14][15] [16][18][19][27][28][29][31][33][34]	2 studies [2][9]	1 study [9]	1 study [9]

The collected data concerned task completion time, error rate, number of strokes required and number of strokes actually input. Qualitative data analysis was obtained by observation, interview or subjective questionnaires. Data was collected from touch contact and sensors such as accelerometers.

3.3 Interaction Technique

Two kinds of input techniques on touchscreen were evaluated: pen and fingers. Multitouch devices allowed interaction with two or more fingers. The interaction techniques employed on these studies are described on the table 6.

Table 5. Interaction techniques (n.a.: not applied).

	Pen	One finger	Two or more fingers
Singletouch	4 studies [8][10][16][34]	14 studies [2][8][9][10][11][12][15] [18][19][25][27][29][31][33]	n.a.
Multitouch	n.a.	1 study [7]	2 studies [5][12]

3.4 Tasks

Different tasks have been proposed on touchscreen devices: digit or text entry, target selection or gestures of interaction. Gestures of interaction were steering or drawing on single touch devices[8] or dragging and pinching on multitouch devices[5][12]. N studies proposed some time for practice or training tasks. One study included a week period for familiarization[12]. Complex exercises as sending an email[7][12][28] allow the use of several kinds of interaction.

Table 6. Conducted tasks.

Training tasks	Text or digit input	Target selection tasks	Gestures of interaction
13 studies [2][5][8][11][12][15][18] [27][28][29][31][33][34]	11 studies [2][7][4][6][12][15] [18][19][27][28][34]	9 studies [7][8][9][10][11] [12][16][28][31]	6 studies [5][8][12] [25][31][33]

4 Impact Discussion

Special needs and disabilities of older people are not specific represented in these studies but authors considered the incidence of sensory impairment, motor impairment and cognitive impairment in older adults. Age-related changes in accuracy are not systematic. The review of the literature shows that age related changes, the incidence of disabilities and chronic diseases should be considered in the design of interaction techniques or interactive systems for elderly people (information and communication technologies as internet navigation, health care systems and assisted ambient living etc.). These impairments affect accessibility and usability of touchscreen interaction, preventing users to have access to interactive systems needed for ageing.

Fatigue has been notified only by subjective questionnaires. Studies about HCI have evaluated fatigue by muscle activities during mouse tasks[13][21] and the relation between fatigue and force[23]. Studies about touchscreen interaction of motor impaired users have detected compensatory movements of trunk and upper limbs[3][21]. Arthritis and overuse disorders have been mentioned but not studied[23][26].

Although more specific surveys need to be performed, there is sufficient evidence to state that touchscreen interaction movements can be used to provide recommendations for developing more ergonomic interfaces, improving accessibility and usability. Better adapted interaction devices and interfaces are important to prevent overuse injuries and musculoskeletal disorders[20][26].

Older users have different characteristics due to ageing and their use of IT. The impact of touchscreen use on user's behaviour should be studied. One challenge is to adapt interaction to special needs of older users.

5 Towards New Studies on Interaction Movement

The review of the literature shows that several parameters may be considered in the design of interaction techniques or interactive systems for elderly people:

- Age-related changes in psychomotor, cognitive and perceptual skills;
- Previous experience with technologies and internet (computer's use, mobile phones, automated teller machines, handheld touchscreen tablets);
- Variability of devices and input techniques (screen sizes and orientation, pen of fingers input, single or multitouch interaction techniques);
- The different situations of use for handheld devices, public places, health centers or at home.

Although more specific surveys need to be performed, there is sufficient evidence to state that touchscreen interaction movements can be used to provide recommendations for:

- designing and developing more ergonomic interfaces and interactive systems;
- the conception of experiments to study accessibility and usability of touchscreen devices and interaction for older people.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-844

The Self-Guide System for the People Who Needs Help at Evacuation: The Second Case Study at Kagoshima City Aquarium

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Abstract. A proposal of a resolution system using electronic communication tools at evacuation and a report of the demonstrations at an aquarium. It is unique to the point that the self-guide system is used either at emergency or at daily situation.

Keywords. Self-guide, evacuation, deaf.

Introduction

Many people with different backgrounds come to our aquarium, such as families with young children, families with elderly members, wheel chair users, deaf, blind and even deaf-blind. Many people from all over the world also come and visit our aquarium. The visitors claim that they can enjoy and see the exhibitions even more if there are some guides, touchable exhibitions and detailed explanations. These comments have made us aware of their needs.

In Japan, many public facilities have been working towards an emergency system. These emergency systems are usually suited for Japanese people with no handicaps and the visitors mentioned above may not be able to follow directions or escape when there is an emergency. Thus we must consider a system that suits these types of people. The present emergency system broadcasts announcements and staff of the aquarium guides them through the emergency. This system may not be suitable for them.

We should offer sufficient additional information through personal communication terminals such as mobiles and rental tablets. Tactile maps, braille pamphlets must be provided for the blind, and for the deaf, signing and texting. We must also think of ways to evacuate people on wheelchairs when all the elevators and the escalators stop.

It is a big problem that these visitors are coming every day without any assistive measures. Many museums and aquariums in the world have little assistive measures to aid these types of people. This paper is a proposal of a resolution system using electronic communication tools based on a human- interface viewpoint. We take Kagoshima City Aquarium (KCA) as a model case and present the results of our on

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going experiments. We hope it will contribute to decrease the number of victims at an emergency and no one is left behind during emergency situations.

1 Background

Earthquakes, tsunami and nuclear reactors meltdown in Japan on 11th March 2011 drastically changed the social mind of the Japanese society. A natural disaster comes unexpectedly and the damage is more than we can expect. We must provide for emergencies at any time at anywhere. However, the most measures for evacuation from a building are for those without any handicaps in Japan. Emergency Evacuation Planning Guide for People with Disabilities by National Fire Protection Association, USA [1] (EEPG below), is opened to public. Japan is still behind in this field where there is no law like ADA. However the system in USA is not directly applicable to Japanese society because the notions, the definitions of disability and the cultural background are different. EEPG thinks the evacuation for a disaster is the same thing, though we think it must be varied to each case, a fire, an earthquake, a tsunami, a typhoon or a nuclear explosion. In particular EEPG does not assume people who cannot evacuate or should fail to escape in time because of their handicaps. In such a case, we must prepare a shelter for them where food, toilet, battery for mobile phones are provided at the very least.

2 Former Research

In our paper last year [2], we proposed a general design of the evacuation guide system and we reported our first demonstration. The summary is shown in the following sections.

2.1 Customer's Location Specifying System

It is important to know where the customer is at an emergency. Our system specifies the present locations of the customers through the customer's mobile with the Bluetooth devices. The GPS system in the mobile, Skyhook Wireless or Place Engine at present is not sufficient for the closed area in a building.

2.2 Demonstration 1

We held an open public evaluation test at Kagoshima City Aquarium in January, 2012. We asked the guests to answer questions after using our guide system through their own mobile phones or through the Android tablets provided by us. We had a limited number of participants. This was due to the fact that the numbers of transmitter

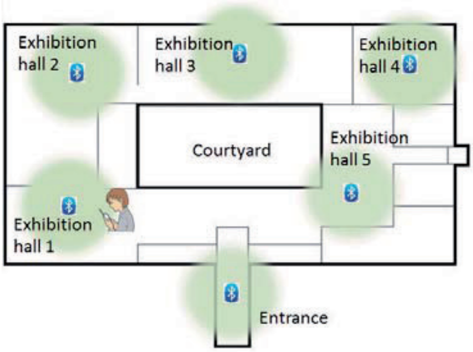

Figure 1. Location specifying system by Bluetooth

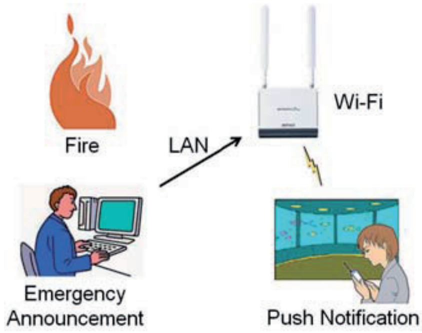

Figure 2. Emergency Announcement System.

carriers were restricted since only NTT DoCoMo phones and smart phones could be used in this evaluation test.

1. Participants

There were 50 hearing participants and 12 deaf participants. Table 1 shows that the distribution of the age of the participants.

Table 1. Distribution of age.

Under 20	20s	30s	40s	50s	Over 60
6%	26%	24%	19%	15%	10%

2. Usage

Access: Most of them (73%) used QR code, partly because they used the regular cellar phones. NFC (Near Field Communication) would be considered in our scope in the near future when smart phones will become popular in Kagoshima Area.

Channels: Some people used the multi channels. Some stated that the guide was hard to listen to since the volume was controlled in advance so it will not disturb the other visitors.

3. Evaluations

We analyzed the response of the participants as follows.

a) **Performance in full scale:** Only a half of the people answered that they would use this system when it would be performed in full scale. We considered it was because the contents this time were the duplication of the regular explanation panels on the exhibitions, and they felt it unnecessary to watch the same information twice.

b) **Necessity:** Most people (76%) thought it necessary and a few (5%) answered it was unnecessary. They thought that the sign language movie or the English guide might be useful for handicapped people or people from abroad.

c) **Contents for the Deaf:** We adopted the standard Japanese Sign Language for the guides. But some signs were different from the local dialect signs in Kagoshima area. If we adopt the Kagoshima dialect signs, the deaf guests outside Kagoshima may not understand. Which sign language dialect to use on the guide is still an issue that we need to consider.

d) **Others:** We used the information used by a guided tour by the aquarium staff. Thus the repeating guests already knew the information on our guides. The change in the information and movies provided on the guides will attract the repeaters.
Concerning the language on the guides, the letters on the display were too small for elderly people. There were also too many Chinese characters for young children to read. Some stated that the yellow letters were difficult to read.
The demonstration was limited to mobiles phones. It must be expanded to handy terminals with 7 inch screen, or others such as portable game machines.
To also encourage the use of the mobile guides, young children may enjoy events such as a stamp rally.
Concerning the inter-net connection, the Wi-Fi system is useful but many guests still used the regular mobiles.

3 Demonstration 2

Considering the results above, we held the second demonstration in January 2013. We revised the system and contents. Also the system, the situation and environment had changed drastically in the two years. The smart phones are popular now and the KCA provided the free Wi-Fi spots.

3.1 Participants

48 people answered our questions. There were 34 hearing participants and 14 deaf participants.

Table 2. Distribution of gender.

Gender	Male	Female	Total
Hearing	16	18	34
Deaf	2	12	14
Total	18	30	48

Table 3. How the visitors found out about the demonstration.

Trigger	Webpage	At desk	Posters	Others	Total
Hearing	3	28	1	2	34
Deaf	0	3	1	10	14
Total	3	31	2	12	48

The gender ratio of the hearing people is almost equal but there were a larger number of deaf females. This may be because the notice was provided by the local deaf NPO and deaf females tend to share more information compared to deaf males.

Table 4. Variety of Age.

Age	Under20	20s	30s	40s	50s	Over 60	No Re	Total
Hearing	2	6	17	6	1	2	0	34
Deaf	0	4	3	1	2	3	1	14
Total	2	10	20	7	3	5	1	48

As for the hearing people, because participation is limited to the smart phone holders, the number of participants concentrated between the 20s to the 40s. We provided the tablets at the reception desk, which might have caused some nuisance for the guests. Some procedures to write an application form and to show an ID for renting a machine were inevitable. The deaf is noticed in advance that there is a rental tablet service and only a few used it.

3.2 Usage

3.2.1 Channels

We provided 5 language channels: Japanese texts, Japanese Sign Language, Spoken Japanese, English texts and Spoken English.

Five hearing people used Japanese texts and Spoken Japanese, and one used Japanese text and sign language. One hearing participant used Spoken Japanese, text and sign language. Two deaf participants used Japanese text and sign language. Two hearing participants used only voice channel because it was useful to them as the voice guide found in other exhibitions. Since the participants were all Japanese, no one used the English text or Spoken English.

Table 5. Language Channels.

Language	Japanese Text		Sign Language		Japanese Voice		Total	
Hearing	80%	(32)	3%	(1)	18%	(7)	100%	(40)
Deaf	17%	(3)	78%	(14)	6%	(1)	100%	(18)
Total	60%	(35)	26%	(15)	14%	(8)	100%	(58)

3.2.2 Easiness to Find the Target

Table 6 shows how easy it was for the guest to find the target guide of the exhibitions. Most of them thought it easy to find the target because the guides are arranged along the exhibition route.

Table 6. Easiness to find the target.

Easiness	Easy		Not easy		No Re		Total	
Hearing	85%	(29)	15%	(5)	0%	(0)	100%	(34)
Deaf	71%	(10)	21%	(3)	7%	(1)	100%	(14)
Total	81%	(39)	17%	(8)	2%	(1)	100%	(48)

3.2.3 Event Announcement

The event announcement is attached to the new system, which indicates the time of the show. The evaluation is shown below in Table 7.

Table 7. Event Announcement.

Event Announce	Useful		Not useful		Either		No Re or No see		Total	
Hearing	74%	(25)	0%	(0)	18%	(6)	9%	(3)	100%	(34)
Deaf	64%	(9)	0%	(0)	21%	(3)	14%	(2)	100%	(14)
Total	71%	(34)	0%	(0)	19%	(9)	10%	(5)	100%	(48)

3.2.4 General Impression

As a general impression, 80% said good or no bad and others pointed out the connection problems but not for the system itself.

Table 8. General Impression.

Impression	Good		No bad		No good		Bad		No Re		Total	
Hearing	47%	(16)	38%	(13)	3%	(1)	6%	(2)	6%	(2)	100%	(34)

Deaf	21%	(3)	43%	(6)	21%	(3)	0%	(0)	14%	(2)	100%	(14)
Total	40%	(19)	40%	(19)	8%	(4)	4%	(2)	8%	(4)	100%	(48)

3.2.5 Necessity and Usage

Table 9 shows the necessity and Table 10 shows the possible usage.

Table 9. Necessity of the System.

Necessity	Necessary		A bit		Not so		Not		No Re		Total	
Hearing	32%	(11)	50%	(17)	3%	(1)	3%	(1)	12%	(4)	100%	(34)
Deaf	79%	(11)	14%	(2)	0%	(0)	0%	(0)	7%	(1)	100%	(14)
Total	46%	(22)	40%	(19)	2%	(1)	2%	(1)	10%	(5)	100%	(48)

Table 10. Possible Usage.

Usage	Use		Won't use		Not now		No Re		Total	
Hearing	68%	(23)	6%	(2)	21%	(7)	6%	(2)	100%	(34)
Deaf	79%	(11)	0%	(0)	7%	(1)	14%	(2)	100%	(14)
Total	71%	(34)	4%	(2)	17%	(8)	8%	(4)	100%	(48)

71% says that yes they will use this system. 86% says that it is necessary considering other people with handicap. For sign language 80% says yes. The 'use' ratio was high for the deaf since we adopted local signs in this demonstration and most participants were from local areas.

4 Consideration

When we compared the demonstration 2 with 1, the electronic environment had greatly changed. The smart phone has become popular and free WiFi spot was provided throughout the aquarium. People are familiar to the smart phones and other devices like the tablets.

On the other hand, people became more sensitive to the next disaster such as Tonankai Earthquake. In the 2011 earthquake, handicapped people were killed or injured, three times the number of people without handicap. It is because of lack of information and less prepared situation in the shelter. We have to understand that they need special support for evacuation.

In order to decrease the number of victims, a sufficient system and daily training is indispensable. Emergency system is often not used daily and the staff is not familiar to the system. People cannot adapt to sudden changes or sudden emergencies just by reading the emergency manual. Our proposal is that we utilize the ordinary regular channel at an emergency. If the guests are familiar with the regular guide system, it will help them to use the emergency channel easily.

Moreover, the monitor system to catch and follow the location of the guest is helpful for the control room to send sufficient information at a pinpoint. At an emergency, we can send an appropriate supporter to the point. Even when there are no emergency situations, we can monitor the interests of the guests calculating the relation of the place and the time. It will help to decide changes in the exhibition since this system can give us some information about popular exhibits and less popular exhibits.

In the demonstration it was proven that the sufficient information and an appropriate guide in the shortest time was the most important factor for evacuation.

We must assume there are some people who cannot or fail to evacuate in time from the disaster even if the evacuation work well, due to the lack of time. The temporary shelter to stay for a few days would save their lives until the rescue comes. We suggest that food, portable toilet, battery for mobiles phones and games to kill time to be stored in the shelter.

The exhibitions with the guide were limited to 12 points in the second demonstration. We would like to expand the number of points gradually for public use. The participants said they enjoyed the exhibitions better than usual. This encouraged us for further improvement and we plan to design a demonstration for emergency in the near future.

Acknowledgements

This work was supported by JSPS KAKENHI Grant Numbers 23242022, 23300215, 23240087 and 24922004

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-851

Innovative Technology to Stimulate Physical Activity in Nursing Home Residents with Cognitive Impairments: Introduction and First Results on Feasibility

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Abstract. Due to the ageing population, the number of nursing home residents with cognitive impairments is substantially increasing. Treatment and instruction of elderly with cognitive impairments by care professionals (e.g. physio- or occupational therapists) is difficult, since not only motor performance may be impaired, but also the understanding of verbal instructions can be limited. Understanding of information may be further limited by a decrease in the capacity ofinformation processing and speed of processing. Nursing homes residents are in general physically inactive. Physical activity during but also outside of supervised therapy should be stimulated in order to prevent secondary complications, enhance movement skills and to achieve or maintain a certain level of autonomy. Innovative technology may be a promising tool to stimulate physical activity; challenging and inviting environments can be created, which can 'seduce' nursing home residents to become more active in a fun way. This article presents three potentially suitable technologies to stimulate physical activity in nursing home residents with cognitive deficits or dementia: 'interactive surfaces', 'Tri-Bot' and 'virtual cycling'. Results on feasibility indicate that the technologies were accepted by the users and they all seem to be promising tools to stimulate physical activity in nursing home residents.

Keywords. Technology, Physical Activity, Nursing Home Residents, Interactive Games, Cognitive Impairments.

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Introduction

Due to the ageing in many parts of the world a substantial part of the population are older people with multiple chronic and neurological conditions, like dementia, stroke or Parkinson's disease. In the Netherlands there are about 350.000 clients with at least one of these neurological conditions, which are generally accompanied by cognitive impairments [1-6]. The incidence and prevalence of these diseases is strongly increasing. It is estimated that there will be 65.7 million people with dementia worldwide in 2030, making the search for effective treatments for this target population one of the biggest challenges in health care [1]. Care professionals, like physiotherapists and occupational therapists, are experts in the area of physical activity and motor learning. For all sorts of target groups and pathologies they provide therapy tailored to the clients' possibilities and preferences so that clients can regain anatomical functions, improve their performance of daily activities and increase participation in society.

Tailored treatment of these clients is more difficult because of cognitive impairments, which often occur as a result of the damage of the central nervous system. The cognitive impairments become especially apparent when patients need to process information. Verbal instructions from professionals, targeting at for instance facilitating movement and exercise are not understood sufficiently. Consequently nursing home residents may be unable to start or continue exercise on their own without supervision or external motivation.

Research has shown that residents of nursing homes are on average only moderately active during 5 minutes a day and sedative during 17 hours (lying in bed, sitting) [7]. Especially in elderly, this passive lifestyle has devastating consequences for both the physical and cognitive abilities. Inactivity may also decrease residents' quality of life [8, 9]. The risk of multi-morbidities and secondary complications (cardiovascular disease, obesity, contractures) as a consequence of physical inactivity is high, which makes an active lifestyle even more pressing.. It would be desirable if people would remain physically active also outside of supervised therapy. Being physically active, including aerobic and resistance training, have been demonstrated to have beneficial benefits on cardiovascular, respiratory as well as musculoskeletal systems in older adults [10, 11]. A recent review by Weening-Dijksterhuis et al. [12] confirms the positive effects of exercise training on physical fitness, functional performance, performance of activities of daily living and quality of life, even in frail individuals. However, becoming more physically active includes more than doing exercises and performance of sports. It also comprises (instrumental) activities of daily living. Thus, every minute of additional physical activity counts in order to improve the general health status [13].

The main barriers preventing an active lifestyle in nursing home residents are that these people often not only lack the capacities to understand instructions, but also lack insight into the relationship between physical activity and their health status. Innovative technologies might be part of the solution for inactivity in this target group. For some technologies there already is some evidence that they may be effective in health care situations, like socially assistive robots [14]. The use of virtual realities or computer games also seems promising to engage nursing home residents in activities [15, 16]. At present, especially 'virtual surroundings' are used in several initiatives in the Netherlands to assess whether or not the application of technology may contribute to the facilitation of movement. Exergaming in virtual surroundings is an example of this way of facilitating. In the literature, several studies on exergaming (e.g. WII-fit $_{TM}$ or Microsoft X Box Kinect $_{TM}$) have been described, however little evidence for the effects of these technologies on movement outcomes has been reported [15, 17-19]. In addition, people with cognitive impairments will often not be able to operate and use these exergames without supervision. Sometimes insufficient physical abilities, like arm-hand-function, will prevent them from using these game consoles (e.g. setting up the computer, creating and using an avatar, using the remote control).

The use of technology in health care is strongly developing and enhances the possibilities to create safe environments that challenge and stimulate people with cognitive impairments. Many initiatives have been identified in various countries, but research results are hardly structured, applied or embedded in policies or protocols within health care institutes. To enable successful implementation and studies on (cost)efficacy of innovative technologies to stimulate physical activity, first, several pilot studies on acceptation and feasibility need to be performed.

1 Projects and Methodology

Several research projects have been conducted in a nursing home (Zorgcentra Sevagram, The Netherlands) to explore the application of innovative technology to stimulate physical activity among people with cognitive impairments (mainly dementia). The main aim of these projects was to assess feasibility of three technologies: 'interactive surfaces', 'Tri-Bot', and 'virtual cycling'. This article focuses on two aspects of these pilot studies: 1. A description of the technology and 2. First results on acceptation and feasibility.

1.1 Project 1. Interactive Surfaces

1.1.1 Description of the Technology

The living surfaces system is a product of Vertigo Systems GmbH. To create an interactive surface, different graphic shapes can be projected from a computer through a beamer on a wall or floor. The projections include for example images as a pond with fishes that swim away when you approach them (Image 1, left picture) or a virtual soccer field. The projections are 'activated' by movement of a person on the projection field, which is detected by a movement sensor (infra-red camera). Interactive surfaces have similarities with computer games as they create a colorful virtual reality in which elements of 'gamification' may 'seduce' people to play, move, respond and interact with it.

1.1.2 Aim

In this study, the spontaneous physical activity of nursing home residents with dementia regarding interactive surfaces on the floor were explored. Care professionals, informal caregivers and researchers did not intervene.

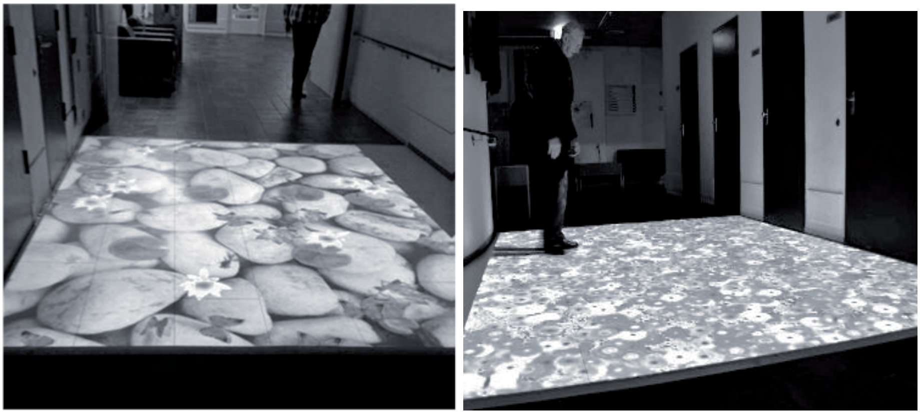

Image 1. Interactive surface projections ‘Pond’ and ‘Autumn’.

1.1.3 Methods

An observational mixed method pilot study was performed. Every day for one hour during an 11-days period an interactive surface was shown in the central hallway of the nursing home (seven different projections were used). Spontaneous physical reactions were assessed; reactions were recorded on video by two cameras and field notes were taken by two researchers. Physical reactions were noted and the frequency and duration (interaction time) of the use of the technology per participant per observation was registered.

1.1.4 Feasibility and Potential Effects on Physical Activity

Physical responses to the projections were recorded in fifty-eight nursing home residents. Results showed a great variety in spontaneous physical responses. More than 50% of all residents noticed the interactive surface and spontaneously engaged physically in the projections during the observation period. On average, clients stayed about one minute on the interactive surface each time. All participants together interacted for almost two hours with the projections. The interactive surfaces technology seems a promising technology to stimulate physical activity among people with cognitive impairments, in a more implicit way.

A spin-off project has been performed, mainly focusing on further improvement of the technology with regard to this specific target population. Adaptations were made to size of the projection field (larger) and tailored projections were developed. The interactive surfaces technology will also be tested among people with intellectual disabilities (such as clients with autism) and elderly clients with psychiatric disorders in the near future.

1.2 Project 2. Tri-Bot

1.2.1 Description of the Technology

This technology consists of a small robot (based on the X-box Kinect $_{TM}$ from

Microsoft) created by students of the Information and Communication Technology-department of Zuyd University of Applied Sciences. The Tri-Bot is a triangular shaped robotic vehicle, composed of a 3D printed polymer space-frame base, reinforced with aluminum, positioned on omni-directional wheels (Image 2). The robot is controlled through 3-dimensional motion of the user by using a x-box kinect camera, which is connected to a laptop. Data is transferred wireless from the laptop to an embedded microcontroller on the tri-bot, controlling its omnidirectional movement within a range of six meters.

Image 2. The 'Tri-Bot'.

1.2.2 Aim

The aim of the study was to stimulate rehabilitation of physical activity and motor learning in somatic nursing home residents after a hip fracture, of which some had diagnosed cognitive impairments.

1.2.3 Methods

The 'Tri-Bot' needs to be 'driven' along a preset course. Different starting positions (sitting, standing) and courses which are increased in level of difficulty can be used as the clients get physically better or gain more expertise in controlling the Tri-Bot. The first level that a client is going to perform should be easy enough to be performed successfully. As the difficulty-level is only increased if the client has successfully achieved the prior level, the client will experience this kind of treatment as a form of 'errorless learning'. Most clients find errorless learning very motivating as it has they are constantly reinforced (positive feedback). Another advantage of this training may be that the client's attention is focused on the surroundings and achievement of the goals of the task (external focus of attention instead of internal focus of attention).

1.2.4 Feasibility

This project combined fun, technology and health care whilst treating six clients after a hip fracture. Preliminary results indicate that the Tri-Bot can be embedded in physical therapy in at least a part of the target population. The prototype of the robot needs further development in order to enhance the applicability and usability for people with more severe cognitive impairments. For instance, the steering of the robot when it is returning to the controller/user needs to be mirrored (left is right and vice versa), which proved to be quite difficult (not only for people with cognitive impairments).

1.3 Project 3. Virtual Cycling

1.3.1 Description of the Technology

The virtual cycling system ('Difiets' developed by Stichting BOZ, The Netherlands), which was developed for use in elderly care, consists of a system that combines cycling on a home trainer with videotaped real life routes on a television screen (Image 3). The videos show routes in environments familiar to the clients, for example their former place of residence or surroundings near the nursing home. The use of live features from environments that clients are familiar with makes this way of cycling training more meaningful, more personal and challenging. It may also induce effects on a social level for example through interaction with other clients, family or acquaintances. Besides improvement of the physical health status, it may also improve cognitive and/or mental health status (reminiscence training).

Image 3. Examples of the virtual cycling technology.

1.3.2 Aim

An explorative pilot study was conducted to gain insight into the experiences of psychogeriatric clients with dementia and their legal representatives with the virtual cycling system.

1.3.3 Study Design

In this observational, qualitative research data were gathered by observations and video recordings of the clients using the system. Immediately after clients performed the activity, five short questions about their experiences were asked (f.i. how it went, whether they liked it). Semi-structured interviews were conducted with the clients' legal representatives (main topics were f.i. the physical load of the cycling, the ease of use). Data analysis of the semi-structured interviews of the legal representatives was based on written notes and audiotapes. Data were analyzed anonymously, relevant information related to the predefined topic list was marked and labeled. A tree diagram was used to cluster all opinions and experiences of the participants.

1.3.4 Feasibility Residents and Informal Care Givers

In general, all 13 clients that used the technology were very satisfied with the virtual cycling system, especially the recognition of familiar routes/environments. Almost all clients wanted to use the system more often in the future (n=10). Legal representatives (n=9) were generally positive about the concept of virtual cycling and the quality of the videos. They believed that virtual cycling had positive effects on the clients, such as stimulation of the level of physical activity, reviewing familiar environments which stimulates using memory and cognition, interaction with other clients, family and professionals, psychosocial aspects such as better mood, fun and relaxation. They also had recommendations to further improve the technology, like a more easy use and start-up of the system, more routes within familiar environments, videos in different seasons of the year and the combination of the television screen with other physical activities, (f.i. virtual walking or virtual rowing).

A spin-off of the project will include making more videos with more different routes (content) and to cut the routes into smaller parts. Other upcoming projects aim at testing and implementing the technology in other interested care organizations, such as a (neuro) rehabilitation centre.

2 Impact and Contributions to the Field

The findings of the abovementioned pilot studies indicate that innovative technology may be applicable among nursing home residents with cognitive impairments to stimulate physical activity in a more implicit way. Since many elderly people, especially those living in nursing homes, in general are physically very inactive every minute of improvement is important and pure gain.

3 Conclusions and Planned Activities

The idea of 'seducing' people to be physically active using innovative technology seems to be interesting as part of therapy and an attractive addition to supervised therapy in these populations. Care professionals should be motivated and trained to use the technologies in order to embed them in usual care. An important prerequisite for care professionals to use technologies is that the prototypes and finished technologies need to be robust and work instantly when needed. They should be easy to use for both the care professional as well as the residents.

More research is needed to assess the effects of these challenging surroundings and interactive games on a physical level and to identify who will benefit from these technologies most. The relation between increased physical activity and improved health status should be established. Future research should also focus on further development of prototypes and half products. Implementation and sustainability of activities in the participating health care institutes should be actively supported. Furthermore, potential application in other populations, such as people with intellectual disabilities and clients with psychiatric disorders, should be explored.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-859

AAL Living Lab Methodologies based on ICF

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Abstract. Ambient Assisted Living (AAL) systems and services must support users' activities and participation. Therefore, AAL evaluation tools must go beyond the instrumental factors and must assess how AAL systems and services can help people to perform complex activities of daily life or social roles. In this context, this paper presents an on-going research work within the Living Usability Lab (LUL) where the International Classification of Functioning, Disability and Health is being used as a comprehensive model for the evaluation of AAL systems and services.

Keywords. Ambient Assisted Living, ICF, Evaluation Methodologies.

Introduction

Ambient Assisted Living (AAL) is, nowadays, an important research and development area supported by the European Commission, Member States, research community and industrial partners. It is foreseen as an important instrument within the required strategies to face the societal challenges related with the demographic ageing.

AAL systems described in the literature [1] are intended for use both indoor and outdoor in any environment. Some of them are being conceived to be used for independent living [2] with the general aim of increasing the performance and independence of older adults in a broad spectrum of activities [3]: personal care, feeding (*e.g.* planning the weekly menu or nutritional adviser [4]), taking care or household activities [5], taking medications as prescribed, ambulating [6] or shopping [7]. Additionally, with the objective of directly or indirectly improve the individuals' quality of life, AAL systems can contribute to the individual participation in society [3]. Finally, AAL systems can also contribute to the reorientation of health systems [8] that are currently organized around acute, episodic experiences of disease, namely, by allowing the development of a broad range of services related to care prevention [9], care promotion or home-caregiver support [10], either by health professionals or by any formal or non-formal caregiver [11]. The ultimate goals are to provide distance support (*e.g.* distance training [12] or telerehabilitation programs [13]) or to provide the

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caregiver with accurate and up to date information [14] so that the right care at the right time can be delivered (*e.g.* monitoring and controlling biological signs, behaviours' or emotions [15, 16]).

The complexity of the design and development of AAL systems and services requires transdisciplinary research and the active involvement of different stakeholders, including potential final users, formal and informal care providers, governmental and local entities, funding agencies or industrial partners. Living Lab methodologies represent a perspective in which the stakeholders actively participate in the different stages of the design and development process. It is, therefore, a user-centred approach that conceives the users and the society as sources of innovation [17].

This paper explains the methodological approach used in the Living Usability Lab (LUL) [18], a joint venture between academic and industrial partners. In addition to the aspects that are usually considered in the design and development of AAL systems and services, namely development architectures or physical infrastructures, the LUL includes a comprehensive methodological approach for the definition of the evaluation instruments, based on the conceptual framework of the International Classification of Functioning, Disability and Health (ICF) [19].

1 Living Usability Lab

The LUL has the following main goals: i) the development, integration and evaluation of systems and services with demanding interactive requirements, such as AAL solutions; ii) the development of comprehensive methodologies to support the different design and development phases, from the initial conception to the final evaluation, involving users and other stakeholders; iii) the translational research related to interaction mechanisms and their adequacy to the users, the nature of the tasks, the surrounding contexts and the technological platforms; iv) the conception of reference models to consolidate knowledge related to the users' needs and critical mechanisms associated with the quality of services, interaction paradigms and development platforms.

In the current implementation, the physical infrastructure of LUL consists of a node in Lisbon and other three in Aveiro. Two of the nodes are intended for service provision and the remaining nodes are intelligent houses that, in addition to the typical house equipment and furniture, have a broad range of AAL components: sensors, actuators, robots and different terminal equipment.

The LUL is supported by a technological platform that includes four layers: applications, LUL services, common services and physical infrastructures.

In terms of applications, the LUL intends to offer conditions for the development of technological applications related to independent living, health and quality of life, occupation and recreation, according to what has been defined by the project Bridging Research in Ageing and ICT Development (BRAID) [3].

Independent living requires technological applications to support the normal activities of daily living (*e.g.,* daily tasks, mobility or safety). Health and quality of life is related with how technology can support health conditions (*e.g.,* remote monitoring, support in emergency situations or supervision of physical maintenance and rehabilitation). Finally, the occupation and recreation areas address, respectively, issues related with how technology can support professional activities and how it can promote socialization and participation of older adults in social life and leisure, learning, cultural, political or religious activities.

The LUL services' layer consists of services built specifically for AAL, while the common services' layer provides basic services, namely services to support communications, security, monitoring or users management. The two service layers group all the support services that are not directly assignable to the application or business logic. According to this principle, a broad range of services can be obtained using or adapting components already developed.

Considering the technological heterogeneity of a broad range of devices from different suppliers, the LUL development architecture is designed to provide mechanisms for rapid integration of various components through a set of services which support the development of applications. One of the initial requirements was focused on obtaining efficient conditions for creating AAL transverse business logics, overcoming a recurrent problem of spending substantial part of the development resources in re-creating common functionalities. Therefore, there was a strong focus on the conceptualization and development of base services that reduce these constraints and allow future chains of added value.

Finally, the infrastructure layer comprises the physical spaces, communication channels and a broad set of AAL physical devices, including sensors and actuators.

2 Methodology

The LUL evaluation methodology is based on a set of procedures that involve the stakeholders from the preconception of the idea (conceptual validation) until the evaluation of the final systems or services (prototype and pilot tests). For the different methodological phases it is required to define a set of conceptual, operational and logistic aspects. In particular, the main objective of conceptual validation is to verify the sustainability of the initial concepts for a potential system or service. In turn, the main purpose of the prototype testing phase is to evaluate the system or service in terms of usability and accessibility. Finally, the last methodological phase is the pilot test that aims not only to evaluate the available functions and their usability and accessibility, but also to determine how the system or service impacts on the users' daily lives.

ICF, as a model that offers a balance between a purely medical and a purely social approach, contains essential information for the users' profile characterization: i) body functions and structures allow the definition of the type of access to systems and services, as well as, the definition and configuration of the interfaces; ii) personal factors allow the characterization of personal preferences; iii) activities and participation together with environmental factors [20] allow the characterization of the systems and services that best fit the person's functioning.

The ICF considers that many factors affect and have influence on the individual's performance and thereby on the decision on what type of service is needed, either delivered by care staff, relatives, aid appliances or technology. Additionally, it considers the context (environmental factors and personal factors) as components that can enhance or limit the performance, depending on how the individual experiences limitations (*e.g*. due to possible weakness, illness and/or handicap).

ICF fundamental concepts are related to the individual functioning and performance in activities and participation. On the other hand, the goal of AAL services for older adults is the development of technological solutions to enhance theirs activities and participation in all aspects of society. Therefore, it should be possible, and desirable, to use ICF for the specification, development and evaluation of AAL services. This may impact the characterization of AAL systems and services, in particular in the adequacy of the semantic structures, modelling of the users and surrounding context and in the evaluation of the developed solutions.

The evaluation of the results associated with technological developments has been based on a narrow view and, in particular, using evaluation tools that focus on instrumental factors (*e.g.*, mobility, sensory and physical limitations and the ability to perform simple activities of daily life) and, rarely, on the ability to perform complex activities of daily living and social roles.

Therefore, as a result of the high requirements of health and social care interventions, there is an imperative to change this paradigm. As previously stated, the level of functioning results from a dynamic interaction between the person and the environment, and the values, interests, habits or routines have a very important and meaningful role. Clearly, a model focused on practical aspects of everyday activities and participation of the person, highlighting opportunities for technology and design solutions to support these activities and participation [21], is a useful framework for guiding the evaluation process.

3 Results and Contributions

During the conceptual validation it is important to understand the overall profile of the target users and to characterize their expectations regarding the use of new technological services, which can be used to define personas and scenarios of use. This led to the development of several preliminary questionnaires that cover the functioning components provided by the ICF. Thus, these questionnaires considered, in general, the following aspects: i) socio-demographic data; ii) assessment of health status; iii) basic and instrumental activities of daily living; iv) social activities, recreation and hobbies; v) issues related to the importance, availability and access to formal and informal services; vi) access to technologies and attitudes towards them; vii) and issues related to the openness to use technological devices.

The information from the preliminary questionnaires is being used to build personas and scenarios of use that are essential for defining the functional requirements, due to the complexity of the systems and AAL services.

The personas are representations of a group of potential users who have characteristics, needs and objectives. The personas, despite being fictional characters, are based on data obtained from the observation of the target population, including the characterization through the questionnaires already mentioned. Although the personas are fictitious should be defined with rigor and precision [22]. The details are important to the effective adequacy of the resulting systems and services to potential users.

In the context of development of AAL systems and services, in which the potential users are older adults, health conditions have a great importance and, therefore, within the LUL, the personas were created taking the ICF as a reference.

Evaluation instruments for the prototype and pilot phases were also developed according to the ICF framework. This allows: i) the use of concepts related with functioning, in particular body structures body functions, activities, participation or personal and environmental factors; ii) to consider relevant aspects related with health condition that may constrain the use of the systems or services; iii) to consider the type of activities; iv) to consider the type of participation, *i.e.* involvement of the person in real life situations.

Since ICF qualifies environmental factors as facilitators or barriers, the developed instruments intend to identify whether a specific interaction mechanism acts as a facilitator or a barrier. Whenever a facilitator or a barrier is identified, additional information must be recorded (open response) in order to understand what should be modified. This procedure must be performed for all facilitators and barriers identified.

For validation purposes, those instruments were applied for the evaluation of an experimental telerehabilitation service with multimodal interaction [23]. The instruments have proved to be more suitable to identify barriers and less to identify facilitators.

4 Conclusions

Currently, the developed ICF based evaluation framework is being applied to evaluate several AAL systems and services in different scenarios of use. This will contribute to validate the developed evaluation model in different contexts. Moreover, it is foreseen future development of additional instruments, namely for the pilot test.

Another on-going work is related to users modelling. Although there might be the need to complete ICF with additional concepts, it can help to overcome a recurring problem that is the lack of data to create robust user models. Properly safeguarding ethical issues, the ICF can allow almost unlimited access to appropriate information properly encoded.

Effective and efficient solutions that meet the challenges of the AAL must combine forces on the part of society and on the part of the technology [24]. This requires semantic models to structure the different AAL services and thereby facilitate their reuse. In this particular, the conceptual structure associated with the ICF can be useful for solving critical aspects related to the organization of services. Once the activities and participation justifies the use of AAL services, ICF can and should be used to build semantic models to structure, classify and catalogue these services. For that an ICF based ontology can be used. This ontology can enhance the semantic interoperability and also facilitate the generation of knowledge: the existence of universally accepted conceptual models, concepts, terminology and information codes allows the aggregation and consolidation of the available information, which is essential for strategic planners, technological innovators, care providers and users involved in the design and development of AAL services.

Acknowledgements

This work was supported by QREN Living Usability Lab for Next Generation Networks and QREN AAL4ALL from COMPETE and FEDER (European Union).

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-865

Mixed Technical and Market Evaluation of Home Automation Networks for AAL Solutions

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Abstract. The demographics are experiencing an elderly population growth. One of the main concerns, due to this growth, is the cost of elderly care which is rapidly rising. Ambient Assisted Living (AAL) has been proposed as a solution for independent ageing in place, reducing the care costs and improving the quality of life of the elderly. Alongside with the benefits like tele-care, health monitoring, and assistance in activities of daily living, ambient intelligence in smart homes offers another important service which is home control. The right choice of the home automation (HA) technology is crucial for an effective home control. This is challenging in a dynamic and competitive HA market with several standards and alliances. A long-term investment on an HA solution requires not only technical evaluation but also a market evaluation of existing technologies and an understanding of how it will be shaped in future. In this work we searched for mixed technical and market indicators in order to evaluate HA technologies and base our smart home platform on it.

Keywords. Home automation protocols, technical-financial evaluation, ambient assisted living, smart home.

1. Introduction

The demographics are experiencing an elderly population growth. Based on United Nations study[1], the population of elderly aged over 60 is projected to be 2 billion in 2050, more than three times the number in 2000, comprising more than two in five persons. Population ageing is characterized by attributes like *unprecedented*, *pervasive*, and *enduring*[1]. One of the main concerns, due to this growth, is the rapidly rising of the elderly care cost. On one hand, health-care facilities will be too costly for families with middle income to afford, while, on the other hand, government policies might favor less support for the elderly to reduce expenses. Ambient Assisted Living (AAL) has been proposed as a solution for independent ageing in place, reducing the care costs and improving the quality of life of the elderly[2]. As defined by the Ambient Assisted Living European Joint Programme, AAL concerns benefiting from Information and Communication

Technology to make it possible for elderly and disabled people to live independently at their homes with an improved quality of life[3].

Alongside with the benefits like tele-care, health monitoring, and assistance in activities of daily living, ambient intelligence in smart homes offers another important service which is home control. Home control enables the residents of a house to efficiently control domestic functionalities like lighting, shutters and blinds, HVAC system, alarms and security, etc. An effective home control solution relies on the right choice of the home automation (HA) technology. The HA market is a very dynamic one with competing standards and alliances. Thus, the authors believe that a simple technical evaluation of HA technologies is not sufficient to identify the best solution, but, rather a mixed technical and market evaluation is necessary.

This work proposes a methodology to choose the appropriate home automation solution based on both technical and market criteria. The main idea is to include non-technical criteria (e.g. the chances of growth in future of a specific technology) in the decision making process. This matters, since nobody would like to make a long-term investment on a technology which has lower chances of survival in the market because of a stronger competitor, despite some possibly slight technical advantages. In the following, a quick technical review of HA protocols is presented; then, the methodology is explained in detail.

2. Home Automation Protocols

There are numerous solutions for implementation of a domotic system in terms of communication protocols and the underlying network. Choosing the right solution is not trivial as multiple factors are involved in the choice. Lightness and low-cost factors (e.g. Z-Wave[4]), interoperability (e.g. KNX[5]), energy harvesting (e.g. EnOcean[6]) besides data rate, topology, network size and communication medium are among the important factors.

Today most important WHANs (Wireless Home Automation Networks) are Z-wave, ZigBee, 6LowPAN, Insteon, Wavenis, EnOcean and MiWi[7,8]. Each protocol has its own alliance of supporting manufacturers which are competing to become the standard solution in the market. Most important Home Automation Networks (HAN) based on busfield technology are KNX(successor of EIB), BACnet, LonWorks, X10, Profibus, Modbus, CANOpen, Universal Powerline Bus, CEBus, C-Bus and 1-Wire. These communication systems are mainly based on twisted pair and power line medium. Some of them like KNX and X10 have been developed for residential and home automation while others have general usage both in industry and home environments.

As each of these technologies offers some specific advantages over others, and due to the vast heterogeneity of solutions for low level and high level protocols, an integration mechanism seems another inviting approach. Zamora et al.[9] have proposed a home automation module which supports X10, Ethernet, KNX, CAN, Zigbee, Bluetooth and Cellular network. Elshani et al.[10] propose a universal domotics integrator mainly based on UPnP. In such network all home appliances and networks are connected and interoperate. It covers HVAC, Audio/Video, Internet Gateways, Telephony, Electrical Installations, Game consoles, PCs, etc. As for home automation, a server connected to a client PC is suggested, with gateways to X10, Insteon and EHS. Liang et al.[11] put forth another integration internet-based approach for home automation system. Their solution is a high-level multi-agent solution. Wu et al.[12] propose a mobile agent based solution for home control architecture. They mention high traffic load of centralized control, dynamics of the environment and the diversity of the control networks as their motivation for their mobile agent based solution. Stefanov et al.[13] list the requirements of a smart home for aged people based on such solutions: automation and control of home, assistive devices, health monitoring devices, information exchange systems and leisure devices.

3. Methodology

As depicted in Figure 1, the methodology employed is based on a two-phase procedure to choose the right technology. In the first phase, the technical one, a pool of possibilities comprising all the available home automation technologies is created. This pool is filtered by the fundamental technical requirements, resulting in a subset of the available solutions, namely, the technically acceptable solutions. Fundamental technical requirements are the main protocol characteristics without which it is not possible to develop the desired automation. For example, *being wired and using powerline medium due to installation constraints*, could be such fundamental criteria by enforcing which it is possible to rule out some availabilities. The criteria should be chosen in a way that the outputs of the first phase are technically equivalent.

This subset is now fed into the second phase of the procedure, the market evaluation. For the market evaluation, in the first step, main manufacturer(s) for each protocol are identified. Then, two main information are extracted from their financial documents in the last year: the revenue of the company and the total number of employees. A score is given to each protocol by averaging over the normalized revenues of corresponding companies. Normalization of revenues is done with respect to the number of employees as an indicator of their size. Since all companies belong to the same industry sector, namely semiconductor industry, it is meaningful to compare their scores to get an idea of their position in the market.

This very simple procedure could be refined by iterations over the two phases to modify the fundamental technical requirements in order to be sure that the outputs are truly technically equivalent from the user's application point of view.

In order to have an idea of the general technical and financial settings in the year 2012, the following was done. At the very beginning step, a pool of 14 wired and 11 wireless Home Automation protocols was created. Subsequently, they were analysed based on their gross technical characteristics mainly related to their residential or building/industrial application. Figure 2 illustrates the outcome of this technical evaluation procedure. Secondly, financial documents of 20 manufacturers were consulted to extract their revenue and total number of employees in 2012. Table 1 summarises the scores

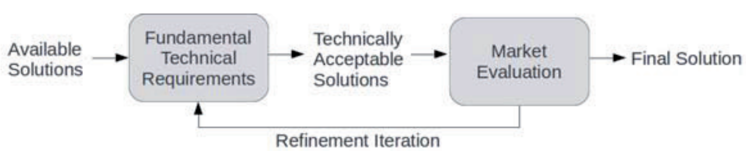

Figure 1. Methodology Scheme.

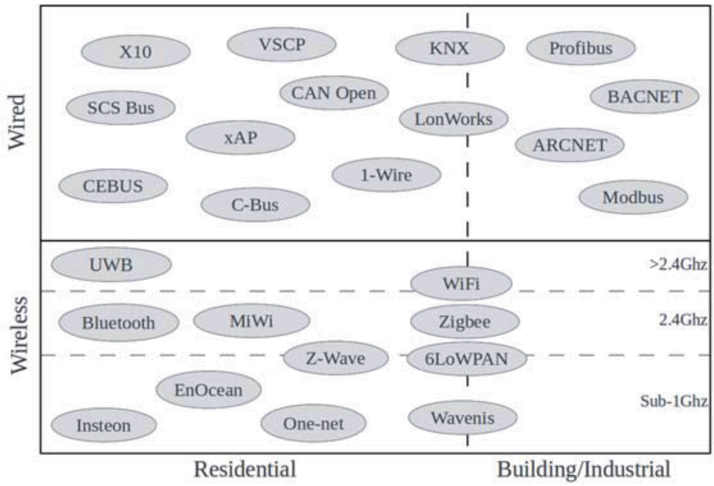

Figure 2. Outcome of the Technical Phase.

for each protocol along with its main technical characteristics. For some protocols the financial information was not available. These information serve as main inputs for the methodology.

4. Results

In order to show how to benefit from the methodology, we put forth an example. For our research purposes, we would like to build a demo room as a simplification of a smart home for elderly people. We set our minimum technical requirements for the first iteration: *a wireless solution in sub-1GHz frequency band for residential applications*. The grey shaded rows of the Table 1 are the protocols which pass. We decided that the three last protocols lost their chance, while further inspection was needed for the three first protocols: 6LoWPAN, Z-Wave, and Zigbee. The main distinct technical characteristic of 6LoWPAN is its natural integration with internet. Therefore we thought its –possibly exaggerated– high financial score is due to this characteristic and the trendy concept of Internet of Things. Between Z-Wave and Zigbee which have closer financial scores and similar technical features, we opted to choose Z-Wave because of three reasons: its marginally higher financial score, its orientation towards smart home applications, and lower cost of products.

5. Conclusion

The main contribution of this work has been taking into consideration the important role of market factor in the field of competing smart home protocols and involving it in a simple evaluation procedure in order to make the decision taking easier and more rational. This is important especially in case of a long-term investment where future support in terms of available products and network extension is essential. This work is

Table 1. Financial Scores.

Protocol	Nature	Score	Technical Details
SCS BUS	Wired	394	Twisted pair, 9.6 kbps, Proprietary
6LoWPAN	Wireless	369	sub-1Ghz/2.4Ghz, 10-100m, 2^{64} devices, Open, No Internet gateway needed
CEBUS	Wired	269	Twisted pair/coax/fiber, 7.5kbps, Open
1-Wire	Wired	258	Twisted pair, 16.3kbps, 2^{64} devices
WiFi	Wireless	204	2.4GHz/5GHz, 100m, 54Mbps, 2007 devices, Open
UWB	Wireless	199	3.1GHz-10.6GHz, 10m, 110Mbps, 8 devices, Open
VSCP	Wired	199	Independent from Physical Layer, Open
MiWi	Wireless	197	2.4GHz, 20-50m, 256kbps, 8000 devices, Not Open
Z-Wave	Wireless	184	sub-1Ghz/2.4Ghz, 30-100m, 9.6/40/200kbps, 232 devices, Not Open
KNX	Wired	179	Powerline/Twisted pair/Ethernet, 9.6kbps, 57600 devices, Open
LonWorks	Wired	178	Twisted pair/fiber/power line, 3.6/5.4/78kbps, 32385 devices, Open
C-Bus	Wired	171	Twisted pair, upto 1Mbps, 255 devices, Open
xAP	Wired	171	RS232/RS458/Ethernet
Zigbee	Wireless	163	sub-1Ghz/2.4Ghz, 10-100m, 20/40/250kbps, 64000 devices, Not entirely open
Profibus	Wired	160	Twisted pair/fiber, 9.6kbps-12Mbps, 126 devices, Not Open
Modbus	Wired	132	Twisted pair/serial port/ethernet, 1Mbps, 247 devices, Open
ARCNET	Wired	94	Coax/twisted pair/fiber, 2.5Mbps, 255 devices, Open
Insteon	Wireless	90	sub-1Ghz, 45m, 38.4kbps, 256 devices, Not Open
BACNet	Wired	88	Twisted pair, 9.6/19.2/38.4/76.8kbps, 127 devices, Open
EnOcean	Wireless	68	sub-1Ghz, 30-300m, 125kbps, 2^{32} devices, Not Open
One-net	Wireless	46	sub-1Ghz, 60-500, 38.4kbps, Open
X10	Wired	46	Power line, 20bps, Open

part of a larger system which is getting shaped for the design of an assisted ambient living environment mainly for elderly people where costs play an important role. And thus, identification of long-term cost-effective solution was important.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-871

Evaluation of PIR-based Presence and Person Fall Detection System

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Abstract. The study has the objective of monitoring person activity at home and detect possible person falls with passive infrared sensor units. The system is targeted to alert of any abnormal activity at home, such as falls, too long visits to the toilet, unplanned leaving of the building as well as some normal activities, such as wake-ups in the morning and persons' presence and movement. Non-visual monitoring system was selected in order to respect the person's privacy. Data collection and alerts are gathered by a web-based service. The alert service is able to send alerts using SMS or a web service – XML or e-mails.

Keywords. Fall Detection, Activity Recognition, Infrared Sensor-based Fall Detection, Web-based Alarm System, Posture and Movement Recognition.

Introduction

Falling down is one of the most important factors threatening the independence of elderly citizens [1]. Fall detection has become a very active topic in the healthcare industry, and technology and products in this field are in demand. In addition to visual solutions, products for prevention or detection of a fall are wearable or based on ambience. Sensor-based approaches can be divided into three categories: detecting acceleration, floor pressure and infrared radiation. Sensor solutions might be less intrusive in a home than cameras because they do not collect visual information. There are also some disadvantages with sensors because they cannot detect multiple events simultaneously. Other than sensor-based fall detection systems are mostly based on visual information. Because spatial information has direct relevance to both posture classification and fall detection and since it is not possible to obtain reliable spatial information using omni- or mono-camera systems, multi-camera approaches, including stereo-vision techniques, have been used. However, they are computationally expensive, as they provide poor results in uniform areas and in low light conditions [2]. Due to legislation, the use of cameras for monitoring at home is prohibited in some EU countries, also in Finland.

1 Main Content

The purpose of the study is to evaluate, through iterative user-oriented research, the usability of activity and fall detection. Non-visual monitoring system was selected in

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order to respect the person's privacy. The person's presence and activity is monitored by infrared passive sensors (PIR) and wireless data collection network. The system is based on a web service portal, in which the user can browse alerts and activities received from the monitored building. Data collection and alerts are gathered by a web-based service. The alert service is able to send alerts using SMS or a web service – XML or e-mails. Also the installation can be done by anyone from the nursing staff. Installation and disassembly should be fast and should not take more than a half an hour to setup.

The fall detection system with PIR is built by using multiple sensors to create an "image" of a person at site with detection whether the person is still standing. An alert is launched once the sensor system detects that the person is in movement at floor level. The sensor system has two types of PIR sensors:

- 360-degree lens monitoring sensor, to detect presence in a space
- directed lens-monitoring sensor, to detect movement above defined height in a room

Fig. 1. The infrared sensor pair with 360 degree and directed lens-monitoring unit and wireless unit.

The room shape and furniture will define the number of sensors and their positioning. The 360-sensors can be placed high or even to the sealing to gain the widest possible view of the room. All 360-sensors are handled as a single "eye" to the room (fig. 1). Directed types of sensors are for monitoring movement in a space above the defined height from the floor level. The functionality of horizontal monitoring above the specified height can be achieved by covering the upper half of the sensor lens.

At first phase of our study alarm was launched when directed type of sensor wasn't not receiving infrared radiation but 360 degree sensor at ceiling was receiving it. The system interpreted situation so that a person was lying on the floor. A delay of sending alarm message was 30 seconds.

Our study is part of a joint project including the Tampere University of Technology Rauma Unit, Tappit Technologies Ltd. and Satakunta University of Applied Sciences, User-centered Building Environment Research Project (in Finnish KÄKI).

The most important contribution of this study is to increase the safety, autonomy and possibilities to extend the independent life of the elderly with them loosing their autonomy and privacy as minimum as possible. Through iterative design process, we want to support the innovations and product development of the business network operating in this field. The costs of passive infrared sensors are quite low and it might also be possible to develop an end-user product.

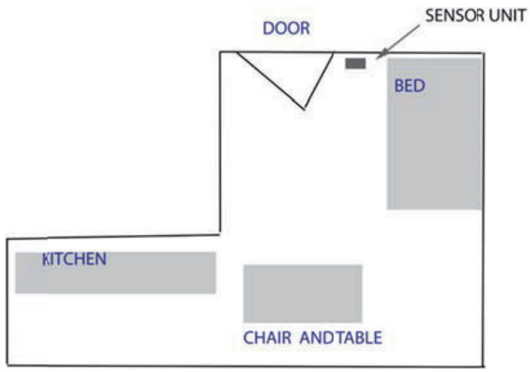

Fig. 2. Placing of sensor unit at test room.

1.1 Methodology

The usability and reliability of the system was evaluated in Living lab conditions in Pappilanlampi Elderly Care Service Center. The system was installed into resident's room over three month. It was critically evaluated by iterative process and one survey carried out among the nursing staff. The user-oriented research was implemented iteratively in a way that it is possible to make necessary modifications to the Living Lab apartment and to re-evaluate the process between the staff and the designers. The interactive evaluation process included free form interviews of the staff and one group discussion.

1.2 Results

Preliminary findings based on the survey demonstrate that the system was too responsive during the first phase and the nursing staff received too many wrong alarms. We also found out that the sensor placing in the room is critical, as the sensor should be placed according to the person and behavior. For example, our test person could sit still even an hour beside a table and this inaction caused a false alarm. It was also concluded that passive infrared sensors are not suitable in a space where there are pets, for example dogs, or persons more than one. Using only one PIR pair unit it was not able cover entire room because table covertops and other furniture caused blind spots for directed type sensor. The placing of the unit was lower than table covertop.

Regardless of this, there were a lot of usability problems, since the nursing staff thought that the system could ease their daily work in the center. Another result from the first questionnaire was that the logic (if alarm is not received or it is not answered) of the alarm system must be redesigned. There were also some problems due to the phones' interface, which was designed for touch screen smart phones not working with rubber gloves used by the staff.

1.3 Further Work

For covering entire space there should be more than one directed type and 360 degree sensors. Using more than one sensor pair unit it is possible to produce a single type of view from entire room. To reduce false alarms the system will also verify if there is recognized movement on the other directed type sensors if a one loose information from the specified level.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-875

Turning off or Turning on?: Two Different Ways to Use a Baby Seal Shaped Robot Paro in Occupational Therapy for Patients with Dementia

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Abstract. The objective of this research is to see the difference between the effect of a stuffed animal and that of an animal shaped robot in occupational therapy. PARO, a baby seal shaped robot, is a sophisticated robot. It responds to users' actions and even remembers particular interactions. Thus, this robot is certainly different from a stuffed animal, yet unlike an alive pet (whose behaviors can be unpredictable), its responses are programmed and controlled. PARO is "inanimate" but interactive like a pet and not passive like a stuffed animal. Our team wanted to see how patients with dementia would react to PARO in comparison to a stuffed animal and what the difference (if there is any) may imply. We concluded that the effectiveness of robot therapy is different from occupational therapy with "inanimate objects," such as stuffed animals. Robot therapy can encourage patients with dementia to be more self-directive.

Keywords. Robot, PARO, Dementia, Occupational Therapy.

Introduction

PARO is a therapeutic robot modeled after a baby harp seal, developed by National Institute of Advanced Industrial Science and Technology (AIST). Takanori Shibata is its chief creator. Robot therapy with an interactive robot like PARO enables similar effects as in animal-assisted therapy, without worrying about safety and hygienic issues.

The number of people suffering from dementia in Japan is about 4.62 million in 2012, according to the Health, Labor and Welfare Ministry (June 6, 2013) [1]. Symptoms of dementia are classified as core symptoms and Behavioral and Psychological Symptoms of Dementia, that is, BPSD. Caregivers of dementia patients is always striving to eliminate as many BPSD as possible or to prevent them from getting worse.

A substantial number of reports showed that PARO can improve BPSD. For example, Patrizia Marti and Kazuyoshi Wada showed in their research that the use of PARO improved dementia patients' communication and sociability and even alleviated their depression [2][3]. The team had a daycare center with nine dementia patients incorporate a therapeutic activity with PARO as part of the daily routine. During the testing period, their urine samples were checked for hormone values (17-KS-S and the

17-KS-S/17-OHCS ratio). The results show that the level of the patients' stress decreased at the ends of the second week and the fourth week. [4]

In a more recent study, a research team led by Wendy Moyle conducted a small scale Randomized Controlled Trial (RCT) with PARO and proved that a group whose members interacted with PARO won highest pleasure scores [5].

The objective of this present research is to see the difference between the effect of a stuffed animal and that of an animal shaped robot in occupational therapy. It is known that the use of toys, such as balls and stuffed animals, can energize patients with dementia, allowing them to become more social. Meanwhile, several studies have proved the effectiveness of robot therapy to treat dementia patients. But how is it really different from a therapy with a stuffed animal? This question led us to the present research: we had dementia patients interact with PARO when its switch was turned on and compared that with when turned off. Certainly, PARO is heavier and slightly bulkier than a regular stuffed animal of the same size, but we decided not to use a stuffed animal because our primary purpose was to see if the interactive aspects of the robot would affect patients in a positive manner or not.

PARO is a sophisticated robot which can respond to users' actions and even remembers particular interactions in the past. PARO is "inanimate" but responsive and interactive like an alive pet and far more active than a stuffed animal. Our team wanted to see how patients with dementia would react to PARO, comparing it with the time when the robot is turned off, used like a stuffed animal.

Fig. 1. PARO (National Institute of Advanced Industrial Science and Technology: AIST).

1 Methodology

Our research team let seven seniors with dementia (six women and one man) play with PARO at their nursing home. We compared their reactions when the robot was turned off (as a stuffed animal) and when it was turned on (as a robot). Dementia Care Mapping (version 8.0) was used to measure their Mood-Engagement (ME) values. The reason we employed DCM for this research was that it is the only evaluation method that can provide qualitative and quantitative data on dementia patients. DCM is an observational tool developed by Dr. Tom Kitwood and the Bradford Dementia Group in UK to evaluate the quality of care for people with a dementia. It seeks to understand the care experience through the eyes of a person with a dementia.

We conducted our tests on May 26 and June 2, 2011, for seven hours each, from 9:00 a.m. to 4:00 p.m. Three DCM mappers (two care-giving professionals and one occupational therapist) observed the patients' behaviors.

Usually, a DCM examination consists of continual observations of a person over a sustained period of time (ordinarily 6 hours). Each segment (every 5 min) is assigned an activity code (for example sleeping, walking, etc) and another code indicating the level of well-being or ill-being the person appears to be in while carrying out that activity. WIB Score is divided into six levels: +5 (very good), +3, +1(Neutral), -1, -3, -5 (very bad).

This research was the first opportunity for the seven seniors who participated in this study to interact with PARO. On May 26, our team observed them without the robot, and on June 2, with the robot. We turned it on from 9:00 a.m. to 12:00 p.m. and turned it off from 1:00 to 4:00 p.m.

2 Results

The result shows that when it was turned on, the robot elicited more interactive responses from the patients, and much higher WIB values were recorded during the period when the robot was on than that when the robot was off.

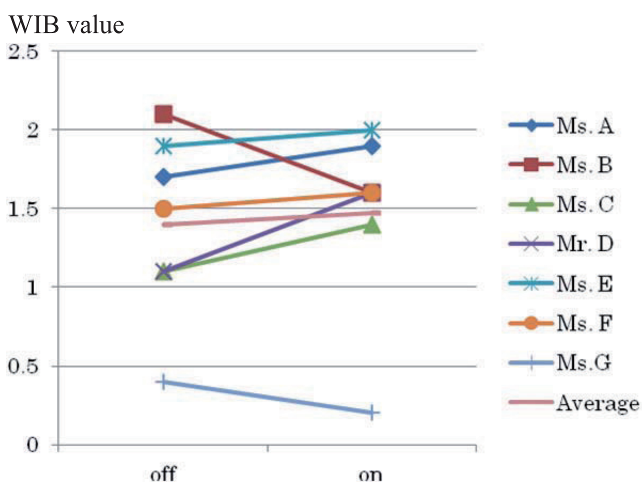

Fig. 2. DCM of seven dementia patients.

+1: Mood: Neutral. Absence of overt signs of positive or negative mood. Engagement: alert and focused on surroundings. Brief or intermittent engagement.
WIB Value

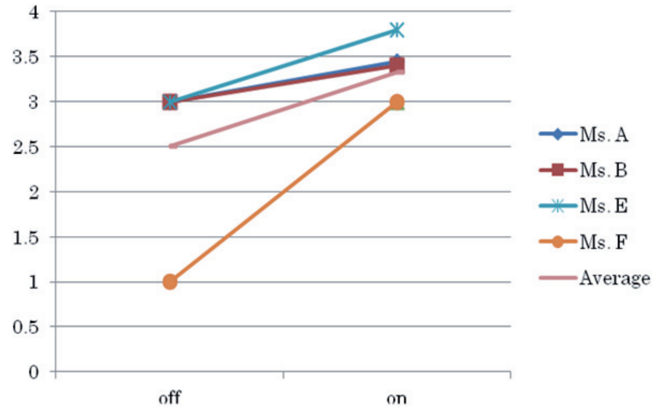

Fig. 3. WIB Score of dementia patients with “O”.

Some of the patients talked to the robot and even cradled it to sleep. The use of PARO reduced the scores of the category "C" (Cool: Being disengaged, withdrawn) and improved "A" (Articulation: Interacting with others verbally or otherwise – with no obvious accompanying activity) and "O" (Objects: Displaying attachment to or relating to inanimate objects). PARO provided the patients a great opportunity to establish a relationship with the "object," allowing them to become more social with other members in the room.

Four people who scored “O” showed better reactions to PARO when it was turned on than when it was turned off. Ms. C did not touch PARO when it was off, but she showed a great interest when it was on. Ms. D and Ms. E earned good scores when the robot was on, but the result was not directly related to the activities associated with PARO.

The overall *average* WIB scores did not show an acute difference between when it was turned off and when it was turned on, but when it was on, the patients clearly marked higher WIB scores than when it was off. Aside from the actual WIB scores, it is important to note that the qualities of patients' behaviors were distinct. For example, some of them began talking to the robot and even started a small conversation with others about the robot. One patient hugged the PARO tightly and jokingly said, "I will never let him go." This type of warm attachment was much more present among the five patients (one failed to show any interest) when the robot was on.

3 Discussion

These results prove that five out of the seven patients earned high WIB scores, and the remaining two showed earned low scores. They failed to enjoy playing with PARO, and one of them even disliked any interaction with staff members. It can be said that not all patients enjoy activities associated with PARO. Also, we have to add that DCM has some minor setbacks as a research tool. For example, a typical DCM analysis averages each patient’s activities throughout the day. That is why it is sometimes hard to detect slight differences taken place in each activity. Additional observations are necessary to make up for it.

When PARO was off, that is, when PARO was used as a stuffed animal (an inanimate object), it was able to encourage communication between the patients and the occupational therapists. When PARO was on, that is, when it was used as a robot with responsive abilities, it was able to encourage not only communication between the patients and the occupational therapist, but also communication between the patients and the robot (“object”). Scoring high on the category “O” means crucial for dementia patients because even a simple play with a toy or a stuffed animal allows them to become more proactive, less passive. Occupational therapists’ goal is to find an effective way to make dementia patients more self-initiative. The four patients who earned high scores on the category “O” when the robot was on. This means that when PARO was used as an interactive robot, as opposed to an inanimate object, it inspired the patients most so that they could enjoy and concentrate on activities.

4 Conclusions

We strongly believe that PARO is effective to treat seniors with dementia. Unlike a stuffed animal (an “inanimate object”), PARO reacts to patients' speech and touch so that it can encourage them to become more interactive and even self-directive. Through this unique tool, we also may discover overlooked or unnoticed sides of dementia patients, which can improve further occupational therapy and dementia treatment.

As shown in this study, some seniors pay less attention to PARO. We need to investigate which aspects of the robot or the method of the robot therapy fail to attract (or succeed to attract) dementia patients, and what kinds of robot therapy are most effective to treat dementia patients.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-880

Comparing Robots with Robot Agents as Information-Support Systems for the Elderly and Those with Mild Dementia

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Abstract. *Background:* The use of robots for providing support to persons with dementia is very promising. In this paper, we propose an information-support robot for persons with memory and cognitive impairments, using field-based methodology. To date, it is not been made clear why a physical robot is more effective than an on-screen agent in presenting information, or what effect this has on the recipient. *Objective*: The purpose of this study is to clarify the effect of the form and type of the two devices used in communication. To do this, comparative experiments using a physical robot and a robot agent were conducted with healthy elderly people and person with mild dementia. *Method:* A communication robot/agent system produced by NEC Corporation, called "PaPeRo®," was chosen as the platform for this system. The comparative experiment design was a between-group design (robot vs. agent; elderly vs. dementia). Sixteen information tasks were set during an interference task in each case. *Result:* The results of experiments conducted with 13 elderly people and 5 person with dementia showed that the average rates of information acquisition of a Robot/Agent with mentally healthy elderly people were 65.5%/66.2%, and 62.5%/55.8% for the person with mild dementia. The participants demonstrated awareness, attention, understanding, replies, and actions to the Robot/Agent 43.3%/47.1% of the time for the healthy elderly people, and 45.0%/41.3% of the time for person with dementia. *Conclusions:* These results suggest that a physical robot is more suitable and more effective than a robot agent for a person who is suffering a decrease in cognitive and attention functions.

Keywords. Assistive Technology, Communication Robot, Cognitive Function, Verbal Communication, Assistive Robots.

Introduction

A robot has a closely allied form and function to a human being and other animals, and these similarities help build a relationship of a close connection marked by a community of interest or similarity in nature or character [1]. This "affinity" function of a robot interface offers an advantage in robot-human interaction. The factors of the characteristics of such an affinity interface include interaction by verbal means, contact, nodding of the head, and expression. One example of such a therapy interface is therapy robots. Many kinds of robots have been developed recently in Japan to provide a therapeutic effect through communication with the elderly, for example, a mental commitment "PARO®" that is

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designed to provide a psychological, physiological and social effect [2], and a communication robot "palro®"[3] that is designed to provide communication by conversation.

We have developed, using field-based methodology, the information-support robot shown in Figure 1 for elderly people who are forgetful, or have mild dementia and mild cognitive impairment (MCI). Figure 2 shows an example of experiment scene of an elderly lady. The proposed information-support robot supplies a daily schedule to such people and prompts them into action. Moreover, interactive verbal communication algorithms were programmed into the robot system and interference experiments showed the possibility of using this robot to support independent living by five persons with dementia [4]. It is interesting that there was characteristic behavior toward the robot when it provided useful information. One participant gradually personified the robot as a five-year-old boy during such interventions. This suggests that the robot has the potential to pay attention to the needs of and provide support to users with an affinity like that of human caregivers.

However, the effect of using an entity to provide an information-support system for elderly users has not been clarified. If an on-screen agent and a tablet PC could prove up to the task of getting the attention of users and conveying information, this would reduce the cost of hardware development. On the other hand, if a robot is more effective than other devices because there is a sense that it is an entity, this fact will become important evidence in developing information systems for the elderly and those with mild dementia. Many studies comparing robots and agents have been conducted [5][6], however, these comparisons have rarely used as subjects elderly people, with or without dementia.

The purpose of this study is to clarify the effect of the form and type of each device used in communication, and conduct comparative experiments using the robot and agent with the elderly and one elderly person with dementia. In the latter case, we focused on the decrease in "shift attention" of dementia, that means returning from the interruption of other tasks.

Fig. 1. PaPeRo® (NEC) [3].

Fig. 2. An experiment scene.

1 Method

1.1 Experiment Design and Participant

The comparative experiment design was a between-group design (robot vs. agent; elderly vs. dementia). The experiment was also designed to compare the robot and agent in consideration of order effects. In the robot experiment, the participant interacted with the robot (Figure 2a) and in the agent's, the participant interacted with a 21-inch display

(Figure 2b). Each device was positioned 1.5 [m] from the participant.

We recruited 9 elderly participants (4 male and 5 female) from a community in the Silver Human Resources Center. The participants' age rang are from 65 to77 years old. In addition 8 patients (5 male and 3 female) in a dementia care clinic and 1 participant (male) with mild cognitive dementia from acquaintance who measures over 0.5 score by CDR[7] were also hired. The participants ranging in area from 71 to 83. 9 patients were diagnosis of AD (Alzheimer's Disease) and other patients were diagnosis of VaD. In this study, mini-mental state examination (MMSE[8]) was adapted for criteria of either healthy or dementia, although 8 participants (patients under medical care) were diagnosed mild dementia or MCI. The cutoff point whether dementia or not is 24/30 of the score of MMSE. 13 elderly participants were with in normal range from 25/30 to 30/30 and 5 participants were with in suspicion of mild dementia (or MCI) range from 16/30 to 24/30.

1.2 Procedure

First, the experimenter described the experiment to each participant. After obtaining informed consent, the experimenter administered a standardized questionnaire. Three cognitive functions: cognitive function (MMSE), attentional function ('Kanahiroi' test[9] is multi cancellation test which is chosen as the task requiring attention control to distract the Robot/Agent), and auditory function were measured by the experimenter. Based on the result of the auditory test, a Robot/Agent volume level of around 60 [dB] was set for each participant, while the background noise level was measured as being 30 [dB].

The intervention task was the same as the attentional function (the Kanahiroi test) in which the participant selects some *hiragana* character from an old Japanese story. The Visual Cancellation Task (subpart of CAT[10]) also intervention task was used more easy intervention task for the MCI or mild dementia instead of Kanahiroi test. During the experiments, the Robot/Agent talks and asked 16 questions during four tasks. Task *A* was related to the intervention task, and question *a* was related to the intervention task; the error correction task *B*, *C* were not related to the intervention task, the question *b* that not related to the intervention task. These tasks and questions were spoken 16 times in 15 minutes at equal intervals. Sample of the tasks and questions are shown in Table 1.

The experimenter told the participant; "perform this task and if you received a 'question' from the Robot/Agent while you are doing tasks, please answer it". It was expected that some participants would select only to perform intervention task, the experimenter added to tell "the task of Kanahiroi test scored 5 points in each word and each question from Robot/Agent answered correctly while performing a task scored 30 bonus points."

Our protocol was approved by the NRCD and School of Engineering the University of Tokyo IRB for human studies.

Table 1. Example of speech tasks and questions by the Robot.

Task/Question No.	Speech of task and question
Task *A*	▪ Would you change the pen to a red one? ▪ Would you change the pen to a blue one?
Task *B*	▪ Would you put the cap on the pen? ▪ Please drink a cup of tea.
Question *a*	▪ Have you done these tasks? ▪ Do you know the story?
Question *b*	▪ What day is today? ▪ What kind of food do you like?

1.3 Equipment

Figure 2*a* shows the communication robot called "PaPeRo®". The robot is equipped with speech recognition, speech synthesis, facial-image recognition, autonomous mobility, head motion, light indication functions, and tactile sensors. The robot agent was displayed on a 21-inch LCD as shown in Figure 2*b*. Both the Robot and the Agent had the same male voice, and the volume was set to match the hearing ability of each participant.

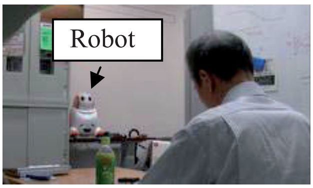

Fig. 2a. Robot.

Fig. 2b. Robot Agent.

2 Experiment Result

The evaluation methodology was based on observations of the participants via a video camera and an IC recorder. Figure 3*a* and 3*b* show the Robot/Agent experiment scene at the clinic. The five evaluation items were: (a) awareness, (b) attention, (c) understand, (d) reply, (e) action. Each rate was calculated from the video data. The definition of each item was determined as follow: (a) awareness is to react to the question, (b) attention is to stare at the target for more than a few seconds, (c) understand is to have a good understanding of what the robot/agent is saying*, (d) reply is to respond to the questions of the Robot/Agent, (e) action is to act in accordance with the instructions from the Robot/Agent. Moreover, the rate for each item was calculated as follow:

e.g.

$$R_{awareness} = \text{(awareness times)/n (n=16 times)} \qquad (1)$$

Table 2 shows the results for each experiment about Robot vs. Agent. Figure 4 shows the results for each evaluation item about elderly vs. mild dementia (MMSE score; over 25 vs. under 24).

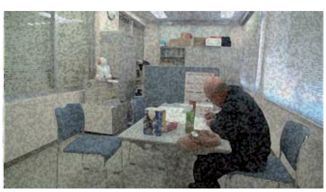

Fig. 3a. Robot (at the clinic).

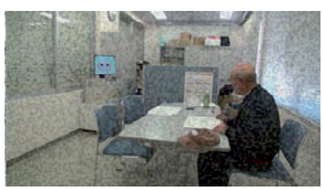

Fig. 3b. Robot agent (at the clinic).

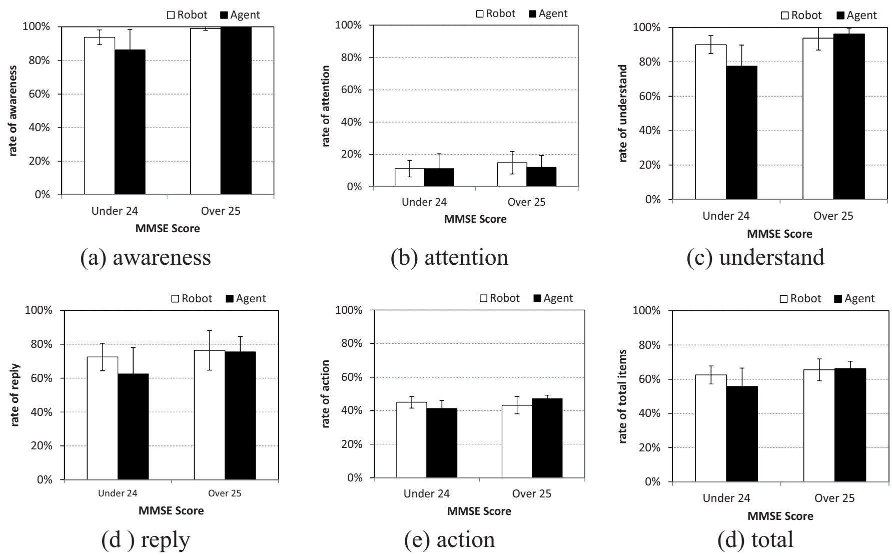

Fig. 4. Results for each evaluation item (MMSE score; under 24 vs. over 25).

The comparison of 'Robot' vs. 'Agent' showed no significant differences (Welch's t test), but the rate of each items of robot tend to be little higher than agent. Moreover, the comparison of 'Under 24' vs. 'Over 25' showed no significant differences (Welch's t test), but the rate of each items of robot tend to be little higher than agent.

Table 2. Results for each evaluation item (Robot vs. Agent).

Device	(a) awareness	(b) attention	(c) understand	(d) reply	(e) action
Robot	97.6%	13.9%	92.7%	75.3%	43.8%
Agent	96.2%	11.8%	91.0%	71.9%	45.5%

*(c)Understand: When a participant couldn't accomplish an instruction from the Robot/Agent and also a reply from him/her didn't indicate that he/she understood an utterance of the Robot/Agent, we interpreted the situation "Not understanding". For example, when a participant who is instructed to hold a blue pen cannot find blue pen and says "There's no blue pen", this situation is interpreted as)

3 Discussion

Table 3 shows the results of each performance of D5 and D2. Decrease of attentional function was found on the participant D5 (MMSE 24), who is with the lowest rate of total score in the participants. The participants showed unawareness on over a half percent of questions and tasks from each device, specifically over 75% of questions and tasks from agent were unaware of. Participant D5 looked at Robot/Agent for a second, but not paid close attention to them when they talked to the participant. On the other hand, the scores in regards to 'understand', 'reply' and 'action' of robot tend to be little higher than agent. The participant D2 (MMSE 19) with the lower rate of total score were found to take longer time of visual cancellation task test. The rate of 'awareness' and 'attention' of agent tended to be little higher than robot.

On the other hand, the rate of 'reply', 'understand' and 'action' of robot tented to be little higher than agent. These results suggest that the participants are merely being able to follow the instructions from the device unnecessarily if they are possible to pay attention, and it's ready to receive information if the patients even notice. The number of times to pay attention was significantly lower in overall. This result shows that it is because the operation for switching attention to stop the work of the task in, see the gaze target did not show up, and because stimulation of the intervention task was too strong. The participant D1 (MMSE 16) with the lowest score of MMSE in the whole participants was thought to be scored the lowest of each item. However, the participant D1, since the performance of each item is high even compared to D2 and D5, it is necessary to indicate that these evaluation items of figure 4 (MMSE score; under 24 vs. over 25); (a) awareness (b) attention (c) understand (d) reply (e) action (d) total are rather than a cognitive ability, and the study of sub-items, for example the function and memory was found.

Table 3. Results for each evaluation item (D5, D2).

ID		(a) awareness	(b) attention	(c) understand	(d) reply	(e) action
D5	Robot	46.7%	0.0%	46.7%	30.0%	20.0%
	Agent	23.3%	0.0%	23.3%	10.0%	16.7%
D2	Robot	81.3%	18.8%	75.0%	75.0%	37.5%
	Agent	87.5%	43.8%	62.5%	50.0%	31.3%

4 Conclusions

In this study, we compared two devices—a robot and a robot agent—as information-support robots for the elderly and people with mild dementia. In the results of experiments conducted with 18 elderly persons, there is likelihood that it has become hard for the individuals to recognize the fact that the display is a device to receive information. Also, to respond in "tuning in" to a sound indicated that the participants receive information slow. In addition, there is a possibility that the participants merely recognize the display as a "picture panel" and not providing them information because of declined attention functions, their reactions against the display were small. In future work, we will focus on analyzing not only attentional function but also other sub items.

Acknowledgements

We would like to thank the participants and Seikatsu Kagaku Un-Ei Co., Ltd. for their invaluable contributions to the insights in this work. This research was partially supported by the Japan Science and Technology Agency, JST, under its Strategic Promotion of Innovative Research and Development Program.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-887

An Affordable Anti Rollback Brake for Wheelchairs

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Abstract. Each year, hundreds of thousands of elderly or disabled patients across the world, that use wheelchairs, fall during the attempt to stand up from the wheelchair. The main cause of these falls is the fact that either the caregiver or the patient himself forgot to engage the brakes. While standing up the patient exerts load backwards and as a result the free wheelchair rolls back and the patient loses balance and fall on his back or his side. As a result elderly people are seriously injured due to this falls which in severe cases may lead to patient's death.
The goal of this paper is to present a practical solution of an affordable anti rollback brake for wheelchairs that can be either operate as an add-on device on existing wheelchairs or be part of a new wheelchair. This brake engages automatically when there is an attempt to push back the wheelchair.

Keywords. Anti Roll-back Brake, Wheelchair Brake, Wheelchair-related Accidents, Wheelchair-related Falls, Wheelchair Safety.

Introduction

Hundreds of thousands of elderly and disabled people fall each year from wheelchairs across the world. These falls cause severe injuries and in some events may cause even death. National data in the US estimate that between 1.6 and 2.2 million Americans rely on wheelchairs to assist with mobility impairments. In 2003, more than 100 000 wheelchair related injuries were treated in emergency departments in the US. Tips and falls accounted for 65–80% of injuries across all age groups of wheelchair users. Injuries among adult users were more likely to occur in homes, hospitals, and institutions (45–90%) [1]. We assume that these numbers approximately represent the situation in Europe. Annual mortality statistics as a result of falling from a wheelchair shows that 154 people died in the US, 42 in Germany, 28 in Japan and overall above 100 people across Europe [2]. An overview of the current data on wheelchair-related falls in the US and some recommendations for avenues for improved quality of care is presented in the literature [3, 4].

There are several types of anti rollback brakes on the market, some of them are for the young or independent users. For example, to avoid back-motion of the wheelchair when the person climbs a hill and decides to rest. [5]

Other solutions are for patients that need caregiver assistance. [6, 7] However, most solutions are relatively expensive i.e. in the range of $250-$350 and above.

Anti rollback brakes for wheelchairs are not available in Israel, although many users get injured due to backward falls. The goal of this paper is to present a design process of a simple and **affordable** brake system. Searching the Israeli market we learned that the price of a basic "institutional" wheelchair in Israel is in the range of $200-$400. In order to encourage institutions and private clients to use our solution, our target cost for an add-on brake system production was **under $50**.

The paper presents the ideas, the design concepts and the final solution.

1 The Design of an Anti Rollback Brake

Our anti rollback brake was developed for a population of elderly patients that resides at hospices, hospitals or at home, those that need attendant assistance. Patients or their assistants often forget to apply the brakes before standing up. The anti rollback system should prevent accidents by locking the wheels automatically when the patient stand up and applies backward load on the wheelchair.

Additional key specifications for the design of the wheelchair were:

- The system should be fully mechanical without any use of batteries.
- Should fit all "institutional" standard wheelchairs and capable to be attached as an "add-on" system to an existing wheelchair without reducing any of its existing functions or features.
- The weight of a patient up to 110 Kgf.
- Additional weight of the brake should be below 2 Kgf.
- Backward motion should be allowed when operated by the caregiver.
- Brakes production cost below $50 per wheelchair.

The design, built and test of the anti rollback brake was part of an annual students' project at the Mechanical Engineering department at the Technion. During the first year, a team of senior students came up with eight different design concept of an anti rollback brake. The concept that was selected was a braking wheel with an eccentric pivot mounting as shown in Fig. 1. The wheel was free to slide on the wheelchair wheel in a forward motion. In an attempt of backward motion the wheel was immediately engaged due to its weight and the friction between the two wheels and stopped the wheelchair from rollback at once. The free body diagram of the eccentric wheel during the braking action is shown in Fig. 2. One can easily observe that the brake "actuating force" is the weight of the eccentric wheel.

Fig. 1. Eccentric wheel solution of 1st year team.

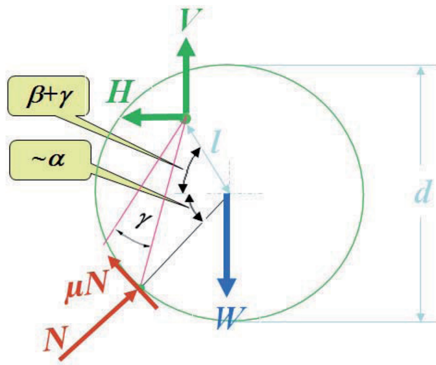

Fig. 2. Eccentric wheel- free body diagram.

The following equations of motion describe this type of anti rollback braking mechanism and are presented below:

$$\sum Fx = 0 \qquad k \cdot u \cdot \cos(\alpha) - \mu \cdot k \cdot u \cdot \sin(\alpha) - H = 0$$

$$\sum Fy = 0 \qquad k \cdot u \cdot \sin(\alpha) + \mu \cdot k \cdot u \cdot \cos(\alpha) + V = W$$

$$\sum Mo = 0 \qquad -\mu \cdot k \cdot u \cdot (\frac{d}{2}) + H \cdot l \cdot \sin(\beta + \gamma) - V \cdot l \cdot \cos(\beta + \gamma) = 0$$

$$The \quad braking \quad torque : \mathrm{M}_b = \mu \cdot k \cdot u \cdot (\frac{d}{2})$$

$$The \quad normal \quad load : \quad N = k \cdot u$$

The braking torque is M_b, and k is the coefficient of elasticity of the wheelchair wheel material (hard rubber); u is the deflection of this material squeezed by the eccentric wheel in a backward motion. The value of k was measured and validated experimentally. All other terms are shown in Fig. 2. The brake was tested in the lab and also with several patients as shown in Fig. 3. At the back of the chair there are two handles, similar to bicycle brakes that allow the care giver to disengage the brake in order to move the wheelchair toward the back. The anti rollback brake worked well, however, we found two important drawbacks: 1. In this solution we removed the existing brake and located the eccentric wheel of the brake on the existing axle. We eliminated the forward braking function, which was found in tests to be unacceptable. 2. The solution was too expensive. We concluded that customers will not purchase an add-on brake at a price greater than $100.

Fig. 3. A patient and his caregiver testing the device.

In order to improve the drawbacks, we decided to conduct a second year annual project with a different team of students that had a mission of "design to cost", i.e. to design an affordable brake system. This time, the specifications included a requirement that the existing brake should remain in place and the anti rollback brake should be designed as a reconfigurable add-on device that will fit to as many institutional wheelchairs as possible.

Fig. 4 shows the design concept of the second year solution. It is a spring loaded brake attached to a disengaging cable. The brake is mounted in a modular box that can be placed in different locations around the wheelchair wheel. The brakes are mounted on both the left and on the right wheel. Similar to the first year design, also this concept was calculated and tested. Since it is a spring loaded concept, it creates higher resistance to the forward motion of the wheelchair. The additional load that the caregiver will have to overcome when pushing the wheelchair is 5N or about 0.5 Kgf. The added weight to the wheelchair is below 2 Kgf.

The second year team produced, built and tested the affordable solution of the anti rollback brake and the prototype is shown in Fig. 5.

2 Testing

Both concepts were tested in the laboratory to validate that the anti rollback brakes operates according to the design specifications. The first year concept, the eccentric wheel brake, was tested successfully in the lab, however during the field tests shown in Fig. 3, we realized that the forward brake is also necessary since even a slope of 1 degree or less may move the wheelchair forward. Therefore, we decided during the second year to leave the existing brake as is and to add an anti rollback brake. Also the spring loaded brake was tested successfully in the laboratory and our plan is to test it in a geriatric hospital with elderly patients. The spring loaded solution allows adjusting the level of the spring coefficient that affects the friction force and the braking force.

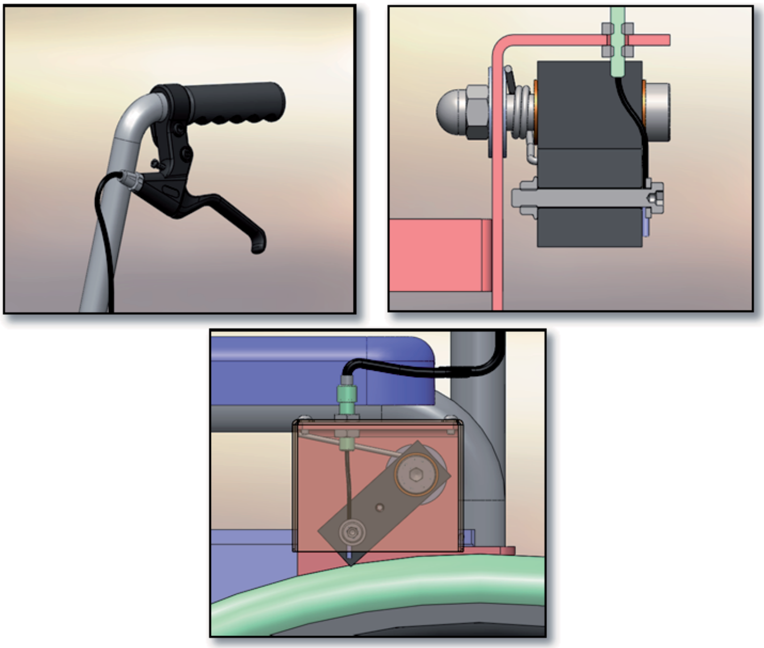

Fig. 4. A concept of spring loaded brake.

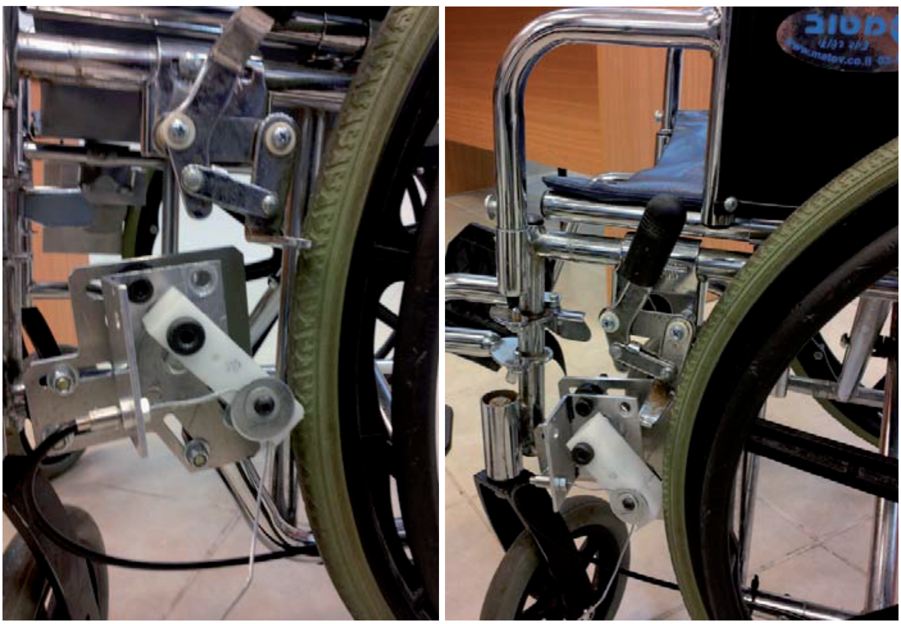

Fig. 5. The spring loaded brake assembly.

3 Conclusions

The novel and affordable anti rollback brake will allow introducing a practical solution to a widespread falling hazard common to many wheelchairs users. We believe that the simple, and easy to install device, will find its way to the institutional wheelchairs market that includes hospitals, elderly people sanatoriums, care giving houses and other non-profit-organization that offer/rent equipment to disabled or elderly population. We hope that elderly people that decided to live at home with a 24/7 attendant, will purchase and use this affordable safety device.

Our key interest is to convince Israeli institutional and private customers to adopt this solution and use it in practice. We would like to keep the invention **open to the public**, so that it will be adopted easily and be used anywhere.

Acknowledgements

The author would like to acknowledge the two devoted and talented students teams that worked on these projects and their advisers. First year team: Dr. A. Gilan, Y. Rivnik, T. Dvir, J. Baruch, G. Zelinger-Inbal. Second year team: K. Cohen, G. Elazar, A. Lichintzer, R. Elhassid.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
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doi:10.3233/978-1-61499-304-9-893

Development of Power-Assisted Transport Wheelchair

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Abstract. Wheelchairs are one of the most common mobility aids for people who are not able to walk independently, which may result from aging, neurological or orthopedic diseases, accidents, and so on. As the problem of population aging is getting worse, the wheelchair users are increasing. However, not every person can operate the wheelchair by himself or herself instead relying on their caregivers. Yet the wheelchairs nowadays do not fully meet the caregivers' needs, and may cause difficulties in some circumstances such as ramps and may also harm the caregivers. From this point of view, we have proposed a transport wheelchair with a new algorithm to predict the caregiver's intention and follow them automatically. In this project, we discussing about a transport wheelchair following a caregiver by using a microcontroller, a laser rangefinder, and motor drivers to operate.

Keywords. Caregiver, transport, power-assisted, automatic following, intelligent wheelchair, robotic wheelchair, assistive technology.

Introduction

Wheelchairs are one of the most common mobility aids for people with walking disabilities which may result from aging, neurological or orthopedic diseases, accidents, and so on[1, 2]. As the problem of population aging is getting worse, the wheelchair users are increasing. However, most of the disabled users cannot operate the wheelchair by themselves but rely on their caregivers. According to the statistics studies in 2006, more than 92% of wheelchairs are operated by caregivers in Taiwan[3]. While pushing a wheelchair on a smooth road for a short distance may not cause problems to them, but caregivers may get tired easily and even injured if they have to manually push the wheelchair through a rough road, up and down a ramp, or a long-distance ride. Powered- transport wheelchairs could be the solution to reduce their burden.

Powered transport wheelchairs can be categorized in 2 different types according to the control methods. For the first type, on/off switches are used to activate a constant add-on power that can be adjusted by a separate nob. As the power output is constant, the caregivers need to adapt themselves or compensate for the power deficiency for different contexts. As for the second type of control method is to detect caregiver's intention or location and to move the wheelchair accordingly. Although the developed systems are still experimental, this strategy seemed to allow caregivers to operate a wheelchair easily and naturally, and it is worth for further research and discussion.

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Researchers have tried different methods to detect caregivers' behavior and move the wheelchairs. Here are some examples. In 2006, scholar Tomohiro had built a power-assisted wheelchair that equipped with 4 infrared sensors to detect the caregiver's location, and made the wheelchair to keep a constant distance from the caregiver by adjusting the speed of wheelchair automatically[4]. It worked in a "clean" context, but was easily affected by environmental factors and cause misjudgment. In 2011, Ratnam's group proposed an autonomous caregiver following robotic wheelchair[5]. The morphological filtering and histogram calculation was applied to detect and track the caregiver with only one camera. It looked like a great idea only that it did not mention whether the variation in light intensity would influence morphological filtering and histogram calculation or not. While in 2009, 2011, and 2012, Yoshinori's group developed two systems using a camera and a laser rangefinder to detect the caregiver's face and shoulder orientation respectively[6-8]. For the camera-based system, the face of the caregiver determined the motion direction of the wheelchair. However, if they face to one direction for a couple seconds, the system will assume that they are looking at something and will stop the wheelchair to insure the safety of passenger. The system based on laser rangefinder followed the similar strategy but caregiver's shoulders were used to determine the wheelchair's moving direction and speed. These wheelchairs showed very good performance in simplified contexts, but still there are problems need to be solved. For instance, if the caregiver turned their body toward the person they are talking to but intended to maintain the original direction, the wheelchair would not work correctly. Therefore, the caregiver's shoulder or face for intention detection may not be a proper option for controlling a wheelchair.

Based on previous researches, detecting the caregiver's location and predicting the intended motion direction is a good strategy; however, which body part of caregivers is to be detected still needs further investigation. In addition, we believe a wheelchair should also provide enough support for the elderly caregivers. Thus we proposed a wheelchair with a new algorithm to address.

1 Methods

1.1 Materials

The overall system structure is shown in Figure 1. We used a laser rangefinder to detect the location of caregiver's feet and to find out the relationship between their feet location and the wheelchair, a microcontroller (Compact RIO) to read and calculate the data from the laser rangefinder, and motor drivers to operate automatically following. The laser rangefinder is mounted on the back of the wheelchair, 40 cm above the ground and tilting downward 20 degrees. This special arrangement simplified the control algorithm development. In addition, we've also mounted a 6-axis force transducers on each of the push handle to measure the supporting force that the wheelchair can provide under various circumstances (Figure 2).

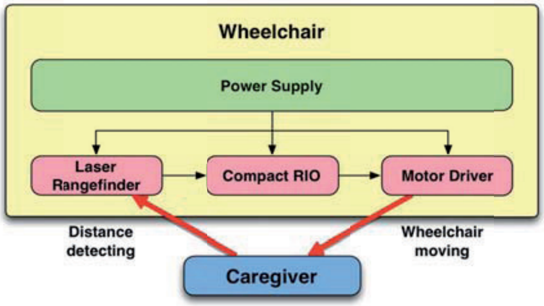

Figure 1. System overview.

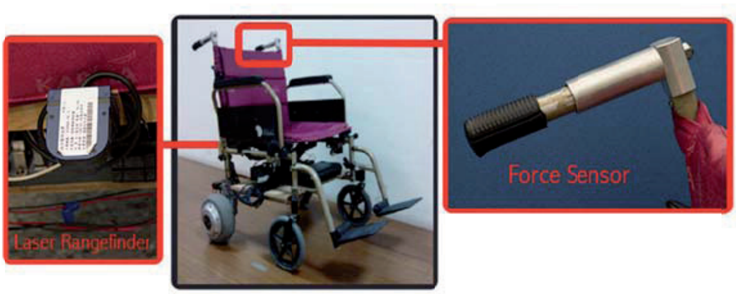

Figure 2. Structure of the wheelchair.

1.2 Algorithm

For the purpose of interpreting the intention of the caregiver, we calculate the area by scanning with the laser rangefinder (Figure 3). With the caregiver stepping forward, the value of the area becomes smaller. If the value is less than a default value, than signals will be sent to make the wheelchair move forward and vice versa. The scanning area is defined as:

$$Area = \sum_{n=1}^{170} \frac{1}{2} \times S_n \times S_{n+1} \times \sin\theta \qquad (1)$$

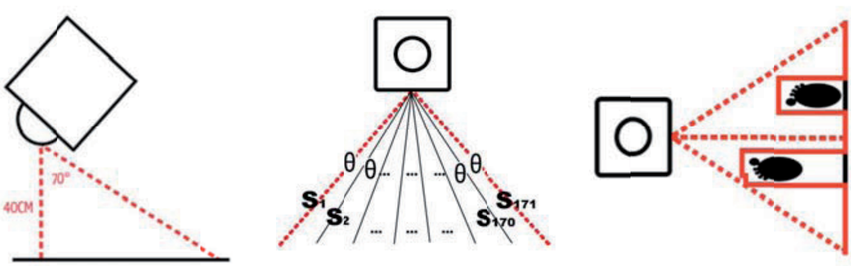

Figure 3. The area scanning by the laser rangefinder.

1.3 Experimental Process

We have recruited 3 subjects to verify the feasibility of our system tentatively (Table 1). The tests were performed indoors and outdoors. For the indoors testing, we used a motion capture system, Vicon MX, which contains 8 cameras with 100Hz sampling rate to measure the trajectory of the wheelchair and observe the relationship between the wheelchair and the caregiver. Two reflective markers were attached to handles of the wheelchair, and another two reflective markers were attached to lateral malleolus of the caregiver. The midpoint between two markers stands for the location of wheelchair and caregiver respectively. Subjects were asked to stand behind the wheelchair and go forward/backward for about 5 meters each time, and 3 times forward and backward respectively. As for the outdoors testing, we performed the test on an asphalt road and grass to measure the supporting force that wheelchair can provide. Subjects were asked to push the wheelchair forward through handles while standing still for 3 times in each circumstance (Figure 4).

Figure 4. Testing under various circumstances.

Table 1. Subjects.

No.	Gender	Age (Mean=25, SD=2)	Height (Mean=182, SD=1.73)	Weight (Mean=86.33, SD=18.77)
1	Male	27	183	108
2	Male	23	180	76
3	Male	25	183	75

2 Results and Discussion

From the indoor tests, it was found that the wheelchair could automatically follow the caregivers smoothly and keep a constant distance from them (Figure 5). It should be noted that no special filtering processing was applied. The smooth motion may be due to the use of area as a reference instead of distance that may average the measuring errors automatically.

From the outdoor tests, it was found that the wheelchair could provide up to 200N supporting force on the asphalt and about 180N supporting force on the grass for the caregivers (Figure 6). The reason for different supporting force between the asphalt and the grass was that the frictions between wheels and various surfaces were different. In the other words, where the friction was larger, the supporting force was stronger.

The limitations of this study were the lack of randomization and the relatively small numbers of subjects. In addition, the wheelchair can smoothly follow caregiver forward and backward but still has some problems in turning.

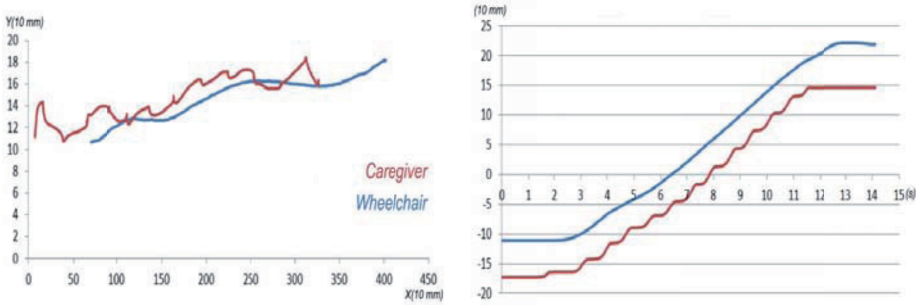

Figure 5. Trajectory of caregiver and wheelchair during moving forward in X-Y graph (Left). Relationship in distance between caregiver and wheelchair during moving forward (Right).

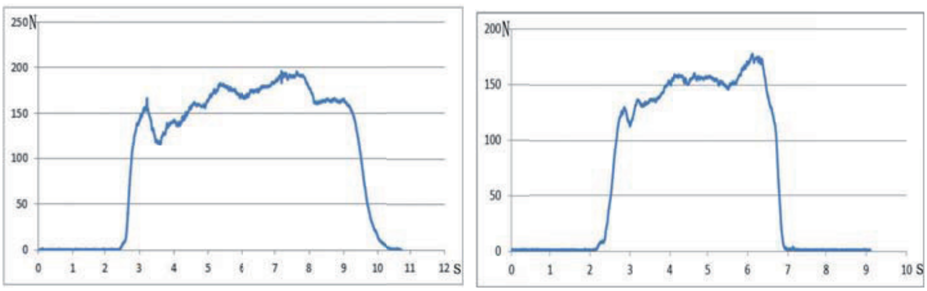

Figure 6. Supporting force on the asphalt (Left) and grass (Right).

3 Conclusions and Future Works

So far, there were not many research and development in the area of power-assisted transport wheelchairs. With increase in aging population, the people need to be taken care of will outnumber the young strong caregivers. The importance of how to reduce the burden of caregivers can thus be seen. This study showed that our system could automatically follow the caregivers. However, there were still some issues need to be addressed. Better algorithm for quick response with smooth wheelchair motion and turning strategies will be the focus of the future studies.

Acknowledgements

The authors would like to thank the National Science Council, Taiwan for supporting the research project (99-2221-E-010-003-MY2) resulting the work presented in this paper.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-899

Evaluation of Body Vibrations during Manual Wheelchair Running over the Newly Developed Indoor Tactile Guidance

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Abstract. TWSIs compliant with the JIS could be an extra barrier for pedestrians, wheelchair users, and baby carriage users. We have considered that bump heights should have been lower for lower limbs disabled and prosthesis users. We developed newly developed Indoor tactile guidance having 2 mm height or less. Especially, this tactile guidance targets indoors. Because indoors are less danger than outdoors and the floor faces are comparatively flat.On the other hand, some studies have suggested that the vibration caused by manual wheelchairs running over the sidewalk and tactile walking surface indicators have risk of secondary disorders for the wheelchair users . The purpose of this study is to evaluate the body vibration for wheelchair users running over newly developed Indoor tactile guidance. Results for the manual wheelchair showed that significant differences existed between TWSIs compliant with JIS and the indoor tactile guidance in body vibration and dis comfort level. TWSIs compliant with JIS are approximately five times as large as the 1 mm height of the indoor tactile guidance and are approximately three times as large as the 2 mm height of the indoor tactile guidance. The development of the indoor tactile guidance in consideration of body vibrations for wheelchair users is necessary.

Keywords. Tactile Walking Surface Indicators, Indoor Guidance, Wheelchair, Body Vibration, Universal Design.

Introduction

Tactile walking surface indicators (TWSIs) help visually impaired people traveling alone. Since being devised in Japan in 1965 they have spread to other nations around the world. In Japan, the shape, arrangement, and height of TWSIs were standardized in 2001（JIS, T9251）. The profile of TWSIs comprises 5 mm height (standard height). When TWSIs have installed newly, the JIS standard has used well. However, TWSIs compliant with the JIS could be an extra barrier for pedestrians, wheelchair users, and baby carriage users. Kuge et al. analyzed walking characteristics of elderly people and examined the height of steps of ground surfaces which have been the cause of the stumble [1]. The result showed that the height of steps should be less than or equal to 2.4 mm not to stumble. We have considered that bump heights should have been lower for lower limbs disabled and prosthesis users. We developed newly developed Indoor tactile guidance having 2 mm height or less [2][3] . Especially, this tactile guidance targets indoors. Because indoors are less danger than outdoors and the floor faces are comparatively flat.

On the other hand, some studies have suggested that the vibration caused by manual wheelchairs running over the sidewalk and tactile walking surface indicators have risk of secondary disorders for the wheelchair users [4]. The purpose of this study is to evaluate the body vibration for wheelchair users running over newly developed Indoor tactile guidance.

1 The Outline of Investigation

1.1 Bump Patterns

- Arrangement: parallel flat-topped elongated bars (see Figure -1)
- Height: 1 mm, 2 mm
- Width: 30 mm
- Spacing: 75 mm
- Material: Vinyl chloride (base) (500 mm×250 mm) ,soft vinyl chloride(bars)

In this experiment, TWSIs compliant with JIS was also evaluated the body vibrations as for comparison.

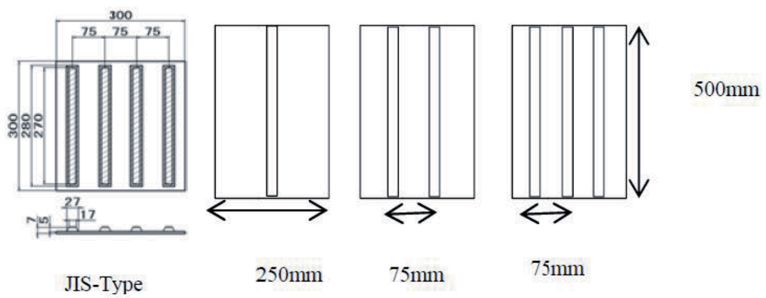


Fig. 1. Bump patterns.

Fig. 2. Experiment Scenery.

Table 1. Arrangements.

Sumple number	A	B	C	D	E	F	JIS
Number of bars	1	2	3	1	2	3	4
Width	30mm	30mm	30mm	30mm	30mm	30mm	ToP 17mm Bottom 27mm
Height	1mm	1mm	1mm	2mm	2mm	2mm	5mm

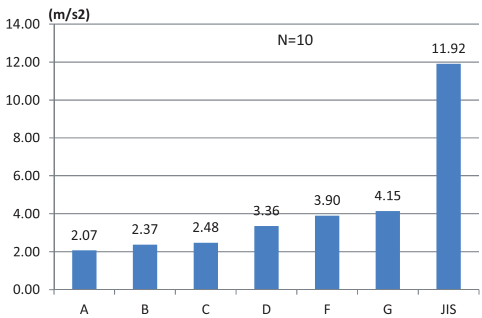
1.2 Methods

- Subjects: Ten nondisabled persons, Mean Age: 21.3, Mean Height: 167.4cm Mean Weight: 59.7Kg

One typical care-type foldaway wheelchair was studied. The body vibrations were measured by using tri-axial accelerometers on the seat of wheelchair. The wheelchair was propelled by one particular attendant. The attendant propelled the wheelchair to keep pace with the temp of metronome which had 58 times per minutes. The speed was 0.383m/s on the average. This study also assessed user's discomfort while wheelchair users ran over the newly developed indoor tactile guidance and TWSIs compliant with the JIS. Subjects answered the discomfort level on the five point scale 1 (very discomforable) to 5 (not discomfortable). Subjects wear the eye masks.

2 Results

Body vibration analyzed Route Mean Square (RMS) of accelerations for one second.Fig-3 showed the mean value of resultant accelerations which composed the maximum RMS of each acceleration X, Y, and Z. The statistical analysis used Steel-Dwass method. The vibration of TWSIs compliant with JIS is very large compared with other samples. TWSIs compliant with JIS resulted in significantly higher RMS than newly developed Indoor tactile guidance.When the number of bars is more and the height of bumps is higher, the each acceleration of the indoor tactile guidance becomes large. Sensory analysis is also the same result（Fig-4）. TWSIs compliant with JIS resulted in significantly lower feel comfort than newly developed Indoor tactile guidance.

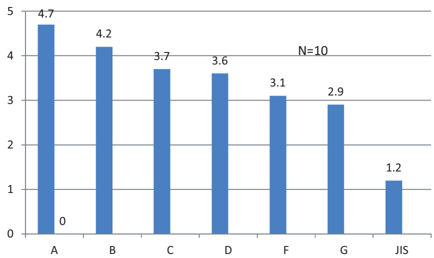


Statistical result

	A	B	C	D	F	G	JIS
A				*	**	**	**
B					**	**	**
C					**	**	**
D							**
E							**
F							**
JIS							

*:P<0.05,**:P<0.01

Fig. 3. The mean value of resultant accelerations.



Statistical result

	A	B	C	D	F	G	JIS
A				*	**	**	**
B					*	**	**
C							**
D							**
E							**
F							**
JIS							

*:P<0.05,**:P<0.01

Fig. 4. The mean value of discomfort point.

3 Conclusions

Wolf et al. evaluated vibration exposure while wheelchair users traveled over different sidewalk surfaces [5]. They found differences between interlocking concrete pavement (ICP) surfaces and a standard poured concrete surface. Maeda et al. issued a questionnaire to wheelchair users to determine if vibration experienced during wheelchair propulsion caused discomfort [6]. Results showed that the vibration experienced during propulsion did cause discomfort. Hashizume et al examined the body vibration when manual wheelchairs running over the tactile ground surface indicators and the tile sidewalk [7]. This study's results showed that the vibration of the tactile ground surface indicators wad very large. Results for the manual wheelchair showed that significant differences existed between TWSIs compliant with JIS and the indoor tactile guidance in body vibration and dis comfort level. TWSIs compliant with JIS are approximately five times as large as the 1 mm height of the indoor tactile guidance and are approximately three times as large as the 2 mm height of the indoor tactile guidance. The development of the indoor tactile guidance in consideration of body vibrations for wheelchair users is necessary.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-903

On the Assessment of an Orthosis for Pathological Tremor Suppression

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Abstract. An orthosis for pathological tremor suppression at wrist level has been designed emphasizing on user acceptance. The orthoses has been tested in 12 patients. These patients used the orthoses as part of their daily life for one month. An assessment on efficiency and acceptance has been made using objective measurements and questionnaires. Results obtained from use show that orthoses has been well accepted by users and are effective suppressing tremor.

Introduction

Tremor is the most common movement disorder. Although no being life threatening is very disabling [1]. Besides, in many cases there is not still an effective treatment to manage tremor in a pharmacological or surgical approach [1]. For these reasons, a number of approaches for tremor suppression have been researched. Among others can be commented mechanical suppression of tremor [2,3,4,5,6]. Although many of these approaches being effective [7,3], in many cases are not accepted by users as a feasible solution in real life environments [3]. For these reasons, an orthosis for tremor suppression at the wrist level has been developed in the framework of the FP7 European Project (Trem–End). This new orthosis has been designed emphasizing user acceptance criteria. In this contribution we present the assessment of the effectiveness of this new orthosis.

1. Material and Methods

12 participants with severe Essential Tremor at the upper limb participated in the study. A new orthosis has been build and fitted to each of the participants. The participants has been asked to use the orthosis in daily live for one month. Three assessments have been made, at the beginning, when the orthosis has been fitted for the very first time to the user. At the middle of the trials (15 days after the init) and one month after using the orthosis.

Three levels of assessment have been made in each of the three sessions:

1. Assessment of tremor reduction at the wrist level, using gyroscopes.

Table 1. ANOVA on the components of PSD for tremor suppression.

	Chisq	Df	p–value
Movement	89.7	1	¡0.001
Phase	6.3	2	0.04
Condition	23.4	1	¡0.01
Phase*Condition	2.2	2	0.33

2. Functional assessment of the patients following and spiral in a computer screen using a mouse.
3. Assessment of patient criteria using questionnaires.

Tremor reduction and functional assessment have been made both by comparing the exercises with or without the orthoses. For the assessment of tremor reduction two activities have been requested to the participants, extending the arms outstretched and repeatedly move the arm to point with the finger at the tip of the nose.

For the assessment of tremor reduction the measure has been the cumulative distribution function of the PSD in the band between $[3-10]Hz$. For the functional assessment the measure has been the mean square error between the spiral drawn by the subject and the spiral shown in the screen.

Repeated measures ANOVA have been made for the analysis of data using the packages *lme4* [8] and *phia* [9].

2. Results and discussion

Probably the best result of the assessment is that 11 out of 12 participants asked the team to keep the orthosis after the trials to keep using it at home. This results is in clear contrast with previous approaches in which the orthoses has not been seen as a feasible solution in daily life [3].

In relation with the questionnaires, the results show high levels of acceptance. Patients reported the orthoses provide them more confidence while doing daily living activities such as dressing, drinking or eating.

With respect the results for tremor suppression. A Functional Data Analysis [10]of the distribution functions of tremor has been made. The ANOVA (Table 1) shows differences in the Condition, meaning that the behavior while performing the movements is different when the patients are using the orthosis. In particular we obtain a reduction in the mode of tremor severity of about 25% (Figure 1). The reduction is even higher for the more severe components of tremor reaching 33% of reduction for the higher PSD of tremor. This result in a Probability Density Function for tremor while using the orthoses sharper but more concentrated in low values of PSD in comparison with the tremor components without using the orthoses.

3. Conclusions

An orthosis for tremor suppression at wrist level has been built and assessed in real conditions. The orthoses has demonstrated being effective in objective measurements of tremor and well accepted by the patients. Therefore, it can constitute a feasible alternative for the management of pathological tremor.

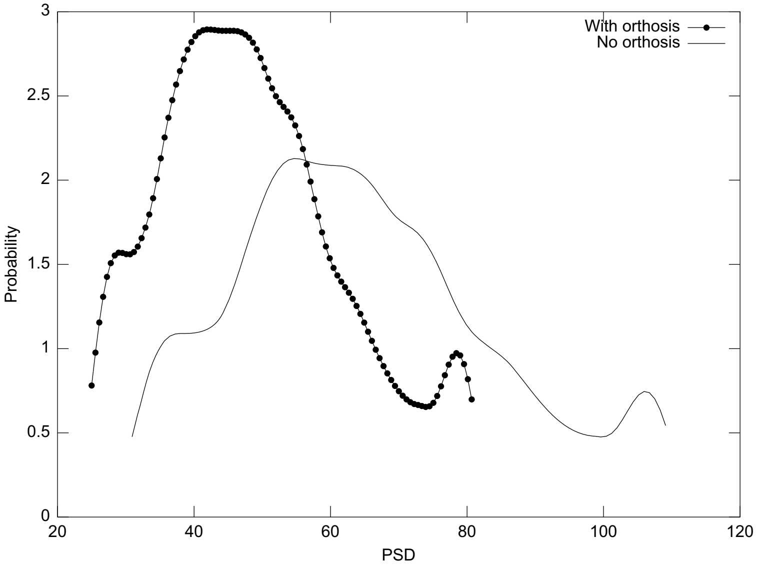

Figure 1. Estimated distribution functions of tremor with and without the orthoses. It can be seen that the distribution using the orthoses is concentrated in the lower values of PSD and extending less to the higher values of PSD in comparison with the distribution of tremor not using the orthosis.

Acknowledgements

This study has been funded by the EU Commission by FP7 under contract FP7-SME-2010-1-262127.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-906

Development of the Data Collection System on Assistive Technology Services in Finland

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Abstract. This paper describes the results of a pilot study on what information from assistive technology services could be obtained from current assistive technology registers used in health centers and central hospitals. In addition it describes the usability and functionality of the used questions about the data on assistive technology. The piloting of the questionnaire showed that it requires improving in order to develop the national data collection system on assistive technology services in Finland.

Keywords. Assistive Device, Assistive Technology Service, Follow-up Data, Assistive Technology Register.

Introduction

There are no national statistics on assistive technology (AT) services in Finland. Information has been collected only with three independent small-scale surveys, the last of which was done in 2006 [1].

Statistical information on AT would enable a regional and international comparison of the data. Analysis of the data could help in detecting problems in service provision and could improve the quality of AT services.

To develop a national data collection system on assistive technology services the National Institute for Health and Welfare (THL) carried out a pilot study to investigate what information could be obtained from current AT registers. The pilot questionnaire was targeted at health centers and central hospitals, which have the main responsibility for organizing AT services.

The objective of the study was to obtain information on the current AT management systems' ability to provide the desired data and to test the usability and functionality of the selected generated questions.

1 Methods and Analysis

The questionnaire was prepared in cooperation with the AT service providers. The chosen question themes were based on the results of previous surveys [1, 2, 3], on the clinical and professional experience of the authors and on information from other Nordic AT systems. The questions concerned the amount and type of assistive devices provided, and the number, age and diagnosis of AT users. In addition there were questions about the personnel and the money spent on assistive devices. The respondents also had the possibility to comment on the questions and further refine their answers in free text.

Five informants from the health centers and central hospital were selected (N=5). They included both those who used the most popular AT management and registration system (system A, n=3) and those who used other systems (systems B and C, n=2). System A is in use at 18 out of 20 central hospitals and at some 90 out of 160 health centers. The questionnaire was sent to the person in charge of the AT services in these organizations in September 2012.

Questions about assistive devices were classified according to the ISO 9999:2007 classification [4] with 2, 3 or 4 (national) classification levels.

The analysis took into account how many of the respondents were able to give their answers directly from their AT registers. Questions that respondents had not been able to answer were analyzed utilizing the free text to identify if a missing answer was due to deficiencies in the registry or the questionnaire or due to some other reason. Questions that proved to be valid were chosen for further development.

2 Results

The response rate was 100 per cent.

2.1 Number of Assistive Devices Provided

Respondents were asked the total number of assistive devices provided to citizens during the previous six months. All respondents (n=5) were able to provide this information.

Respondents were also asked the total number of all devices that were marked as provided in the registry. Users of system A (n=3) were able to report the requested figures, while users of system B and C (n=2) could not obtain the requested figures from their registers.

Respondents commented that although the total number of all devices registered as provided could be obtained from the registry, the number does not correctly reflect the true number of these devices. The reported amount could have been influenced by the fact that the 'unit' for a device was interpreted in different ways. For example, if four leg extensors had been given to raise a bed, the number in the register could be 1, 2 or 4 pieces depending on the method of registering.

2.2 Number of Definite Assistive Devices

Respondents were asked separately the numbers of the following assistive devices provided (ISO 9999 classification codes in brackets):

- electric wheelchairs (12 06 23)
- electric mopeds (12 03 23)
- manual wheelchairs (12 22)
- walkers (12 06 06)
- electrically adjustable beds (18 12 10)
- hearing aids (22 06 12, 22 06 15)

- eyeglasses and contact lenses (22 03 06)
- computers (22 33 06 01, 22 33 06 02) and
- toilet raisers (09 12 12, 09 12 15, 09 12 18).

Information on the provided devices covered the previous six months and the total number of devices provided.

All the respondents (n=5) were able to report figures from the previous six months, but C-system users had to extract the numbers manually. Only A-system users could provide the total number of all devices.

2.3 Assistive Device Users

All A-system users were able to report the gender and the age of the person receiving assistive devices. The C-system user could report the age of persons who had received assistive devices during the previous six months. The B-system user could not report age or gender-related information.

All central hospitals (n=3) were able to report the total number of assistive device users in their registry, but the health centers (n=2) were not.

Two of the central hospitals reported that they had registered the diagnosis (all or the main diagnosis) of the users of wheelchairs, electric wheelchairs and electrical beds.

The remaining three respondents (systems A, B and C) were not able to answer the question, either because the diagnoses were not all recorded, or there were several diagnoses and they were not able to determine which diagnosis was related to the assistive device in question.

2.4 Amount of Money Spent on Assistive Devices

All (n=5) respondents reported the amount of money spent on assistive devices during the previous six months. They were asked to include in the reported sum the costs of modifications and accessories for the purchased devices.

Although the question was very precise, responses were not. Based on the respondents' comments, it seemed that they had given incomplete figures or the costs could not be outlined as requested in the question.

2.5 Personnel at Assistive Technology Services

All (n=5) respondents reported the number of professionals working at the AT center. Respondents were asked to distinguish between health care professionals, maintenance and warehouse staff, office staff and other personnel. They were also asked to differentiate between the number of positions, persons, and person-years. In addition they were asked the amount of services being outsourced. Respondents commented that they had difficulties in comprehending the categorization of this question.

3 Conclusions

The pilot questionnaire showed that the questions were not clear, that not all the desired information could be obtained from the registry, and in addition, responding to the questionnaire had proved laborious.

Responses to the question on the total number of assistive devices provided were not reliable and comparable, with the major reason being the different methods for registering assistive devices.

With minor changes, the question on the number of defined assistive devices that were loaned out during the previous six months could be made valid. The respondents understood the assistive device attributes uniformly, so that the figures are comparable – excluding glasses and contact lenses. In addition, the use of the classification on assistive products (ISO 9999, 2007) helps to make the responses more uniform. Respondents did not report any problems with the use of the ISO classification.

Information on the number of assistive device users and their age appears to be valid when it relates to a specific period of time. Diagnostic information on the other hand is recorded infrequently, such that diagnostic data collection at national level is not currently feasible.

A comparison of the number of different professionals working in AT services was difficult and would require more detailed instructions with the question.

Establishing the total costs of AT services is possible if the data requirements were to be better defined and if respondents were told in advance that they would need this information.

The follow-up questionnaire should be reformulated to cover only those data that were found to be useful. These include: the amount of defined assistive devices provided per year, the number of assistive device recipients and their age, and (with some refinements) the amount of money spent on AT purchases.

The survey sample was small, but because three of the informants used system A, which is the most used in Finland, in their AT service management, the responses can be generalized. Different registration systems for AT services in Finland are currently storing different kinds of information. None of the systems could provide all the required information. Users of system A were best able to answer the questions. Users of the other systems (B and C) were forced to extract the data manually.

4 Discussion

The piloting of the questionnaire on AT services showed it requires further development. A renewed electronic survey could be sent to all assistive device centers in 2014. Detailed definitions on the data content stored in registries for AT services as well as unified criteria for the definition of customer data should be created in cooperation with health care stakeholders, so that information can be recorded in a uniform manner, and made comparable. The range of assistive devices being monitored should be further expanded to cover all specialties.

In future it could be possible to collect nationwide statistics on assistive devices and AT services electronically from patient entry data, without a separate survey. Information should be collected together with the unique personal identity number, so that data can be linked with other national registers in analyses.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-911

Assistive Technology Services Delivery System in Slovakia

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Abstract. Assistive technology plays important role in the development of an Inclusive society. As accessible mainstream services rise relatively slower than needs and requirements of increasing population of seniors and of course persons with disabilities, assistive technology often have to be the main tool for obtaining an accessible service. AT experts in Europe are looking for more efficient and useful AT service delivery system. There is no chance to have only one common system in the whole Europe. However, transfer of knowledge between countries and good examples together with some international basis for AT database and more deep cooperation in research shall be helpful. Paper describes some ideas and results from authors' experience in Slovak AT service delivery system.

Keywords. Assistive Technology, Services, Accessibility, Inclusion.

Introduction

How to facilitate transfer of AT technology and inclusive ICT services throughout the whole Europe? This is an important task especially in the East and South countries. New EU countries like Slovakia are in the process of implementing new social policy focused on Inclusion and Accessibility, especially in link with new products and e-services enhanced by strong ICT industry.

New social and rehabilitation procedures require improving structure of mainstream social services and Assistive Technology market, especially by the involvement of SMEs. Slovak research in rehabilitation engineering is very limited; market with AT counts only a few companies, new ICT services are focusing on mainstream but often not inclusive solutions [1]. Accessible ATM machines are not part of banking, transport or other public systems [2]. Design for all is not a standard part of education in our universities, accessible or even inclusive products don't belong to mainstream vocabulary in technological or social knowledge. So, there is a lot of to do in the concentration of the effort of academic, research, industry, and market spheres. Academic and research facilities shall play an important role in such process. We present some ideas based on authors experience in this field in relation to domestic and international domains and organizations.

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1 AT Service Delivery System Structure and Key Players in Slovakia

1.1 Providers of AT – Key Players

Two official bodies are responsible for delivery of AT services in Slovakia - Ministry of Health (MH), and Ministry of Labour, Social Affairs and Family (MLSAF). On the base of medical prescription, a person can obtain an AT published in the approved categorization list by the Ministry of Health, which is quarterly updated. The amount of a financial contribution is stated by the Act 447/2008 on direct payments on compensation of severe disabilities [3]. The Act includes direct payment for personal assistance to support independent living. These AT are grouped as follows:

- I-individually produced orthopaedic-prosthetic devices and accessories.
- J-Proprietary orthopaedic-prosthetic devices (prostheses, orthoses).
- K-rehabilitation and compensation devices (canes, crutches, antidecubit and positioning devices, devices for personal use hygiene, food preparation, dressing and undressing, inhalation and respiratory aids).
- L-trucks and strollers, walkers, jacks, adjustable beds.
- N-aids for persons with hearing impairment (hearing aids, bone glasses, electro larynx).
- O-glasses and aids for visually Impaired persons (lens also contact, spectacle frames, magnifiers).

The Ministry of Labour, Social Affairs and Family provides AT mostly devoted to support daily activities of person. Mainly, the following AT products are included in this list:

- Aids that support mobility: (second mechanical/electrical wheelchair, etc.).
- Aids to facilitate self-service (device for dressing, feeder, key holder, door opener, the writing tools, kit for hair washing, and other).
- Electrical and electronic equipment (washing machine, dishwasher, microwave, electrical slicer or knife).
- Equipment for communication for people with severe hearing impairments, for example flashing or vibrating alarm, wrist watch, light device that indicates a ringing phone, domestic or bell housing, child crying, flowing water, television with teletext).
- Special software (speech output).
- PC (including DVD drives and other accessories, speakers program and Internet access).
- OCR software, scanner, printer.
- Braille embosser, tactile display, magnifier.
- Devices for persons with visual impairment (calculator, colours indicator speaking identifier of labels, navigation, and a device that allows to identify barriers using sound signal, personal electronic devices).
- Tactile information devices.
- Devices enabling to deaf people receive information by telephone, text phone, phone amplifier with induction loop, fax.

There is overlapping in these two systems – health care and social care - in providing of mechanical and electrical wheelchairs and hearing aids (Fig. 1). Disabled persons can get second wheelchair electrical/mechanical and second hearing aid covered by social insurance, but with higher interest.

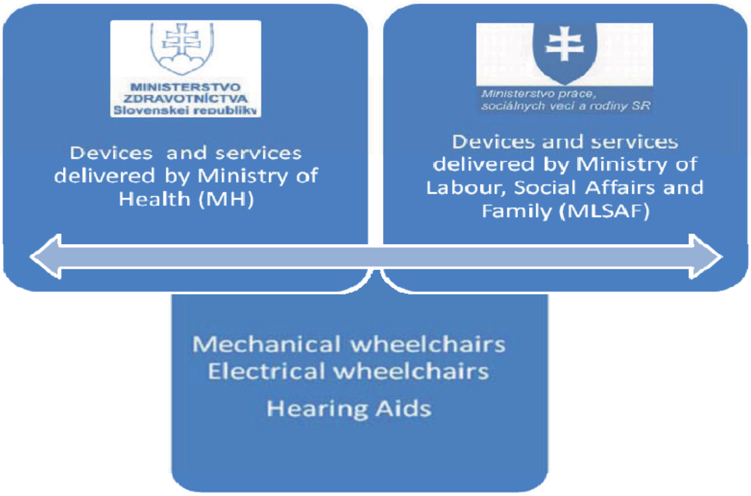


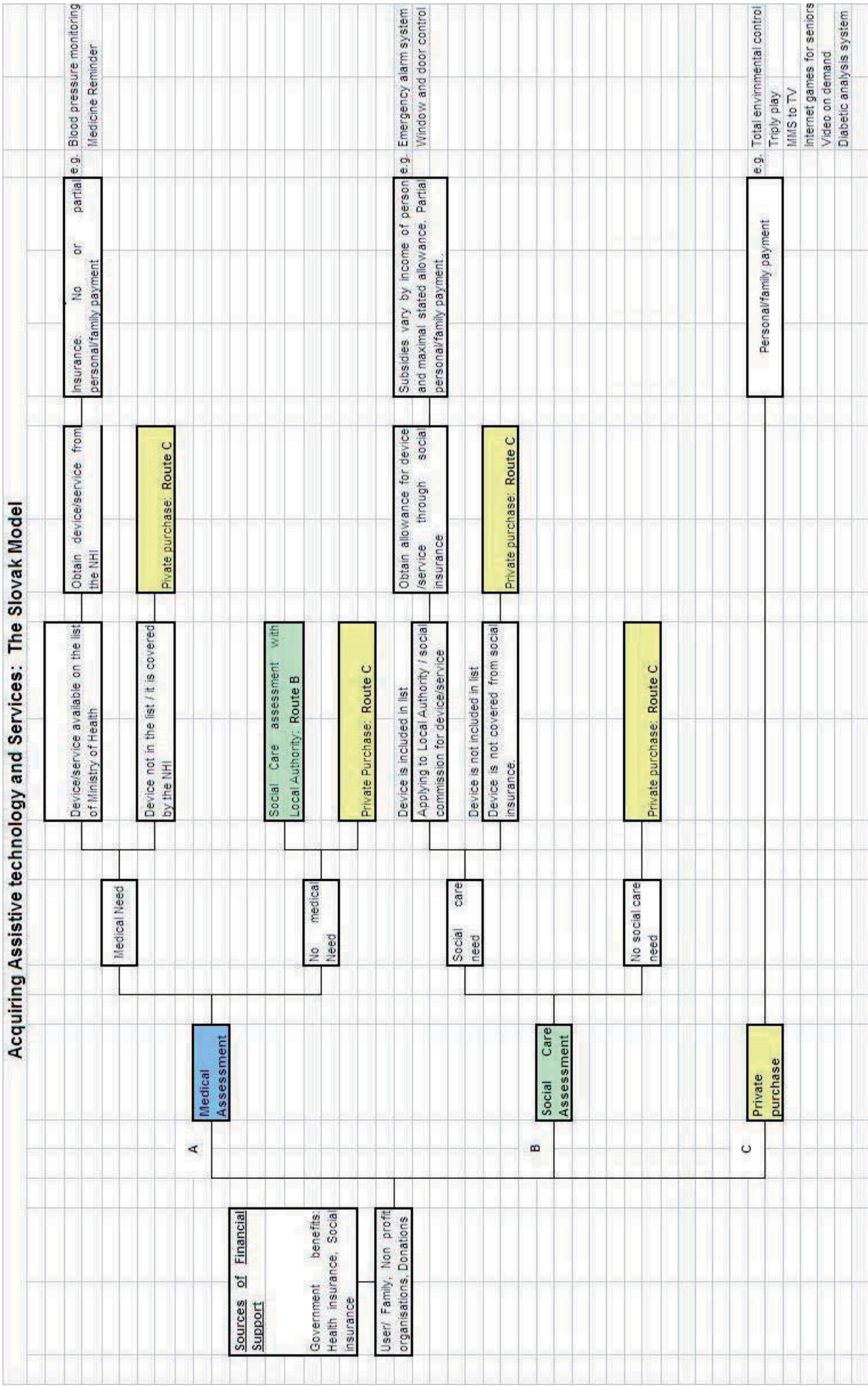
Fig. 1. Overlapping in two systems for AT delivery.

The social system can't work effectively without additional providers like Nongovernmental organizations (NGOs); Private sources (grants of bigger companies, donations); Non profit organisations; Charity. Many times, those organizations bring new innovative services to public, faster than mainstream services providers. It is true that usually they have only local regional impact. Fig. 2 presents Slovak model for AT provision.

1.2 Categorization of Medical Devices and AT

Medical devices and AT are assessed through a categorization process. This includes an application by the producer or marketing authorization holder to include medical device in the list, evaluations by working groups, a reimbursement proposal prepared by the Reimbursement Committee, prescription limitations, indication limitations, approval of revision medical doctor with payment for medical device, limitation for amount, financial limitations, patient's contribution.

The reimbursement decision, if a medical device or AT will be covered by the Health Insurance (HI), is the competence of the Ministry of Health and its Reimbursement Committee. This decision is taken after an assessment and classification of the medical device. Some procedures, costly pharmaceuticals and medical devices such as artificial joints and pacemakers are reimbursed separately and are covered by the hospitalization fee.


Acquiring Assistive technology and Services: The Slovak Model
Sources of Financial Support
Government benefits: Health insurance, Social insurance
User/ Family, Non profit organisations, Donations
A
Medical Assessment
Medical Need
Device/service available on the list of Ministry of Health
Obtain device/service from the NHI
Insurance: No or partial personal/family payment
e.g. Blood pressure monitoring
Medicine Reminder
Device not in the list / it is covered by the NHI
Private purchase: Route C
No medical Need
Social Care assessment with Local Authority: Route B
Private Purchase: Route C
B
Social Care Assessment
Social care need
Device is included in list
Applying to Local Authority / social commission for device/service
Obtain allowance for device /service through social insurance
Subsidies vary by income of person and maximal stated allowance. Partial personal/family payment.
e.g. Emergency alarm system
Window and door control
Device is not included in list
Device is not covered from social insurance.
Private purchase: Route C
No social care need
Private purchase: Route C
C
Private purchase
Personal/family payment
e.g. Total environmental control
Triply play
MMS to TV
Internet games for seniors
Video on demand
Diabetic analysis system

1.3 Financial Allowances for AT Covered by MLSAF

It is possible to get financial allowances from MLSAF for purchase, training and modification of AT, only if AT is not provided on the basis of the health care insurance. Exception is for the second mechanical or electrical wheelchair and for a hearing aid. Client can get first device from health insurance and the second one from social insurance.

Limit for financial allowances for buying, training and adjustment of AT is stated as a percentage. It is calculated from the price of AT and from income of disabled person. Financial allowance is also limited by the maximal reimbursement, which is stated in the list of AT. Client can get financial allowance only for AT in list. List of AT and maximal financial allowance is stated by the Ministry of Labour, Social Affairs and Family.

Financial allowances for severe disability compensation are available for: personal assistance, purchasing and repairing aids (assistive devices), purchasing a personal motor vehicle, housing adaptation, additional expenses (special diets, hygiene or clothing, footwear and furnishing replacement, operating a personal motor vehicle, care for an assistance dog) and for caring.

1.4 Accessibility and AT Development in Slovakia

The situation in legislation and social policy can be characterized by several critical facts:

- Accessibility is understood very often only in relation to persons with disabilities. Seniors represent a big users potential, but mainstream services haven't realized this fact so far in a sufficient and efficient way. There are only some little attempts to address seniors with new accessible services and/or empower them with AT in a wider scope to get higher impact on improvement of autonomy, safety, ad social inclusion. There is a lack of legislation and motivating actions, which would support SMEs in this area.
- It seems that MLSAF don't have enough power to take care of AT and e-services development in social area focused on autonomy and accessibility. Current activities don't have real impact on positive changes in legislation and implementation in praxis for seniors and persons with disabilities. AT professionals ecxpect that Government takes Accessibility, AT, Ageing policy as a global national program facilitated by the content of the UN Convention on Rights of Persons with Disabilities.
- The Ministry of Education, Science, Research and Sport is a good example in supporting access to education. There have been several activities lead to preparation of a new strategy and new law improving support of students with special needs at higher education. Our Access centre plays in such national role an important knowledge base, demonstration and training functions.

It is not realistic to expect to have one common system in EU with same rules and conditions in each country. National social systems are different and rather sensitive to actual political and economical situations in each country independently. However, there is a strong need for exchange of experience and good examples throughout the EU. And there are some sectors where we can profit from integrated international approach.

The Slovak Republic has signed the United Nations Convention and the Optional Protocol. One way how to bring Article 4 into praxis is to use International Classification of Functioning, Disability and Health – ICF in health and rehabilitation systems. Mainly part of ICF dealing with environmental factors like: products or devices for personal use, for communication, education, employment, for culture, recreation and sport activities, product and technology of external appearance of public and private buildings, design and construction of products and technologies.

Important contribution to AT provision in Slovakia is also participation in the e-Inclusion program through the European networks like EDeAN, and EASTIN. Important role in our activities is played by powerful professional organizations, especially AAATE. A specific role has Rehabilitation International, which prefers strong users' aspect, but in the same time welcomes experts from different interdisciplinary fields. Related EU projects DfA for e-Inclusion, eACCESS+ [4], ETNA and others help us to improve links to industry and facilitate international research and education process at our University.

Conclusions

Medical professionals in Slovakia who prescribe AT in health care system dont have any special education in area of AT. They have only a little information about variety of AT on market. The only advisors for them in mainstream services are suppliers of AT. The final decision for selection of AT supported by social insurance is made by staff of regional social office, and they are in majority also without good knowledge of AT. Users have minimal influence on AT selection. Our experience shows that EASTIN database may play important role as a good source for them, especially after completion of the full Slovak version, but still there is a strong need for advisory centers in Slovakia like the Access centre at our University.

Acknowledgements

The research leading to this results was supported by the national grant VEGA 1/1162/11 „Theoretical principles, methods and tools of diagnostics and rehabilitation of seniors mobility", and EU grant 7FP, CIP-ICT-PSP-2009-3, 250568, eACCESS+: the eAccessibility network" ICT for health, ageing and inclusion.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-917

Supporting Autonomy in the Aging Population by using an Accessible Information System on Comfort Products and Assistive Technology

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Abstract. Objective: The purpose of the developed information system on comfort products and assistive technology called SJOBOKS, is that the system easily can be used by end users. **Main Content:** A growing percentage of the population belong to the elderly people. Because of the phenomenon of aging these elderly experience limitations in functioning. Ingenious solutions, handy and comfortable products and simple assistive technologies are available to support the independent functioning of these people. The gap between the need and the knowledge requires more information and advice about the existing products. In various European countries databases on assistive technologies are available. Mostly these databases are accessibly by the internet. However, this information is often not easily accessible for people who are not familiar with using a computer or the internet. There is a need for an information system that is easily accessible and inspires users to buy products that give them greater independency and autonomy. Therefore SJOBOKS was developed, which is an easy accessible interface containing information on comfort and handy products and simple assistive technologies. It can be operated by a touch screen or by a computer mouse. It contains 300 product descriptions and 80 short films. **Method:** Data was gathered by using questionnaires and observing people using SJOBOKS. Participants were independent living elderly of 75 y/o and over, people with physical and visual impairments and people with low Social economic status and professionals in the field of assistive technology. **Results:** According to the majority of the participants the SJOBOKS did provide in the need for information. The information was found interesting and attractive and the interface easy to use. Half of the participants needed encouragement to use the system. SJOBOKS could assist in living independent for a longer period, according to half of the participants. Suggestions for improvement were about the content, to add information such as availability of the products and more detailed information. Most participants found it obvious to have the SJOBOKS free of charge on the market. **Conclusion:** According to the participants, SJOBOKS gives relevant information on handy, comfort and simple assistive technologies, provided that encouragement in usage is given.

Keywords. Autonomy, elderly, aging, home environment, interface, health promotion, comfort products, assistive technology, touch screen.

Introduction

A growing percentage of the population belong to the elderly people. Because of the phenomenon of aging these elderly experience limitations in functioning. Ingenious solutions, handy and comfortable products and simple assistive technologies are available to support the independent functioning of these people. This becomes more and more important because of the changing policy towards elderly care. In the Netherlands, but also in other European countries, elderly become more responsible for their own health and the care they need. In the Netherlands living independently in their homes as long as possible is supported by the WMO (Law on Societal Support), executed by the municipalities. This law is not only for the elderly, but includes all people that need support in living indepently and participating in society.

Many of the products available are useful for everybody, not only for the elderly and people with disabilities. The problem is that the elderly often are not aware of the existence of these products and if they are, it is not clear how the products can be of much help for them. This gap between the need and the knowledge requires more information and advice about the existing products.

Furthermore, an increasing amount of products are available because of the rapid developments in technology. To make information on useful products open for the elderly, there is a need for an accessible information system. For this reason, an information system called SJOBOKS has been developed, by a consortium of a university, a design consultancy company and a knowledge centre on long-term care. To find out whether SJOBOKS is accessible and provides relevant information on comfort products and assistive technology for the elderly, a survey was conducted.

1. State of the Art

In various European countries databases on assistive technologies are available [1, 2, 3, 4]. Mostly these databases are accessibly by the internet. In the Netherlands, the 'Vilans Hulpmiddelenwijzer' provides information about assistive technology [5]. The 'Vilans Hulpmiddelenwijzer' is a very complete and extensive database, but developed originally for professionals in the field of assistive technology. To gather all data from these databases the EASTIN system was established. EASTIN (European Assistive Technology Information Network) is an engine that aggregates the contents of the independent national databases [6]. These national databases and EASTIN grant access to enormous amounts of products available on the markets, but are often too complete and too complex to be easily accessible for the average elderly people looking for products to make their live just a little bit more comfortable.

On the other hand, assistive technology providers and companies who sell comfort products are more and more likely to display their products in a clear and extensive manner on their websites. However, this information is diffuse and not easily accessible for people who are not familiar with using a computer or the Internet. The two reasons mentioned before create a need for an information system that is easily accessible and inspires users to buy products that give them greater independency and autonomy. The need for and appreciation of an easy accessible information system is described by Heijkers et al. (2011) [7].

2. Application Idea

SJOBOKS (figure 1) has an interface that gives access to a database of comfort and handy products and simple assistive technologies. SJOBOKS can be operated by a touch screen or by a computer mouse. It contains 300 product descriptions and 80 short films. A unique feature of SJOBOKS is that its structure is not based on the product or the disability, but on the location in which the product can be used. To access information you either enter a house or an 'on the go' picture and within three mouse clicks the final information about the product and how to use it can be accessed. This information is written in an accessible manner by using the 'leesniveau tool' of the accessibility foundation [8], which uses scores to determine the level of reading, set by the Common European Framework of Reference (CEFR). Texts were written on a B1 level, which means that 95% of the Dutch population should be able to read and understand it.

The product information section contains descriptions of a product, an explanation of what type of problems it can be used for, the average costs and where it is available. Short films show the problems one can experience and how the use of the product can solve this problem. The short films and the interface were built up by using guidelines of the accessibility foundation [8]. The products in the system are easily updated and new products can be added. Also, adjustments can be made, such as by adding information on companies, prices and availability. The database is linked to the database of the 'Vilans hulpmiddelenwijzer', which means that information on products in SJOBOKS can also be displayed in the 'Vilans Hulpmiddelenwijzer' and vice versa.

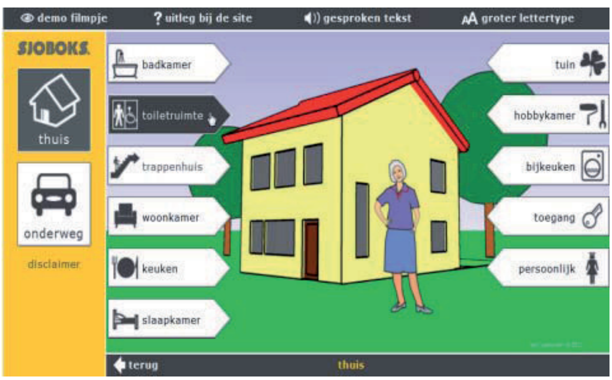

Figure 1. Example of the SJOBOKS interface.

3. Method

3.1 Objective

The purpose of SJOBOKS is to make information on handy comfort products and simple assistive technology accessible for the elderly, so that their autonomy can be supported. The research question is formulated as follows: Does SJOBOKS provide adequate and relevant information on handy products and assistive technology, according to the target population, the elderly and people with disabilities?

3.2 Method

To define the end users' characteristics previous research [7] and the recommendations of the Dutch 'Revalidatiefonds' were used. The main populations to be investigated were professionals in the field of assistive technology and end users. End users are people who have an interest in making use of the products in the database. Subpopulations of the end users are:

- Independent living elderly 75y/o and over
- People with physical impairments
- People with visual impairments
- People with low Social Economic Statuses (SES)

Low Social Economic Status is a function of three aspects: 1. material circumstances, 2. skills, capacities and knowledge, 3. the social network and status and power of the people in this network. Each one of the indicators measures more or less a part of the dimensions of SES [9]. This subpopulation was added in the survey because of the changing Dutch legislation of the WMO, as explained in the introduction. End users were selected to fit one of the described subpopulations and were excluded when it was not possible for them to answer any questions. Skills in using assistive technology or computer were not required. The professionals should be working in the field of consultation of assistive technology and frequently dealing with the subpopulations of the end users. The sample size should be at least 10 participants out of every sub population.

Data was gathered by using questionnaires and observing people using SJOBOKS. Participants were asked if they would take the initiative to use the system whether they had been able to use it effectively. Questionnaires were developed for end users and professionals, based on the following topics:

- Does SJOBOKS provide for the needs for information of the users?
- Does the user find the information in SJOBOKS interesting and attractive?
- Does one take the initiative to start looking and searching?
- Do the short films attract sufficient attention? Does the user actually watch them?
- Is the user able to handle the interactive interface?
- Is display text and speech clear?
- Does the user understand the information?
- Does the user find the information within three mouse clicks?
- Does the user have the attention span to actually take action on the information found?

A short explanation on the project and the product SJOBOKS was given beforehand. When testing, users' reactions to the product were observed. Only when a user could not proceed was assistance given. All observations were registered.

After the directed observations and questionnaires, opinion polls were held. A PowerPoint presentation with information on SJOBOKS was conducted, followed by opinion polls during and after these sessions.

Participants were gathered from the networks of the members of the consortium and the team of researchers, including the KBO (Katholieke Bond voor Ouderen) situated in the municipality 'Leudal', which is a catholic advocacy for the elderly, the care centre 'Beek of Bos', the 'zorgketengroep' of the municipality of Weert, citizens of the neighbourhood of 'de Lindenheuvel' at Geleen, Wijnandsrade SGL (Stichting Gehandicaptenzorg Limburg), the municipality of Kerkrade, senior citizens' society Heythuysen, 'Stichting Ondersteuning Senioren Verenigingen' of Leudal and the 'Het Paradies' meeting centre.

At the Support fair 2012 in Utrecht, a workshop took place and SJOBOKS was tested by visitors to this fair. Participants were furthermore recruited at Visio (an institute for people with visual impairments) and the nursing homes Vivre and Sevagram and Kentalis, which is a centre for people with communication deficits.

SJOBOKS was tested on Apple iPad touch screens, recommended by the Zuyd ICT-department, to be the best working touch screens at that time. Wireless MIFI hotspots were used to make sure an internet connection was operative. SJOBOKS was utilized in a test environment, which means that an internet connection was necessary to perform the testing, also the function 'text to speech' was not available for testing.

IBM-SPSS statistics 20 were used to analyze the data. Data of 69 respondents were analyzed, information of professionals and end users were compared. Also data of people with low SES, older than 75 y/o, physical impairments and people with visual impairments were compared. Only significant and noteworthy differences were reported.

4. Results

4.1 Research Population

The average age of the end users (N=58) was 63 years old, in a range from 19 to 93. 57% of the end users were female and 43% male. The majority (almost 60%) live together with a partner, 16% live alone and 10% lived in a nursing home. 8% and 6% respectively lived in sheltered accommodation and at home with their parents.

31% of the end users were 75 y/o and over, 26% of the respondents reported a physical disability, 22% reported a visual disability, while almost 20% were categorized as having a low SES.

The position of the professionals (N=11) were nurse, physiotherapist, occupational therapist, WMO-consultant, board member of the MS (Multiple Sclerosis) society, policy consultant of a municipality, board member of a senior citizens' society.

4.2 Results Questionnaires

The majority of respondents rated SJOBOKS at 8, with an average of 7.5, on a scale from 0-10, in which 0 was low and 10 high, as shown in figure 2.

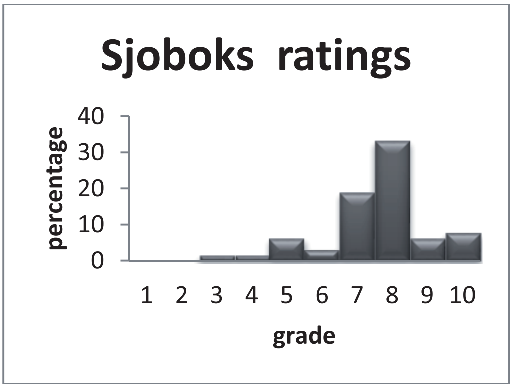

Figure 2. Overall ratings of SJOBOKS.

The vast majority of all respondents thought that there was a need for the information that SJOBOKS offers and found the information useful and the display appealing. Half of all respondents would take the initiative (without the encouragement of others) to start looking for and searching SJOBOKS. Those who could not take the initiative were predominantly from the subpopulation of 75 y/o and over. They suggested adding a folder with explanation. The majority of all respondents found that the short films gave a good clear idea of the usage of the product shown. Three quarters of the respondents were able to handle the interactive interface including the touch screen. One quarter of the end users did not know what to do. These were mainly people with visual impairments. The text is readable according to the majority of the respondents. Most end users who did not agree, were people with visual disabilities including elderly of 75 y/o and over, who do not live independently. But after enlarging the text by using the standard features of the iPad, they were able to read the text as well. Pictures and symbols were clear according the vast majority of the respondents. Almost all respondents understood the information given by SJOBOKS. Three quarters of all respondents could get to the information within three mouse clicks. Slow internet access was mentioned to be the biggest barrier in this case. Almost all respondents found the information useful, although one third ads: ‘but not for me’, because they ‘did not need it yet’. In the opinion of some professionals the SJOBOKS would not be used by their clients.

Half of the end users thought they could live independent for a longer period with the information of SJOBOKS, the professionals shared their opinion. Half of the end users found that professional care and government funding (WMO) could be postponed by using SJOBOKS; only one quarter of the professionals shared their opinion. End users mentioned that the impact of physical or mental disability was still present and personal assistance is needed. The professionals mentioned the importance of personal contact and the usage of SJOBOKS would be too difficult for the elderly. Important suggestions for improvement were: add internet links and addresses of companies and stores where the products are available, add more products and some more detailed information on products.

Respondents were asked through what channels they would like to be informed about SJOBOKS. The channels mentioned were respectively: national television, an elderly advisor, regional television and municipality.

4.3 Results Observations and Opinion Polls

Upon showing the SJOBOKS, professionals' reactions were mainly positive about the content and the appearance. There were no suggestions given for improvement, they were primarily interested in when SJOBOKS would be available on the market. They presumed that it would be available for free. A frequently asked question was whether it would be available as an app for smartphones. They also suggested using the SJOBOKS in addition to their professional work.

Observations showed that end users did not automatically started using the SJOBOKS, they needed encouragement. Once using the SJOBOKS, they found it very easy to operate.

5. Conclusion

The evaluation shows that according to the end users and professionals, SJOBOKS gives the right and relevant information on handy, comfort and simple assistive technologies to the end users and the professionals, provided that, an encouragement in usage is given. SJOBOKS can be used effectively by professionals in addition to the care and services that they have provided for them. It should be used preferably independent from the wireless internet. Choices made in the design of the interface resulted in a easy to use information tool.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-924

Hybrid Book – Universal Access to the Content

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Abstract. Hybrid Book provides a universal access to the content for users with various disabilities as well as for users without disabilities and it is based on synchronization of various types of components of audio, video and text media.

Keywords. Document Accessibility, Synchronized Multimedia, Sign Language, Universal Design.

Introduction

Hybrid Book is a document format which was created by Masaryk University and has been used to publish digital documents at the University since 2002. It was originally a digital text synchronized with an audio recording and navigable through its hierarchical structure, primarily intended for students/users with visual impairments. Over the last ten years, the Hybrid Book has developed into a mature document format enabling an undistorted access to information to students and other users with various disabilities (visual or hearing impairment, learning disabilities etc.) as well as users without disabilities find this document format advantageous for its multi-modality.

As an electronic document type, the Hybrid Book belongs to the family of documents with synchronized multimedia content – other representative of that publication type could be for example the Daisy DTB format. More rich multimedia equipment and aiming to wider target group of users, however, predestinate the Hybrid Book to slightly another way of use.

1 The Content of the Hybrid Book

Hybrid Book consists of three media types:

- digital text,
- audio track (usually contains a recording of the text made by human interpreter),
- video track (usually contains a translation of the text to sign language for deaf).

All those media should support a sufficient information, but they also act as a complement to each other, especially multimedia to text. This means that user can follow selected media only without a serious information loss. On the other side, the complementary function of multimedia track might highly improve the accuracy of

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retrieving information. Simple but great example may be pronunciation of unfamiliar terms or names: A user reading a text in foreign language, it may be supportive to get unknown terms pronounced by a native speaker and simultaneously displayed in text; in the same manner it is helping to get such text translated and interpreted into sign language. This technique may be used backwards to clarify an information retrieved from multimedia track with referring matching part of text. For example, if a part of the document currently read is a table, it is ordinarily better to switch from audio (or video) to digital text, especially if a user is blind and is using a screenreader which after all offers comprehensive navigation in such structures.

2 Synchronization

All medias of Hybrid Book is synchronized. Each part of text may have its multimedia equivalent.

Accurate synchronization is reached by dividing the content of the documents to small parts called “phrases”; a phrase may contain a sentence, paragraph, list item or whole list, table column or row or cell, or any other logically separated text element. Each phrase has its internal name (number) that is used to manage synchronous playback and navigation steps by reading application.

3 Special Content

Hybrid book can contain practically any linear (textual), non-linear or graphical material; those non-linear types of content needs to be adapted not only to multimedia form (translation to sign language and reading up by voice), but in most cases they have to be adapted as a special addition to the text. For example no chart or schema, which is presented as a graphical object, is accessible for blind users, even if appropriate screenreader is used. Voice interpretation also does not match needs of subtle navigation in those structures. For that purpose the Hybrid Book includes a system of layers, which can keep such additional (alternative) textual content and can be shown/hide on the user demand. As the Hybrid Book content is fully synchronized, the multimedia form of the alternative texts is processed in case they are visible.

4 Technology Applied

While the reader application for the Hybrid Book is actually HTML 5 compliant, the coding of Hybrid Book content respects HTML 5 standards, too. Any other usage of that content is, however, kept by chosen standard and widely supported with those data formats for each type of its media:

- Text is treated as a standard HTML code with its all advantages and limitations.
- Audio recordings are encoded in MP3 and OGG format, video tracks are coded as H.264 (MPEG-4) and OGG Theora formats.
- Synchronization data are encoded in XML.

5 Reading the Hybrid Book

Currently, the only platform, for which a player is available, is the Hybrid Book Reader web application (http://www.teiresias.muni.cz/hybridbook). It actually allows to utilize the most of the features of the format, including:

- full content synchronization;
- complex navigation
  - by phrases,
  - by headings with/without respect to its hierarchical structure,
  - by using tree structured outline view;
- alternative media (text layers) processing;
- muting audio playback;
- hiding video screen;
- repositioning screen elements;
- every command or function can be reached by graphical on-screen controls or via computer keyboard shortcuts.

5.1 Means of Reading

While the Hybrid Book structure is complex, it has to allow a simple access to all of its content. The reading should be highly affordable to all users and respect their style of work. We aim its usage to be as ready as conventional print of a book or digital document in the hands of a reader without disabilities.

This accessibility is all above made by dedicated navigation functions, including steps as follows:

- go forward: phrase, heading, same-level heading;
- go backward: phrase, heading, same-level heading;
- go up (a higher level heading).

Those navigation features help a reader to get the overview of document structure very quickly. They are enough to assure quick skimming through the content and navigating to a specific position and in the same time there are not many of them to remember. All navigation steps act exactly the same way regardless what type of media is currently followed by user – no matter if only text or all of media types are processed or whether multimedia playback is turned on or off.

To find a specific part of content quickly (meaning a chapter or another selected part of the document), the outline tree-structured view can be used. The secondary functionality of the outline is displaying the current position of the document.

5.2 User Interface and Adjustments

The Hybrid Book Reader application provides adjustments to the user interface. It is based on "layout system", meaning there are several pre-defined screen layouts. Dynamic changes of the user interface made directly by moving objects on the screen is also planned to be implemented. These settings are kept with user profile for further use.

6 Target of the Hybrid Book

Hopefully, there are no exact borders of using the Hybrid Book technology in any type of multimedia plus text synchronization, but some types of content stay in the foreground anyway:

- Educational documents on languages: audio recording made by native speakers is available;
- Any educational material in general: audio interpretation of an extensive textual content may prevent eye-strain of (not only) visually impaired user; or complex, indented or highly structured document, where subtle navigation is helpful;
- Any document originally provided in sign language for deaf, which can be supplied with textual track to improve its lucidity for people using another language.

There are also some known issues with publication of a hybrid book: firstly, the production of a hybrid book may be an expensive job. The most resources consuming process is, naturally, preparation of multimedia content, especially the translation to the sign language.

7 Prospects and Outlooks

The Hybrid Book needs to accommodate to the current world-wide technological conditions and to requirements of users, which includes:

- improving of the Hybrid Book Reader web application to offer support for all main suitable todays devices, which can connect to the internet;
- building desktop applications for reading documents off-line;
- building web-based or native mobile applications (mainly iOS and Android platforms) to empower their users to work with the Hybrid Books (online/offline);
- improving layers system for working with alternative content in documents;
- implementing “native” navigation in tabular structures to hybrid book code and to reader applications;
- working on implementation of displaying and navigating mathematical formulas, flow charts etc.

8 Summary

The current state of the art of the Hybrid Book technology may be a solution of couple of situations, in which synchronized multimedia content is needed to prevent information distortion; it is especially well suited for language studying materials and for publishing materials to a wide range of people with some disabilities. It eases sharing information amongst these users and helps in corporative work of impaired and non-impaired people.

Hybrid book tends to be a heavily complex document format; complex inside, but all the more simple in its usage.

Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-928

Methodology for Rehab Technology Education of Heterogeneous Student Groups

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Abstract. In the education of specialists in rehab, health, nursing etcetera, e.g. in further education or Masters courses, often students with very different backgrounds from humanities to technologies come together. It becomes very difficult to create a common understanding of the relevance, options and issues of various technological support interventions. The paper presents an approach to consider the diversity of backgrounds as resource. With the concept of personas an individualized level of reflection is introduced in order to make positive use of the different backgrounds of the attendees. The exchange within the study group supports a good overview of different perspectives for all students. The course takes up the concepts of personas, case concepts and ICF as methodological baseline, applies a combination of presence teaching and e-learning and makes use of the heterogeneous backgrounds and interests of the students. The presented methodology has been developed and implemented in the framework of a joint Masters module of two different Masters, one on the ageing society and one on rehabilitation science.

Keywords. Higher education, ICF, assistive technology, design for all, ICT, personas, e-Learning.

Introduction

The use of modern technology is a very important element supporting people with disabilities and older persons in daily life. The introduction of the context factors - personal and environmental factors - in the ICF model [1] underpins this importance.
Therefore, based on the rapid development of technology the topic of how to best support people through technology becomes an increasingly important issue in education of specialists. However, in the education of specialists in rehab, health, or nursing students with very different backgrounds like technology, psychology, pedagogy, economics, social science, aging, nursing, therapy, medicine come together. The diversity of the background can make it very difficult to create a common understanding of the relevance, options and issues of various technological interventions. Some students are very open to the use of technology others more hesitant and prefer human assistance. And indeed not each and every technology can be successfully applied or adapted to each and every person. Typically, cases are considered as very concrete and relevant in the professional practice of many of the above mentioned disciplines. On the other hand new technological options as presented by technologists are often perceived by representatives of these professions as nice, but impersonal and not really appropriate for humans. Indeed, it is often easy to find negative examples which lead to a quick negative assessment. If one remains on such

general level of reflection, unfortunately the overall outcome does not appropriately consider the potential of such new technologies.

Actually, having diverse backgrounds present in a seminar can not only be difficult but also a very positive resource in the course. An individualized level of reflection is helpful in order to make positive use of the different backgrounds of the attendees. If this is taken and exchanged within the study group a good overview of different perspectives can be achieved for all students. This paper presents a methodology that has been developed and implemented in the framework of a joint Masters module of two different Masters, one on the ageing society and one on rehabilitation science. It takes up the concepts of personas, case management and ICF as methodological baseline, applies a combination of presence teaching and e-learning and makes use of the heterogeneous backgrounds and interests of the students.

Personas and Cases

The concept of personas [2,3,4] has been developed and is used in the context of usability of technical equipment. Personas are fictitious persons, who are constructed very concretely trying to give them a very clear image. Usually more than one persona is constructed in order to cover an appropriate range of potential users. These personas are the considered in usage scenarios in order to investigate usability aspects. Personas and scenarios help to develop a concrete understanding of the use of appliances in a concrete situation. Personas have already been used in the context of disability and rehabilitation, e.g. in [5]. In rehabilitation a qualitative approach of investigation is the single case research and a relevant approach in practice is case management [6]. Case based concepts are well known in rehabilitation and health based professions. As a persona can be interpreted as a (fictitious) case it is a good option to introduce and transfer the persona concept for students with different backgrounds. Personas and case concepts have in common that a case is being assessed or handled in detail and in depth.

ICF

While the ICF as a concept has been understood and used by many experts, the use for classification is less widespread. Only few ICF core sets exist up to now and often the ICF is used as a thought model of "(dis-)ability". Especially the use of context factors, which was one of the great achievements of the new bio-psycho-social model, remains low. However, it creates a framework for a reflective assessment also in the context of technological interventions. Here the environmental factors can be used to systematically assess the levels of activity and participation by using the classification.

E-Learning Elements

So far new teaching approaches such as e-learning have been either used as replacement of traditional teaching or as combinations with classical teaching approaches in face to face settings. Often learning platforms are just used as data storage of materials or communication tools for administrative issues and do not use other options of cooperation. In the presented methodology e-learning elements can create substantial benefit based on the diverse backgrounds of the student group.

1 Outline of the Educational Methodology

1.1 Methodological Elements

The course is outlined and announced as a traditional face to face seminar running with 15 weekly 90 minutes sessions. The presence sessions are used to introduce the seminar concept, to provide input from the teaching staff, presentations of the students, for discussions and administrative support/ exams. In particular, technology options for the support of people are presented in the face to face sessions. All course attendees share a Moodle platform for storage of material, production of individual course achievements, discussion and commenting. The exchange is performed mainly by the use of discussion fora, wiki and predefined online tasks. The online platform is the main space for documenting the individual reflection of each student. This is based on the construction of a persona by each student, which is documented in the Wiki. The students are taking the role of a kind of case manager for their respective persona, use it throughout the course as a reflection base and document this in the Wiki. They are requested to comment on the potential use of all technology solutions for their respective persona. All students can read all reflections of all personas (limited to the course). The approach allows to mirror the general subjects (e.g. technology for mobility, AAL, use of computers, web access, etc.) in the perspective of students' individual interest first and then share the perspective by cross-reading and commenting to the personas of others.

During the course students investigate in small groups selected technology themes as potential support options and make short presentations to all attendees.

One particular item of the individual work is the use of the ICF classification. Many of the personas are constructed in a way facing disability problems. Students are requested to classify the characteristics of their perspective persona in terms of body function and structure, activities and participation. After the introduction of potential technologies they are asked to assess possible changes and re-classify levels of activities and participation considering the technology as environmental factor.

For the last session of the course students are requested to revisite their persona, present it in split groups and critically discuss if all options for the best support of their persona have been taken up.

In the end all students have heard about a number of technological support options, have investigated and presented one of it themselves, have individually reflected the options and have used ICF to reflect the impact on activities and participation levels for their respective persona, have commented and discussed the reflections of others and have access to the complete range of personas as documented in the wiki.

Overview of Course Content

The described educational approach has been developed and successfully implemented over the last 4 years. The subject was always a selection of technologies, which varied according to the selections of the students. Of course the overall set-up was kept and refined over the four periods. The course was conducted 4 times with attendance between 12 – 30 students. Currently the course is run with 35 students. The changing and increasing number forced to adapt the presence sessions in particular the presentation of subjects and the work in split groups. With the increasing number of students more time for presentations and discussions is needed, which leads to a limitation of the number of attendees. With the given time of 15 sessions a group between 20-25 participants seems optimal based on the experience so far. A good range of technology options (about 16) can be presented, a reasonable number of personas (20-25) is considered and there is enough room for discussion. Many less or more topics and personas proved not to increase the course quality, but lead to time problems and administrative issues. The following table 1 shows an example of sessions and topics.

Table 1. Example of course sessions and subjects.

Session	Content
1	Course objectives and overall contents, intro of the E-Learning platform
2	Personas and Scenarios
4	Access to Computers and Software (PC-IO)
5	Safety measures for people with dementia
6	AAL, Home adaptations
7	ICF
8	Workplace adaptations
9	Access to Media and Internet
10-14	Selected themes presented by students, e.g.: Universal design, robotics, walking aids, wheelchairs, aids for personal hygiene, hearing aids, assistive tech (AT) for older people, AT for blind people, AAC, car adaptations, buildings and dementia, orientation support, telecommunication, tablet PCs, smart phones, telemedicine, social media, aids for children, low tech aids, e-book readers, e-Bikes, sociological aspects, UN-CRPD and technology, market, etc.
15	Discussion of Cases

2 Assessment of the Results of the Methodology during its Implementation in Brief

The courses have been evaluated by the moderators with the help of the students. Usually one session was used to discuss about the methodology, workload, learning outcome, content, and administration. The students used also the option for feedback after the exams. With only 4 terms experience and a total number less than 100 students no final assessment is possible. However, a number of observations have been made, which seem suitable to share. The observations are based on the statements, which have been issued by students and aggregated for this presentation:

- The use of mixed interaction in presence sessions and through the e-learning platform creates a challenging but very intense frame for the collaboration. Sometimes it is perceived as too much work between two sessions.
- Use of individual reflection base is mostly helpful to motivate to consider the pros and cons for the technologies introduced. Some technology options turn out to have a bigger potential than initially expected. Also limitations become obvious.
- The exchange with other students on their personas supports to open up understanding the overall potential of new technologies (if not relevant for my own persona, it can be relevant to many others).

- The perspectives of different backgrounds construct a wider knowledge spectrum and can be used to increase the understanding of potentials among the peer students.
- The discussion about the limitations and risks is integrated in the process.
- The attempt to use ICF for classification of a case has been new for all students so far. It is challenging but supports a systematic view. However, without a (software-) "tool" it is perceived as cumbersome.
- Students take the role as case managers seriously and defend their proposed interventions; however they also take up the observations and recommendations of their peers in the final discussion.
- Students learn about potential of new technology and its relevance for daily living, healthcare, quality of live, participation and inclusion.
- Students receive a skills training in interdisciplinary discussion and exchange, use of wiki, fora, presentation.

3 Conclusions and Future Work

The use of personas with disabilities and the classification with ICF and ICF context factors has been introduced successfully in heterogeneous student groups as a reflection basis of interventions with new technology. Students of very different backgrounds achieved a high level of motivation, depth of investigation with their persona and an overview discussing the cases of the fellow students. The use of e-learning elements supported the exercise and the communication. Students with disabilities were able to deal with the Moodle system, whereas the Wiki in the particular installation showed usability problems.

The use of ICF supported a systematic reflection, but created practical problems in the handling, documentation and explanation of the coding before and after the virtual intervention. It is therefore planned to develop a tool to support this process. We are also looking to replace the Wiki by a more usable and accessible version.

Finally, we will investigate the option to use the approach and the e-learning elements in cooperative courses with other universities.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-933

Development of Breath Mouse Employing a Gas Flow Sensor: A Data Input Device for People with Severely Disablities

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Abstract. Breathing is a function that humans can voluntarily control, and thus is an effective means of operating devices such as PCs and ECS. Only the switch function, however, is currently used within a single device. First of all, we conducted experiments using a gas flow sensor, with the initial objective of investigating whether a multichannel control signal based on breath could be acquired. The results show that control that differentiates strong and weak exhalations allows more channels than the two “exhale” and “inhale” channels seen in conventional breath switches. Based on these results, we proposes and developed a new input device that utilizes breathing data from sensors, experimentally investigating the possibility of voluntarily controlling the output of a gas flow sensor through breath control. In addition, an experiment was conducted to determine the effect of incorrect responses to breath direction and strength on operability and mouse cursor movement. The result showed almost no difference between the settings. This research has enabled the development of a device that further extends the functionality of conventional input devices for some people with disabilities.

Keywords. Gas Flow Sensor, Input Device, Breath, Severe Disabilities.

Introduction

Breath switches are used as PCs or environmental control systems by people with severe disabilities. Breathing is a function that humans can voluntarily control, and thus is an effective means of operating devices such as PCs. Only the switch function, however, is currently used within a single device. This research proposes and develops a new PC input device that utilizes breathing data from sensors, experimentally investigating the possibility of voluntarily controlling the output of a gas flow sensor through voluntary breath control. We also report on the development of an input device called a breath mouse, which realizes nearly the same functions as a conventional mouse, but is controlled by the flow of breath.

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1 Flow Sensor Experiment

1.1. *Aim*

An experiment was conducted to investigate whether target values displayed on a screen could be reproduced through breath control, and if so the amount of time required accomplishing this task. The results are used to consider the possibility of controlling a PC with breath.

1.2 Experimental Device and Procedures

In the experiment, participants used breath to move a dot on a monitor up and down in response to displayed target voltage values. The dot would move up and down according to the volume of breath exhaled into a gas flow sensor (Keyence Corp.). The flow sensor used was an amplifier-separation gas flow sensor that detected flow in only one direction. The experimenters could display target values (1.5 or 3.0 L/min) on the participant's screens at arbitrary time intervals by pressing a switch. The participant was instructed to blow into the flow sensor to achieve the displayed target value. Data on the time required for the participant to achieve the target value were recorded with LabVIEW system through an analog-to-digital converter (es-8 TEAC Corp.) and analyzed.

1.3 Results and Discussion

The participants in the study were five able-bodied adults. The time required for each participant to hold the cursor within ±15% of the target value for 0.3 s was used as an evaluation index. The results were as follows.

For a target value of 1.5 L/min, the average time for the five participants was 0.62 s. For a target value of 3.0 L/min, the average time was 0.57 s. Since these values each meet the target holding time of 0.3 s, it was indeed possible for participants to hold the cursor close to the target value for 0.3 s. These results suggested the potential for a breath-driven computer input device, and so the device described below was developed.

2 Development of Breath Mouse Employing a Gas Flow Sensor

The two main mouse operations are free cursor movement and right- or left-clicking. The objective was to develop a system that realizes these mouse functions to the extent possible by means of breath control. The specifications of the breath mouse are outlined below.

Moving the cursor up, down, left, and right on the screen are realized through four breathing actions: strong exhalation, weak exhalation, strong inhalation, and weak inhalation. Breath strength is measured with a flow sensor, and a microcomputer in the device determined whether the breath is strong or weak based on a threshold set by the user in advance. The developed breath mouse system is next explained in more detail. A single-chip Atmega328P microprocessor unit was used to process voltage from the flow sensor and to move the mouse cursor. Moreover, the device is equipped with an emulator for moving the mouse according to the signal output from the microcomputer.

Figure 1 shows a block diagram of the breath mouse's components, and Figure 2 shows the breath mouse's body equipped in a box containing the system .

Figure 3 shows the breath mouse connected to a PC.

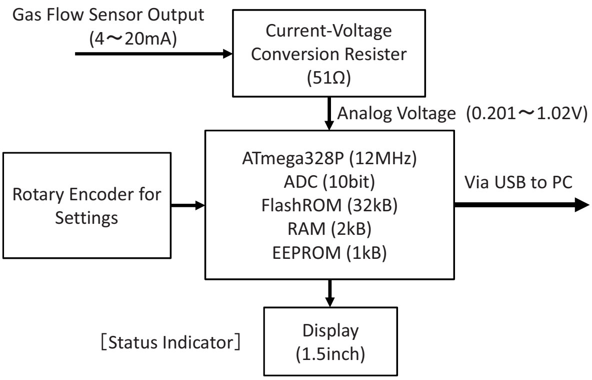

Fig. 1. Breath mouse block diagram.

Fig. 2. Breath mouse's body.

The device uses two unidirectional flow sensors oriented in opposing directions (Fig. 3), enabling measurement of breath flow in both directions. A current-voltage conversion resistor in the AD converter converts the 4–20 mA current output from each of the gas flow sensors to a full-scale voltage of 1.1 V or less, which is then input to the MPU.

Turning the knob of the setting rotary encoder, shown in the lower middle part of the image in Fig. 2, it is possible to change between breath and switch functions, and to change the setting values. Additionally, the device is connected via a USB port to a PC as shown above, and it is possible to control cursor movement similar to regular mouse movement using a mouse emulator.

Figure 4 shows a software flowchart. System initialization is first performed, followed by setting the 1 ms timer. Next, flow direction is detected from sensor data output.

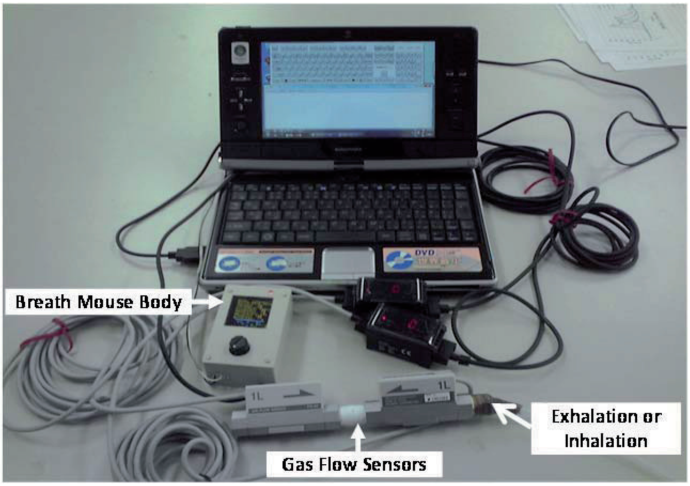

Fig. 3. Breath mouse connected to PC via a USB port.

A small time lag occurs in the cursor movement due to click operation detection. Data are input into a variable of the USB mouse communication driver based on the detected pattern. The data for this interval are used in the display routine to display the status on the screen.

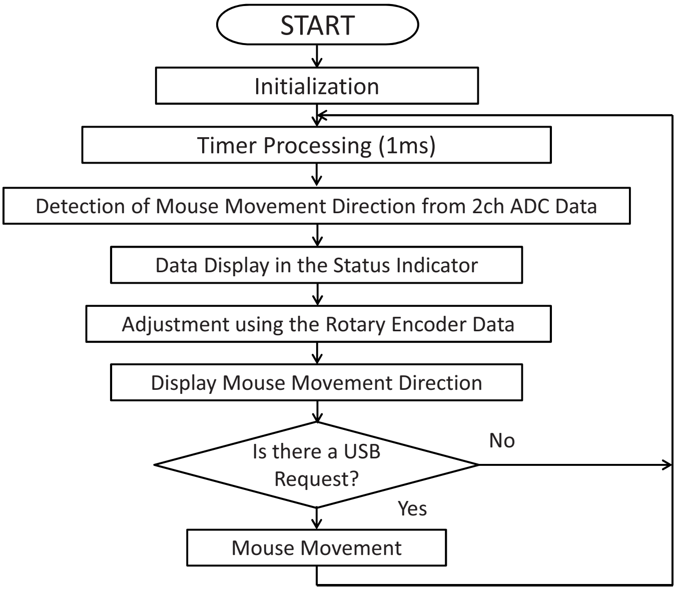

Fig. 4. Breath mouse flow chart.

Next, the rotary encoder input is executed and the processing routine is changed. The rotary encoder data are read in, and the setting value is adjusted when there is an increase or decrease. The next routine is the mouse click display routine. When a click operation is performed, the click state is indicated by the screen display color changing to light blue. The next routine is related to the PC issuing a mouse polling request to ascertain whether there has been a request from the PC unit. Next, at the bottom of the diagram, is a routine related to mouse movement. Specifically, mouse cursor movement data are passed to the USB driver and sent to the PC. This moves the mouse cursor up, down, left, or right in response to breath. It is possible to vary the movement direction settings by changing the constant values. The device thus allows mouse cursor movements and click operations without using the upper limbs.

3 Experiment on Direction of Operation

An experiment was conducted to determine the effect of incorrect responses to breath direction and strength on operability and mouse cursor movement. The task given to participants in the experiment was to select “Tab,” “m,” “a,” and “Enter” on an onscreen keyboard. An observer recorded the time required by each participant. The participants were 10 able-bodied adults.

The experiment was conducted with four mouse settings: (1) move right on strong inhalation, up on strong exhalation; (2) move up on strong inhalation, right on strong exhalation; (3) move left on strong inhalation, down on strong exhalation; and (4) move down on strong inhalation, left on strong exhalation.

The results showed almost no difference between the settings (values expressed as mean $\pm$ standard deviation): (1) 24.2 $\pm$ 3.1 s, (2) 24.0 $\pm$ 3.3 s, (3) 23.2 $\pm$ 2.8 s, and (4) 22.5 $\pm$ 2.7 s, respectively.

4 Conclusions

We conducted experiments using a gas flow sensor, with the initial objective of investigating whether a multichannel control signal based on breath could be acquired.

The results show that control that differentiates strong and weak exhalations allows more channels than the two “exhale” and “inhale” channels seen in conventional breath switches. Based on these results, an algorithm was designed to acquire input needed for mouse control from breathing, and a device was developed that uses a flow sensor, MPU, mouse simulator, and other components.

This research showed that if two degrees of breath strength are used, control is possible without creating much time lag between strong and weak states. In other words, this research showed that channels in at least four patterns can be controlled by breath (strong exhalation, weak exhalation, strong inhalation, and weak inhalation). A system using these four channel signals allowed free movement of a PC mouse cursor in up, down, left, and right directions. Appropriately setting breath strength and timing should also allow right- and left-clicks.

With the same device, it was possible not only to select ordinary menus displayed on a PC, but also to input characters using a screen keyboard included in the computer’s operating system. This research has enabled the development of a device that further extends the functionality of conventional input devices for people with disabilities, so that breath switch input can be done through selection of scanned menus. In addition, we hope this system with some improvements to be able to use for the general public who, for example, could not be used by both hands for some reasons.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-939

SOKEYTO V2: A Toolkit for Designing and Evaluating Virtual Keyboards

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Abstract: Designing virtual keyboards adapted to the needs of upper limbs motor impairment for text input or application control command requires an integrated tool to design and evaluate it. There are platforms of virtual keyboard design. These platforms enable to design virtual keyboards for text input, environment control command but also application control application like Internet. Several studies have defined models and parameters to measure the performance of text entry. Some adjustments of Fitts'law have been proposed to consider the motor behavior of upper limbs motor impairment. This paper will describe the SOftware KEYboard TOolkit (SOKEYTO v2). It is an upgrade of SOKEYTO v1. Text entry and environment controls are available functionalities of software keyboards designed by (SOKEYTO v2). SOKEYTO is the result of brainstorming sessions, review of related work on tools and test of current environment Clavicom NG, CiviKey. SOKEYTO v2 is a complete tool: it enables to design, generate and evaluate software keyboards. The evaluation process is an integral part of SOKEYTO; then it is possible to measure the impact of the layout on speed rate, for example, at each design step of virtual keyboard SOKEYTO v2 also allows the management of multi-layer of software keyboard; each layer could be customized. In regards to related work, SOKEYTO particularities are: predictive models adapted to motor impairment; possibility of customized keyboard layout and a program generator of software keyboard. Firstly, this paper will describe the method used to define the components of SOKEYTO and the characteristics of SOKEYTO with an emphasis on the SOKEYTO particularities. Then, we will report the predictive evaluation of software keyboards designed by the SOKEYTO platform.

Keywords: Motor Impaired Persons, Software Keyboard, Fitt's law, Hick-Hyman, Soukoreff, Assistive Technology.

Introduction

Designing virtual keyboards adapted to the needs of upper limbs motor impairment for text input or application control command requires an integrated tool to design and evaluate it. There are platforms of virtual keyboard design [17], [18]. These platforms enable to design virtual keyboards for text input, environment control command but also applications like Internet, text processing, etc.

[10], [11], [13] and [15] have defined models and parameters to measure the performance of text entry. [16] has proposed some adjustments of Fitts's law [6] to different types of motor impairment.

This paper will describe the SOftware KEYboard TOolkit (SOKEYTO v2). It is an upgrade of SOKEYTO [1]. Text entry and environment controls are functionalities available of software keyboards designed by SOKEYTO v2. SOKEYTO is the result of brainstorming sessions, review of related works on same tools [17], [18] and test of current environments Clavicom NG1, CiviKey2. SOKEYTO v2 is a complete tool: it enables to design, generate and evaluate software keyboards. The evaluation process is an integral part of SOKEYTO; then it is possible to measure the impact of the keyboard layout by the speed rate of text input, for example, at each design step of virtual keyboard. SOKEYTO v2 also allows the management of the multi-layer of software keyboard; each layer could be customized.

In regards to related works, SOKEYTO particularities are: predictive models adapted to motor impairment; possibility of customized keyboard layout and a program generator of software keyboards. Firstly, this paper will describe the method used to define the components, the characteristics with an emphasis on the SOKEYTO particularities. Then, we will report the predictive evaluation of some software keyboards designed by SOKEYTO.

1. Design Platform Analysis of Virtual Keyboard

Eight environments (See **Table1**, **Table 2**) have been analyzed from user trials, technical documents or/and scientific papers. Five classes of criteria have been defined: interaction techniques available for the virtual keyboard; types of function; morphological features and feedback of key, and models of evaluation. The SOKEYTO environment gets one of the top places in terms of available feature. The scanning interaction is still missing: we have planned to develop soon this function. The n-layer management is the main useful improvement because this feature offers the possibility to have several keyboards in one. The ergonomics of SOKEYTO offers intuitive functions easily used by practitioners. The set of key types allows controlling all applications such as home environment and all types of software (internet, text processing, text-to-speech synthesis, etc.).

The Table 2 reports the morphological characteristics of the keys. SOKEYTO allows defining several shapes (rectangular, hexagonal, square) of key. Only two environments offer the possibility to fix the opacity. The main feature of SOKEYTO is the availability of five reference metrics for evaluation. One of them is adapted to persons with motor impairment. This evaluation is useful to design interactively virtual keyboard.

[1] Clavicom NG, http://www.icomprovence.net/?ClavicomNG

[2] CiviKey, http://www.civikey.fr

Table 1. Virtual keyboard characteristic: interaction technique and key type.

	Interaction technique				Key type				
	Pointing	Scanning	Repeatition	Auto-click	Running program	Smart home control	Layer management	Macro	Ambiguous keys
SOKEYTO	1	-	1	1	1	1	1	1	1
KeyVit[3]	1	1	-	-	1	1	-	1	-
Qualikeys[4]	1	1	1	1	1	-	-	1	-
CiviKey[5]	1	1	-	1	-	-	-	-	-
Clavicom NG[6]	1	1	-	1	1	1	-	1	-
TnToolkit [18]	1	-	-	-	-	-	-	-	1
E-Assist II [17]	1	-	1	-	-	-	-	-	1
Madentec Discover[7]	1	1	1	1	-	-	-	1	-
Total	8	5	4	5	4	3	1	5	3

Table 2. Comparative table: Morphological, Feedback and Evaluation.

	Morphological characteristics			Feedback					Evaluation Model
	Key shape	Dynamic adaptation	Key size	Sound	Text to speech	Multi-language	Opacity	Key color	
SOKEYTO	1	-	1	-	1	-	1	1	1
KeyVit	-	-	1	-	1	-	-	1	-
Qualikeys	-	-	1	1	1	1	-	1	-
CiviKey	-	-	1	-	-	-	-	1	-
Clavicom NG	-	-	1	1	1	1	1	1	-
TnToolkit	-	-	-	-	-	-	-	-	1
E-Assist II	1	1	1	-	-	-	-	1	1
Madentec Discover	-	-	1	1	1	1	-	1	-
Total	2	1	7	3	5	3	2	7	3

2. Main Content

2.1. the SOKEYTO Platform

The design of the SOKEYTO platform is a combination of field studies, interviews, participatory design prototyping, and use of anterior versions. Physicians of physical rehabilitation, occupational therapists, end users with motor impairment of the upper limbs or speech disorders, human computer interaction researchers were involved to design SOKEYTO. It consists in three components:

- Functions to design virtual keyboard;
- Program generator of software keyboard from a description given in XML (extended Markup Language);

[3] KeyVit, http://www.jabbla.com/products.asp?itemID=26

[4] Qualikeys, http://qualikey.software.informer.com/

[5] CiviKey, http://www.civikey.fr

[6] Clavicom NG, http://www.icomprovence.net/?ClavicomNG

[7] Madentec Discover, http://healthproductsforyou.com

- Evaluation metrics to estimate the performance of virtual keyboards.

2.2. SOKEYTO Functions to Design Virtual Keyboard

The SOKEYTO platform is based on a Definition Type Document (DTD) of software keyboard. This DTD describes all the characteristics of the keyboard. Every element described in the DTD has been implemented as a highly configurable item through SOKEYTO.

This DTD allows the description of any type of software keyboard: text, pictograms, sound or application control. The DTD is writing in XML (eXtented Markup Language), whose the objective is to describe all characteristics of a virtual keyboard keys.

Pattern definition key
This function has been developed to enable the reproduction of a key pattern. This function was defined during a brainstorming meeting with end-users to reduce the design time of a keyboard.
The pattern definition of a key consists in defining: 1) the morphological characteristics of the key (color, form, spacing, etc.); 2) the number of the layer linked to the key (see below) and finally the function of the key..

Layer level management
SOKEYTO v2 permits the management of n-layers; each layer can be customized. The Figure 1 gives an example of a three-layer representation of keyboard.

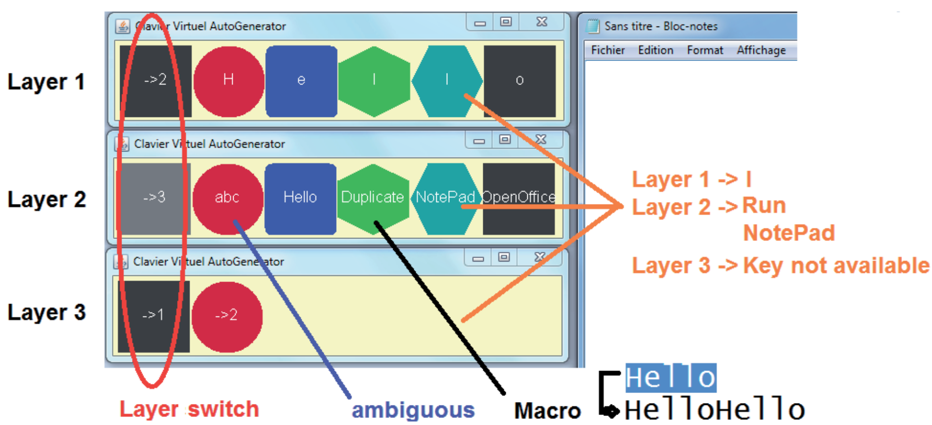

Figure 1. Three-layer representation.

Five types of events (**Figure 1**) have been designed to cover all types of key functions:

- Text Input. For instance, pressing the "l" key will input the character "l" (layer1).

- Ambiguous key. Typing on these devices, the user presses the key corresponding to the letter. See [19] for a description of UKO–II designed for low motor demands (“abc” key layer 2).
- Macro is an event file that includes text keys ("Hello” key, layer 2), and/or keyboard shortcut of functions (“Duplicate” key, layer 2 which corresponds to “ctrl+c->ctrl+v”).
- Execution key of an application. In Figure 1, pressing the “NotePad” key (layer 2) will run the “NotePad” application;
- The "Layer switch" key changes the active layer of the keyboard. In Figure 1, pressing the key “-> 2” switch to the Layer 2. Pressing the key “l” on the layer 1 input a “l”, while that corresponds to the execution of Notepad at the Layer 2.

Interaction configuration
Software keyboard designed by the SOKEYTO platform can also be customized. Thus, it is possible to select the interaction technique according to the user abilities: inputting with click method by pressure, delayed click or scanning; key repeat with a timer. Multimodal feedback of keys has also been defined after discussion with end users and occupational therapists. These customizations (See **Figure 2**) are : visual feedback color of the key pressed/inputted; size expanded to make the key input easier, configuration of the text-to-speech synthesis to restitute the string inputted; several options are available (no audio feedback, character, word or sentence). Following the request of several end users, we have added the keyboard opacity to visualize it. All these configurations are saved in XML files to make the customization easier.

Figure 2. Visual Feedback: Color, Opacity, Size.

2.3. Evaluation Metrics of SOKEYTO to Assess Virtual Keyboard

The efficiency of these different text entry layouts must be measured. The Fitts’s law [6] as the prediction of movement time in human-computer interfaces is considered as the reference. Several refinements to improve the theoretical and empirical accuracy of the Fitts’s law have been done: refinements including the adaptation of Fitts’ law to different population (tetraplegic, myopathy, able-bodied) have produced the Vella’s model [16]. The Soukoreff-Makenzie’s model [13] is based on the Hick-Hyman’s law for the time of keyboard identification [7] [8]. The KLM (KeyStroke Level Model) [5] based on the estimation of different actions is also included. All these metrics are available on the SOKEYTO platform to assess the virtual keyboards.

In Table 3 is an example of results obtained with the Soukoreff-Mackenzie's model [13] which takes into account the relative frequencies of letter-pairs (bigrams) for French. These measures are useful for occupational therapists. They provide indicators to adapt the representation of the keyboard to the user's abilities.

These results can be computed in real time during inputting task through any virtual keyboard of his/her choice. The GAG keyboard is the most efficient (+39% compared with AZERTY) whatever the predictive evaluation model used.

Table 3. Keyboard performance theoretical with Soukoreff-Mackenzie's model.

Name	Word Per Minute (WPM)
Azerty	**49.6**
Annie [16]	**57.3**
Opti [3]	**62.9**
Fitaly[8]	**63.0**
Metropolis [2]	**67.5**
GAG [4]	**68.8**

3. Conclusion

SOKEYTO platform is a complete tool to design, to adapt and to assess virtual keyboard for text input. The functions "key pattern", the multi-layer layout and the management of several events permit creating a database of software keyboards with ease. The great customization of the virtual keyboard (interaction technique, key types, morphological features and feedback of key, evaluation models) allows a fine keyboard adaptation to individual needs of the subjects.

The SOKEYTO platform is currently used in an education and rehabilitation center by occupational therapists. Azerty layouts have been adapted according to the motor behavior of child (for instance, timer click, text-to-speech, etc.). The first uses are promising: the customization property is high appreciated.

Acknowledgments

This work was partially funded by the National Research Agency TECSAN (PALLIACOM Project).

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-946

A Low Cost Brain Computer Interface Platform for AAL Applications

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Abstract. Brain Computer Interface (BCI) technology can provide users lacking voluntary muscle control with an augmentative communication channel, based on the interpretation of his brain activity extracted, for example, from the EEG. In this paper, a low cost BCI development platform is presented; it consists in a customized EEG acquisition unit and a Matlab-based signal processing environment. An application example using SSVEP paradigm is discussed. BCI can be used in AAL applications, providing an alternative interaction scheme.

Keywords. Brain Computer Interface (BCI), Augmentative Communication, AAL.

Introduction

Ambient Assisted Living Technologies (AAL) aim at making the home environment more intelligent and cooperative, providing help to accomplish daily living tasks. Besides AAL main focus at supporting independent life of elderly people, many AAL solutions (e.g., those aimed at environmental safety and control) may be usefully exploited by people with severe impairments too. However, effective interaction between these individuals and an AAL system may result troublesome, or even not viable without any external assistance; tools need to be developed, in this sense, to enable effective interaction. Nevertheless, at least for these scenarios, it is worth mentioning that any help coming from such technologies could not replace the presence of specialized caregivers, nor render their potential users completely independent; however, they could foster the ability to better interact with the surrounding environment, making the user feel more in control, with a positive impact on its psychological wellbeing.

A possible solution to the discussed problem can be found in Brain-Computer Interface (BCI) technology. A BCI is an alternative/augmentative communication device [1] that aims at providing the user (for instance lacking voluntary muscle control) with an interaction path, based on the interpretation of her/his brain activity; in this sense, a BCI can be regarded as an Assistive Technology (AT) device. In this paper, the development of an EEG-based BCI communication unit is introduced, explicitly conceived for (even if not limited to) AAL control purposes.

CARDEA [2] is a flexible AAL system developed by the University of Parma, Italy. It is an open system, based on standard LAN technology, and it is characterized by high scalability and easy reconfigurability, which allow the system to be deployed in many different contexts and locations. Besides common home automation system functionalities, such as security, environmental control, smart energy management, CARDEA seamlessly integrates AT services in its core. Examples are fall detection, localization, vital sign monitoring [3]. In order to access and control all the AAL system services, many user interfaces are available, including button switches, touchscreen, vocal, remote internet control. Still, as previously mentioned, effective interaction with individuals affected by severe impairments is an issue. Our goal is to develop a compact, low-cost BCI module, provided with local autonomous processing capabilities, which can be seen by CARDEA simply as an additional control device. The main application for this BCI module is, then, AAL system control. Therefore, with respect to most common BCI approaches, the proposed strategy focuses at relatively simpler tasks, leaving room for lowering costs, user's effort and invasiveness. In [4] the interaction scheme between CARDEA and a simple BCI is discussed; other examples of AAL-focused BCI can be found in [5]-[8]. Our approach is mainly focused at obtaining a compact, low-cost embedded module.

In this paper, we describe the ongoing development of a dedicated embedded system, including three main units (Figure 1): *i)* an Analog Front End (AFE) for acquiring the EEG signal, *ii)* a digital signal processing unit, implementing feature extraction and classification and, *iii),* an output/feedback unit for display and implementation of active controls. We first developed and tested a novel hardware AFE unit, whereas the last two blocks are currently implemented on a PC architecture, allowing for more flexibly testing and tuning performance of different configurations, algorithms and methods. Eventually, integration in a compact, low-cost embedded module will provide a standalone device, capable of handling BCI operation and communication with other systems with no needs of further bulky or expensive equipment.

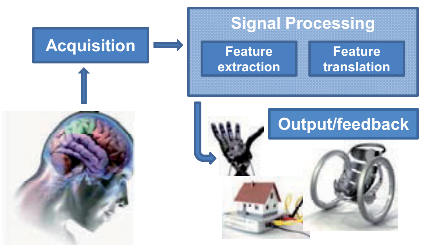

Fig. 1. Functional blocks of a BCI.

1 Methodology

With reference to brain signal acquisition issues, a very popular approach exploits ElectroEncephaloGraphy (EEG) techniques; EEG signals can be non-invasively acquired from the scalp, by sensing the electrical signal with (dry or wet) skin-surface electrodes. To our purposes, EEG offers a satisfactory tradeoff between spatial and temporal resolution, as well as reasonable costs and compactness when compared to other methods (e.g., based on functional Magnetic Resonance Imaging (fMRI), Near InfraRed Spectrography (NIRS) or Positron Emission Technology (PET)).

Focusing on EEG-based BCI, several paradigms are currently exploited for regulating their operation. Among them: Slow Cortical Potentials (SCP) [9], Event Related De-synchronization (ERD) [10], P300 [11],[12], Steady State Visual Evoked Potentials (SSVEP) [13]-[17]. The latter paradigm, in particular, exploits brainwave features elicited by the involuntary response to a continuous, repetitive stimulus, such as a blinking LED: in the 4-40 Hz frequency range, the blinking frequency reflects on the onset of a isofrequency component in the brain power spectrum.

With respect to other paradigms, the SSVEP paradigm makes synchronization issues less critical, and possibly lends itself for simpler acquisition architectures. This is particularly valuable, given our low-cost, embedded-module oriented approach. In this sense, high-end, clinical EEG equipment with a large number of electrodes are scarcely suitable for the application at hand, and low-costs, small-size devices are to be designed, suitable for extracting basic information on brain activity [4]. The adoption of low-cost, standard electronic components also fosters product interoperability. Moreover, careful design should also consider scalability, allowing users, for example, to flexibly select the number of EEG leads. On these grounds, the custom AFE circuitry has been designed. Most critical specifications, in this stage, came from noise concerns: acquiring EEG waveforms involves extremely small signals (featuring amplitudes in the range of a few μV), which require to be amplified before digitization: Analog to Digital Converters (ADC), in fact, may feature a noise floor significantly higher than the signal level. Therefore, low-noise techniques must be exploited in the design of such biopotential amplifiers, to ensure that the informative content of the signal is not corrupted by the noise contributed by the instrumentation. In the aimed application context, further sources of Signal to Noise Ratio (SNR) degradation may come from electrical and power line interference. While the use of active electrodes may help in mitigating those issues, the related higher costs and complexity made us opt (at this stage, at least) for the worst-case design, adopting passive electrode technology.

From such requirements, a multi-channel AFE for EEG signals was designed and realized on a 4-layer Printed Circuit Board (PCB). Fig. 2 shows the schematic of each EEG acquisition channel, terminating with a multichannel, high resolution (24 bit) Σ-Δ ADC, along with a Driven Right Leg circuit, introduced to improve common mode noise rejection [18]. The module, battery operated, supports both single supply or split supply modes; it features up to 6 differential/common reference EEG-specific channels, plus 2 spare, fully-differential channels. These additional channels can be used, for example, for simultaneous recording of other bio-potentials, such as ElectroOculoGram (EOG), ElectroMyoGram (EMG), ElectroCardioGram (ECG), enabling combined analysis (e.g., analyzing the correlation between the recorded EMG at the onset of a movement and the correspondent ERD [19]). Noise performance of the AFE was tested with input terminals shorted, extracting an input-referred noise lower than 1.8 μV_{pp}, which is more than sufficient for our purposes.

At this stage of research, a Matlab-based platform for paradigm testing and algorithm prototyping was designed. From such environment, we can control several AFE parameters, such as ADC gain and data rate, as well as interact with the controllers of the stimulation units, such as flashing lights or arrays. Matlab-ADC interfacing is achieved by means of an Arduino Board, communicating via serial protocol. Whenever a new stream of EEG data is available and ready to be processed, a classification algorithm (an example is given in the next section) infers the user's choice from the input data. The decision is then communicated to the AAL system as a simple command, representing the action intended by the user (e.g. the switching of a light). Communication occurs via a simple messaging protocol based on the TCP/IP standard.

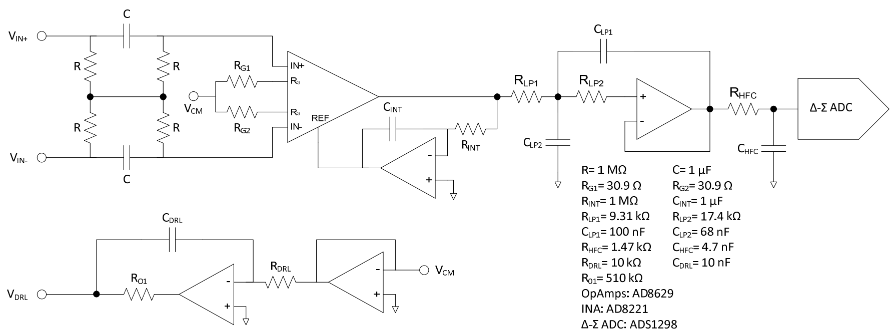

Fig. 2. Schematic of a channel of the proposed AFE.

2 Application Example: SSVEP-based BCI

In the following, a preliminary investigation on a SSVEP-based BCI is illustrated, focusing at automated recognition of SSVEP patterns. The experiments were devised as follows. In the first one seven healthy volunteers (age 23-26, five of them without any prior BCI experience, with normal or corrected to normal vision) were asked to stare at a flickering LED while resting on an armchair at approximately 1 m from the visual stimulus. Each trial lasted for 6 seconds, and 6 trials were performed on each stimulation frequency (12-22 Hz in steps of 2 Hz, plus 28 Hz and 30 Hz). EEG was acquired at 250 SPS from 6 scalp locations over the temporal and occipital area (namely O1, O2, T3, T4, T5, T6, according to the International 10-20 electrode placement system). Standard 10 mm Ag/AgCl disk electrodes were employed for the recording, along with conductive paste. One stimulus frequency at a time was shown in order to investigate which SSVEP peaks were best detectable for each individual.

In order to classify the SSVEP response, a new algorithm was developed and tested, illustrated in Fig. 3. First, the input EEG waveforms are low-pass filtered for out-of-band noise reduction; then, the Power Spectral Density (PSD) is estimated using Welch's method. Then, given a pre-determined band of interest, the channel power are equalized over this band. The algorithm exploits the *a priori* knowledge of the possible stimulation frequency set, by checking the conditions only on such set. In particular, the channel powers are summed at each target frequency. Candidate targets are selected whenever, at least, 50% of the active channels exhibit a local maximum in the PSD at the given frequency; then, candidates are compared: if the power associated to a given candidate exceeds all the remaining ones by a given threshold, the decision is made. Otherwise, a more selective power sum is compared, including all frequency components and raising the threshold.

A simple interface for controlling a light switching through CARDEA was then developed. Two flickering LED were used in this example, one for issuing the turn on command, the other for the turn-off. In this experiment, 4 participants were asked to select the "on-off switches" following a pre-determined sequence. Each subject performed a total of 40 trials; the experimental setup was the same as described above except the fact that only the two subject-specific best frequencies were displayed, simultaneously.

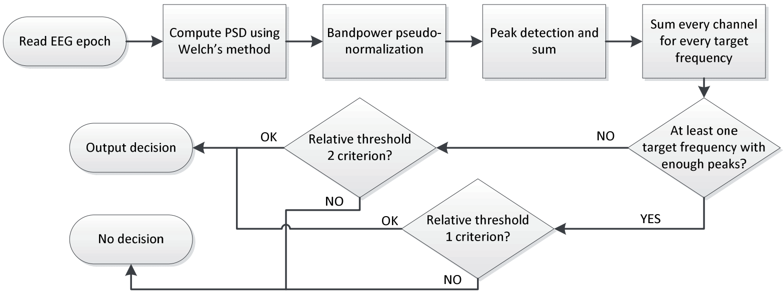

Fig. 3. Proposed SSVEP classification algorithm.

A cue-based operating mode was adopted, alternating EEG sampling epochs (6 s time windows) to rest periods. EEG epochs were processed by means of the aforementioned algorithm and the output decision was used to send the corresponding commands to CARDEA via a TCP/IP socket. Results will be discussed in the next section

3 Results and Conclusions

Examples of measured SSVEP responses are shown in Fig. **4**. The proposed classification algorithm achieved an average classification accuracy of 94.4%, comparable to other multi-class SSVEP-BCI. The result is more than adequate for effectively interacting with CARDEA, the accuracy of the selection process being more important than the speed, at least for our purposes of AAL systems control. Following the formulation reported in [1], the maximum Information Transfer Rate (ITR) achievable with this classification accuracy, supposing a decision is made every 6 s, is 7.01 bit/min.

The introduction of band-power normalization is shown to slightly improve the classification performance, especially when there is a strong inter-channel imbalance, due to, for example, different electrode impedance; the normalization improves the classification robustness by somehow self-adapting to variable scenarios.

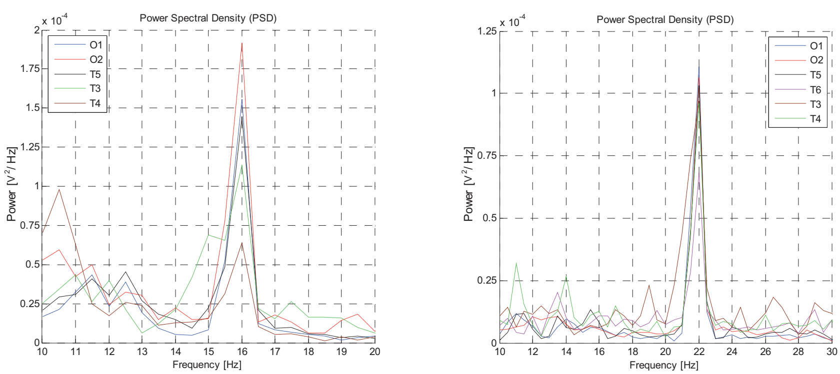

Fig. 4. PSD plot of SSVEP responses 16 Hz (left), 22 Hz (right).

In addition, the proposed algorithm is relatively simple and suitable for implementation on low-power, mobile digital processors, such as DSP or ARM microprocessors. Finally, it does not require synchronization between the stimulation and the acquisition unit, thus simplifying the overall design of an embedded BCI system. Further optimizations will lead to a compact, embedded system capable of processing the signals locally; the BCI will be fully integrated into the CARDEA system, which will interact with the module as with the other existent user interfaces. Online, self-paced operation is currently being investigated to provide the user more flexibility and classification speed.

Finally, future work includes testing and providing support for other BCI paradigms (e.g. Motor Imagery), investigating also the possibility of using multiple paradigms simultaneously [21].

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-953

Development of a Low-Cost BCI Application using Neurosky Mindband and Lego Mindstorms

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Abstract. Brain-Computer Interfaces (BCIs) are a major technological breakthrough. These systems were first developed mostly for clinical purposes and their usage was limited to specific patient populations. Consequently, BCI technology and applications were quite expensive. In recent years this technology has become increasingly low-cost while maintaining suitable performances, making it available to the general population. Consequently, novel applications are sprouting. In this paper we present a simple and low-cost BCI application, which uses two off-the-shelf items: Neurosky Mindband, a novel consumer-electronics BCI, and Lego Mindstorms NXT, a robotic system based on Lego bricks. These two devices were bridged with Matlab. By using brainwave-related "Attention" and "Meditation" values, two-dimensional control of the robotic system was achieved: the Lego robot was able to move forwards and to the left/right, and was positively evaluated by 8 healthy subjects. Due to its low-cost and simple set-up and usage we believe that this application could be used not only for entertainment but also for paving the way for simple control of motorized devices by the elderly and patients with motor impairments.

Keywords. Lego Mindstorms, Neurosky Mindband, Brain-Computer Interface, BCI, Attention, Meditation.

Introduction

Brain-computer interfaces (BCI) allow a person to send messages or commands to the external world, through information encoded in electro-encephalographic (EEG) activity, in order to control devices such as computers and robots [1-3]. These devices are highly relevant to patients with diseases such as amyotrophic lateral sclerosis, because this kind of pathology leads to severe motion impairments. BCI's may improve quality-of-life by improving the ability to move and communicate [4]. Besides EEG, other techniques such as functional magnetic resonance imaging (fMRI), positron emission tomography (PET) and magneto-encephalography (MEG) can be used to monitor brain activity, although these methods are more expensive and require technical knowledge to be operated [2,5]. In addition, the equipment involved in these techniques requires the user to remain static, while there are portable EEG devices.

BCI's are a very recent technological development. The first BCI was described in 1964, when a subject who had electrodes connected to motor areas was able to advance

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a slide projector with his electrical activity before he pressed the button assigned to the same task [6].

Nowadays, there are commercially available BCI's like g.tec's IntendiX®, which is designed for patients with limited communication abilities [7]. This kind of device is expensive in comparison with other commercial solutions, and requires the use of an electrode cap. Low-cost solutions such as Emotiv EPOC or Neurosky's Mindband have recently been made available. In addition to their lower price, these devices are non-invasive and easy to set up. Currently, they have several software applications available, such as games and even an "on screen" keyboard (for Emotiv EPOC) [8,9].

Neurosky's Mindband is an EEG device that allows raw EEG measurement, as well as "Attention" and "Meditation" levels. These two parameters are estimated by the Mindband with a frequency of about 1 Hz [10]. The EEG is measured with only two dry electrodes, placed on the forehead, attached to a headband. The reference (ground) electrode is placed over the ear and signals are sent to the computer via a Bluetooth device. In this research, the Mindband was used to interpret the user's volition to move a robot. This robot was a Lego Mindstorms NXT, assembled as a tricycle, with the ability to move forwards and to turn to both sides. It was connected to the computer via USB cable, although the connection is also possible via Bluetooth. Both the Lego and the Mindband are low-cost devices, which are appropriate to build a simple BCI.

Vourvopoulos et al. used Neurosky's MindSet and Mindwave (similar to Mindband) to move the Lego NXT, connecting it via Bluetooth to a computer [11]. In this work, the authors installed LeJOS (a JAVA virtual machine) on the Lego NXT and did the programming process in this language. Only one-dimensional motion was achieved using Neurosky devices, whereas two-dimensional motion was done resorting to Emotiv EPOC.

In our project two-dimensional motion control was applied to the Lego NXT using the Mindband device. The robot's original firmware was kept and the programming language bridging both devices was Matlab. The goal of this work was then to build a simple BCI application, which is based on low-cost devices such as the Lego and the Mindband, and which do not require previous user experience.

Methodology

The study enrolled 8 healthy volunteers (4 males) aged between 20 and 28 years with no prior BCI experience.

Both devices (Lego NXT and Mindband) were controlled via Mathworks software Matlab®, running on Windows XP x86. The program MotorControl, for controlling the Lego motors, was sent to the Lego NXT memory chip. This program is provided by the Aachen University, as well as the corresponding toolbox for Matlab [12]. Based on this toolbox, several command programs were built in order to integrate desired actions (move in a certain direction) in single Matlab functions.

Neurosky provides a Matlab function to read and display the raw EEG, power spectrum, "Attention" and "Meditation" levels (arbitrary units from 1 to 100) in a single figure [13]. This function was modified in such a way that when certain thresholds were reached a specific command would be sent to the Lego NXT.

When the value of "Attention" equaled or was higher than a certain threshold value, the modified Neurosky function sent a "go forward" command to the Lego NXT. The power (resulting in robot speed) sent to the motors was proportional to the "Attention" value. This parameter was always the first one to be verified. After this, if the "Attention" value did not result in robot motion, "Meditation" value would be checked. If this latter value was equal or higher than a certain threshold, then the robot would rotate to the right, as default. To change the rotation direction the users had to blink. This action was chosen to determine the rotation direction because forced and abrupt blinks cause an electro-oculogram (EOG) artifact to appear in the EEG signal, which has its amplitude highly increased during the blink. After each command was sent to the Lego NXT, a delay command was introduced. These delays pause the execution of the function and are related to the duration of the Lego motion. Several delay commands were tested in order to improve robot control and minimize computer load.

Testing of the BCI application consisted of determining the adequate subjects' threshold, allow users to understand and familiarize with the control features for a few minutes and take a simple control challenge. This challenge involved moving the Lego from one point towards another, with an obstacle (15x20 cm) between them (Figure 1). The start and end points were separated by a distance of 120 cm, and the obstacle was 60 cm away from the start point. During this process, the users were allowed to look at the robot and to the computer screen where the "Attention" and "Meditation" levels were being displayed, as well as the number associated with left or right rotation (-1 or 1, respectively).

The first minutes before the challenge were used to record the maximum values of "Attention" and "Meditation" for each user. The threshold values were obtained according to the Eq.(1).

$$threshold = \frac{3}{4} \cdot max \quad (1)$$

where max is the maximum value of "Attention" or "Meditation" attained by each subject. The time required by the subjects to control the robot from one point towards another was registered.

Results

The application performed successfully since the users were able to control the robot out of their volition and reach the final point bypassing the obstacle.

Figure 1. Mindband-controlled Lego NXT placed at the starting point of the challenge. The small white box represents the end point, whereas the larger one is the obstacle.

The delay commands were optimized: these delays should correspond to the time the robot takes to complete the motion command it has received. This is a relevant topic because if there are no delay commands, the Neurosky function continues to read signals and sending commands to the robot, which either "pile up" and cause an unstable and desynchronized robot motion or the computer load will cause function interruption. If the delays are too long the user will not be able to control the robot as soon as it has completed an action, which will cause undesirable lag. The time associated with the delays was then optimized to match the robot motion, by trial-and-error.

The average time needed to complete the challenge was 308 seconds, with a standard deviation of 175 seconds. The results of the survey (**Figure 2** to Figure 7) reveal that in general the application can translate the users' volition into movement, and watching and hearing the robot is helpful to control it. The subjects also considered that the training prior to the challenge was useful for a better control. Qualitatively, it was also observed that during the experiment the subjects' control ability improved over time.

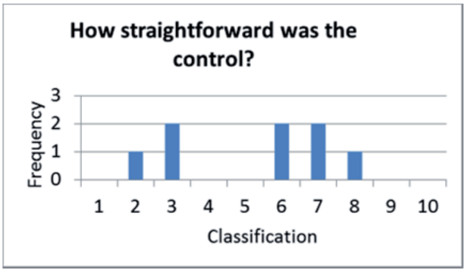

Figure 2. Histogram of the subjects' classification of robot control, where 0 stands for "very hard" (to control) and 10 stands for "very easy". Mean=5.25.

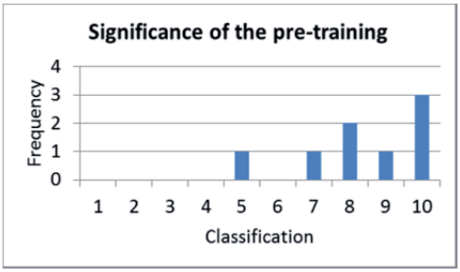

Figure 3. Histogram of the subjects' classification of how important pre-training was, where 0 stands for "not important at all" and 10 stands for "very important". Mean=8.38.

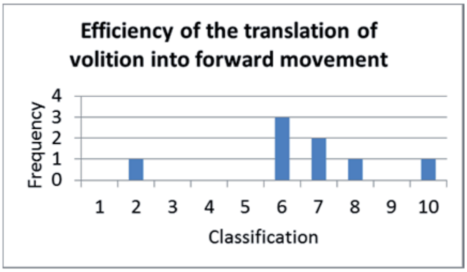

Figure 4. Histogram of the subjects' classification of how efficient was translating volition to forward motion, where 0 stands for "not efficient at all" and 10 stands for "very efficient". Mean=6.50.

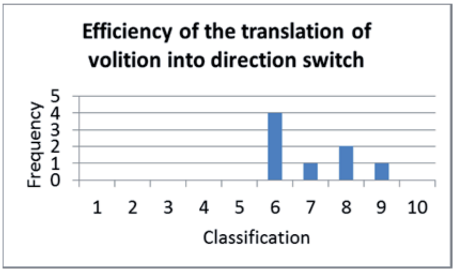

Figure 5. Histogram of the subjects' classification of how efficient was translating volition to direction switch, where 0 stands for "not efficient at all" and 10 stands for "very efficient". Mean=7.00.

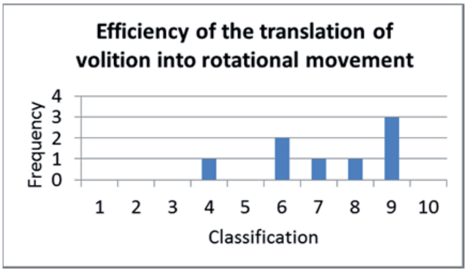

Figure 6 – Histogram of the subjects' classification of how efficient was translating volition to rotational motion, where 0 stands for "not efficient at all" and 10 stands for "very efficient". Mean=7.25

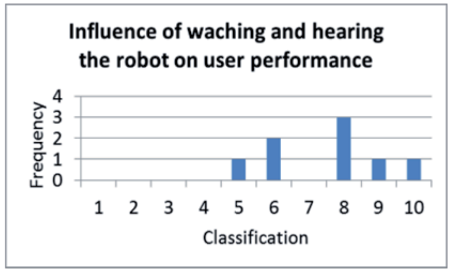

Figure 7 – Histogram of the subjects' classification of how hearing and viewing the robot was helpful to its control, where 0 stands for "very negative effect" and 10 stands for "very positive effect". Mean=7.50

Discussion

We have successfully developed a BCI application using Mindband and Lego NXT. The delay commands duration could have been determined directly by the NXT motion functions. The robot can be controlled with commands based on time or motor rotation. Due to higher precision in rotational control, the commands were based in this parameter. The impact of using time control instead of rotational control should be evaluated, although rotational control guarantees that despite the power delivered to the motors, the distance travelled by the robot is always the same. Therefore, different types of movement should be evaluated, either to make the movement smoother or with better handling.

Due to impossibility of measuring a person's real level of "Attention" or "Meditation", which are subjective concepts, the subjects were inquired about the efficiency of the application. Even though most subjects considered it was relatively easy to control the robot (**Figure 2**), pre-training was considered to be important (**Figure 3**). They also considered that rotating was easier than moving forward (**Figure 4** andFigure 6), despite the thresholds were calculated for each subject. This might suggest that different thresholds should be used for "Attention" and "Meditation", and other methods for calculating them could be used, such as the mean of a series of measures (not necessarily maximum). Because the direction switch is performed using an artifact, it depends on the subject and the electrodes placement. Even though some false forced blinks were detected and some real forced blinks were not, the subjects considered this detection to be relatively efficient (**Figure 5**). A quantitative evaluation might have been performed, but due to placement sensitivity, it is more reasonable to adjust this threshold according to the user's feedback. The question about the influence of hearing and watching the robot was asked because when the robot moved, the user might have gone distracted and thus lowered his/her attention. This hypothesis was not supported by the users' feedback, since they considered that such influence had a positive effect in controlling the robot (Figure 7).

Further research might involve applying the current EEG control to other devices (motorized wheelchairs, domotic devices, robotic limbs), and building a robust EEG parameter set for simple and universal use. As it is now, this application could be an interesting toy for children with motor impairment, although a fully automatic program and user-friendly interface would be mandatory. We believe that high performance and low-cost BCI devices such as Mindband may become interesting assistive tools for the elderly and patients with motor impairments.

Acknowledgements

The authors would like to thank the members of Brain Networks and Interfaces Group from IBEB-FCUL for valuable discussions. This work was supported by Fundação para a Ciência e Tecnologia (FCT) and Ministério da Ciência e Educação (MCE) Portugal (PIDDAC) under grant PEst-OE/SAU/UI0645/2011.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-959

Developing Assistive Technology with Multidisciplinary Teams: A Front-End Procedure to Stimulate Collaboration and Manage Expectations

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Abstract. Since developing assistive technology in multidisciplinary teams can be a challenge, we propose a procedure to bring all actors in the project together using a user centered approach. This procedure starts with writing a use case of the envisioned assistive technology. Next, it continues using a questionnaire to make expectations of all partners explicit. During a multidisciplinary meeting, the survey and the use case together serve as a basis to come to a hypothetical scenario describing current and future practices. The final step is to test the extent to which the assumptions in the hypothetical scenario hold. By interviewing relevant users, the hypothetical scenario will then iteratively evolve to a current practice scenario. The case of the Fallrisk project is used in this paper to illustrate the envisioned procedure and lessons drawn from applying this procedure.

Keywords. Assistive Technology, User Centered Design, Patient Centered Design, Scenario, Multidisciplinary Teams.

Introduction

When developing assistive technology, actors from different domains are essential (e.g. different specialties in health, technical and social sciences) to create a solution that provides an optimal user experience. Creating such an experience is studied in the domain of user centered design, a multifaceted field beyond its infancy (e.g. [1]). Applying user centered design is slowly becoming more common in healthcare (e.g. [2–4]). For instance, Terpenny and her colleagues [5] compared multidisciplinary student teams (industrial design and engineering) and engineering only student teams while developing assistive technology. Their findings suggest that results of a higher quality are accomplished and that collaborating with people from another field is appreciated [5].

However, working in a multidisciplinary team in a user centered way can be challenging since each partner (each actor involved in the project) has a different background and a different approach (e.g. [6]). Challenges can include problems such as managing research priorities and objectives or managing teams with different academic and work cultures [7].

Therefore, we have been developing a procedure that brings all these partners closer together while developing assistive technology and focusing on the users (such as

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patients, nurses or other stakeholders). This procedure is the result of and based on our experiences with different past and current projects within the field of assistive technology. Although the procedure's roots are not very innovative in the field of user centered design (e.g. the use of narratives in the form of scenarios), we think it is essential to describe and reflect on the new ensemble use we propose to be useful as a boundary object in a multidisciplinary project with multiple goals creating an innovative assistive technology in a user centered way. Another innovation in this procedure is that it already starts at the phase of writing the proposal. In this way we try to deal with the observation that collaborating within the multidisciplinary team is the ideal situation, but not realized in practice - or too late in the process [8].

We describe the four steps of our procedure in four subsequent sections: 1) describing a current and a future use case as a point of reference in the project proposal; 2) developing and distributing a questionnaire to make expectations explicit; 3) organizing a multidisciplinary meeting to resolving questions which will result in the last step: 4) creating multiple scenarios.

To illustrate how we applied the procedure we use the case of the ongoing iMinds Fallrisk project [9] (2013 - 2014). The aim of this project is to develop a system that uses multiple sensors to detect fall incidents of elderly people in their (nursing) homes. The system (supported by an algorithm) uses this information then to alert in a dynamic contextual aware way (in)formal caregivers based on their proximity to the elderly and their availability. Since fall incidents can negatively impact the quality of life of elderly people (e.g. due to fear of falling, injuries) [10], it is important to detect fall incidents and monitor the fall risk of elderly at several moments in time. In this applied research project, four research groups at various universities in Belgium, four technical companies and a home care organization are involved.

The next section explains the four phases of the procedure. This section is then followed by the lessons learned from applying this procedure to the Fallrisk project (section 2) and how we will further use this procedure throughout the project (section 3).

1 Four Phases to Facilitate User Centered Multidisciplinary Design of Assistive Technology at the Start of a Research Project

When writing a proposal for a research project, this procedure encourages collaboration and communication between the partners by making expectations explicit. In our experience, it is essential to stimulate this at the start since partners tend to use their own background as the norm, as well as underuse the different kind of background knowledge diverse partners bring to the table. Therefore we developed this procedure we discuss and illustrate in the next sections. The goal and outcome of this procedure is to come to a common agreed research based future scenario describing the context of the field where the assistive technology will be used.

1.1 Phase 1: Point of Reference in Proposal: Current and Future Use Case

The project proposal is not only a document to convince funders of the worth of a research plan, it is first and foremost a research plan that is used as guidance when executing the project. It is therefore worth the effort to create room for a first explicit reflection of the expectations of the different participating partners. More specifically, we advise to integrate a use case that schematically describes the situation as it is now and also the proposed future situation in which the assistive technology solution is integrated. Not only is this a strategy to make the value of the project clear to the funding agency, but it also creates a pivotal point of reference to users and their practices that will be designed for. The envisioned research contributions and its interdependencies are easier to talk through before the project is even approved, and a faster start is possible for people that were not involved in the proposal-writing phase.

In the Fallrisk case, the core writing team (three persons) of the proposal designed two figures of the use case of the system after consulting the different partners. These figures describe both the current and the future envisioned situation. The use cases also illustrate how we attempt to integrate two processes (fall detection and fall risk estimation) in the new assistive technical system. These processes are currently separate care processes and they could be improved in performance (efficiency and quality of care) by continuous monitoring and reasoning experience.

1.2 Phase 2: Creating and Distributing a Questionnaire to Make Expectations of Multidisciplinary Project Team Explicit

During the second phase, user researchers within the project develop and distribute an explorative questionnaire with open-ended questions. The goal of this questionnaire is to encourage all partners to make their expectations of the project at that moment in time explicit. In particular, each partner is asked to describe the current and future situation based on the use case from the proposal (its actors, its practices, and the technologies used).

In the Fallrisk case, the user researchers in the project developed a digital questionnaire. Questions included identifying the research problem and identifying relevant actors. More importantly, we asked each partner to explain the current situation and the proposed solution based on the use cases from the proposal. We also asked for visuals (such as drawings and pictures) of their vision of the future they want to support with this new assistive system.

In our experience, project partners find this a difficult exercise and many questions arise from it. However, asking these questions is a good thing, since it highlights aspects that are unclear and have to be defined more clearly.

1.3 Phase 3: Multidisciplinary Meeting to Create Common Ground by Asking and Resolving Questions

In the next phase a multidisciplinary meeting takes place with at least one representative of each project partner. In this meeting, the current and future use cases are presented based on the responses of the questionnaire. The purpose of this meeting is to agree to a more detailed description of both use cases, but also to stimulate discussion and interaction among partners. In this way, all partners can contribute to using their knowledge, and a common hypothetical story is created, a contextualized use case further referred to as a scenario.

In the Fallrisk project, use cases were created based on the input of the questionnaires. Next, we had an interactive multidisciplinary meeting in which these use cases were presented. This meeting was only not important to agree to a common hypothetical scenario, but having such a meeting and similar following meetings is essential to stimulates collaboration and dialogue between partners.

2 Phase 4: Scenario

The last phase is focused on **scenarios**. These scenarios aid in communicating user research to other - in particular technical - partners in a project. This method starts with a use case, a tool familiar to technical partners, and this tool will evolve in the last phase to a scenario, a tool often used in user research [11]. These scenarios can then act as a boundary object [12] for the multidisciplinary team by providing the opportunity to work together from different worldviews without needing consensus on every detail.

After the multidisciplinary meeting, an adapted version of the **hypothetical scenario** is created based on the use cases describing the situation as it is and the future situation with the new assistive technology in its context.

These hypothetical ("sunny day") scenarios are solely based on the assumptions and knowledge of the project partners [13]. The aim of this scenario is to make all expectations within the project explicit and this scenario will most likely undergo several iterations until all the partners and assumptions are integrated in this scenario. This scenario also introduces personas, also known as hypothetical characters [14] that represent the users for which a technology will be designed.

The next step is then to create a **current practice scenario**. Writing this scenario, clarifies how and whether the assumptions of the hypothetical scenario hold in the current practice. To create this scenario, interviews with relevant stakeholders are conducted, stakeholders in their context are observed and a literature review is conducted. Findings from these research activities, will confirm some aspects of the hypothetical scenario, or negate other aspects. Creating this current practice scenario is an iterative process where the after each round of data collection, new insights are integrated in the scenario.

All previous described phases, are a preparation to create a future scenario. In this next phase, stakeholders (such as patients, nurses or other relevant actors) will be involved in the research to co-create the design of the future assistive technology.

In the case of Fallrisk, we created a **hypothetical current and future scenario** based on the use cases and the input of the questionnaires. The current scenario describes Marie, an 85-year-old lady, who uses a personal alarm system. In case of a fall, she can push on a button. The scenario further describes how her call is followed up and how informal caregivers are sent to help her. The future scenario describes a similar situation, but in this case the personal alarm system is extended with a system that automatically can detect falls. Also, in this future scenario (in)formal caregivers are contacted based on their proximity to the elderly and their availability.

Both hypothetical scenarios went through a couple iterations, where project members added their comments or questions to the scenarios. During this process, we had two multidisciplinary meetings. When no more input was given, we decided to start with the **current practice scenario**. To validate or negate our assumptions written down in the hypothetical current scenario, we did two observations at a call center, one observation where a personal alarm system was installed, one interview with a nurse who installed such systems and one focus group / co-creation session with nurses specialized in fall prevention.

Currently, we are in the process of analyzing this data to iteratively improve and complete the current practices scenario.

3 Preconditions and Lessons Learned

Based on our experiences with applying the procedure to the Fallrisk project, we describe the preconditions for successfully applying the method and what lessons we have drawn from this case:

- **Multidisciplinary Team Advocates for the Procedure.** An important precondition is the willingness of all project partners to participate in all four phases. To create this willingness, a clear explanation of the advantage of the procedure at the start of the process, not only a user researcher should advocate the approach. It is essential that someone with technical expertise is willing to advocate this approach actively as well.
- **Balance Length and Information learned from Questionnaire.** Collecting completed questionnaires from the partners required some reminders, probably because it took quite some time to fill in the questionnaire. It is recommended to balance the amount of time needed to fill it in and the information gained from it.
- **Scenario as a Boundary Object.** We observed that the scenario did work as a boundary object and it stimulated collaboration between (both technical and non-technical) research groups and the home care organization. Not all partners contribute as active; the technical companies are often taking a more passive approach and depend heavily on the input of other partners.
- **Starting from your Imagination: Hypothetical Scenarios.** Starting imagining hypothetical scenarios, can be difficult when people do not know the field. Emphasize that the goal of that exercise is to find the knowledge gaps as well as the assumptions from each partner. Make clear that the function of the hypothetical scenarios is to give a baseline to compare with other sources, and show what is learned throughout the project. Highlight the difference between the hypothetical scenarios and the ones created after validation of the assumptions to illustrate the value of the process.
- **Involve other Partners in user Research Activities.** One of the multidisciplinary meetings took place at the homecare organization partner. This allowed the partners present to observe at a call center handling fall alerts. This particular visit resulted in resolving the issue whether the operator should stay in or out in our system. Also, in other projects we have the experience that inviting non-user researchers in the field creates more common ground for the further discussions.
- **Communicate Goal of each Scenario.** It is important to communicate the goal of each scenario clearly to avoid misunderstandings. Some partners are very goal oriented and cannot wait to fix the scenario so they can start developing the proof of concept. It is therefore important in the discussions to define generic technical components that are still flexible enough to change with the input from the user research. It is only in that way technical and user research can proceed concurrently.

- **Divide scenaRio in Mini Scenarios and Represent Visually.** After some scenario iterations, the scenario kept growing in length and keeping an overview became difficult. To solve this, we divided the scenario in multiple mini scenarios each targeted at describing a specific situation. Also, a scenario as a story can become less practical to describe multiple options. A schematic representation might be more suitable in that case. Keeping some narrative active, however, is necessary to keep a link to contextual information.

4 Contributions and Future Work

In sum, we have illustrated a procedure to encourage collaboration in a multidisciplinary project. The procedure requires making the different expectations from all the partners explicit. It also pinpoints issues that remain unclear and have to be clarified. Then, it encourages coming to a consensus and the scenario created during this procedure, can as a “red thread” be used throughout the project. We have applied the first phases of this procedure in the Fallrisk project by iteratively evaluating and transforming the hypothetical scenario into a current practices scenario.

The current procedure has some limitations. For instance, there is still a translation gap between the technical architecture and the scenario. To integrate these two, there is still a need for other tools that can improve the communication between technical and non-technical partners. Also, there are differences regarding the extent to which different partners within the project adopt this procedure. Additions to the procedure are needed to facilitate bring the technical architecture and the scenario closer together and to encourage adoption by all project partners.

The next steps will include involving stakeholders (nurses, elderly and informal care givers) via focus groups, interviews and co-creation sessions to inform the design of the future system. Data collected from these research efforts will iteratively result in a future scenario describing the envisioned context and use of the assistive technology.

Acknowledgements

The Fallrisk project is co-funded by iMinds, a research institute founded by the Flemish Government. Companies and organizations involved in the project are COMmeto, Televic Healthcare, TP Vision, Verhaert and Wit-Gele Kruis Limburg, with project support of IWT.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-966

Technology Support in School for Pupils with Disability

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Abstract. The Swedish Institute of Assistive Technology runs two projects which analyzes how the use of technology in school can support pupils with disability. The projects have been following the pupils and offering them different kinds of support with the aim to prepare them for a future employment or further studies. To be able to identify the pupils and their disabilities, an instrument called the School Setting Interview (SSI) has been used. The SSI is an occupational therapy assessment developed at Linköping University in Sweden. The projects have employed occupational therapists to perform the interviews of the pupils. Occupational therapist is not a common profession in the Swedish schools. In the preparation of the projects it was needed to include this profession with the aim to expand the perspective of the pupils and their needs of support. So far, approximately 400 pupils have been interviewed. A majority of the interviewed pupils have a cognitive disability or dyslexia. More than 50 percent of these pupils had no earlier on documented diagnosis. The results so far indicate that the SSI instrument has made it possible for the pupils to explain their situation for the occupational therapists about their situation in school. The most common assistive technologies which have been distributed to the pupils in the projects are tablet computers and smartphones with different kind of applications, scanner mice, spelling programs and time-aids. It is too early to draw general conclusions from the projects. However we have indications that the pupils perceive that different kind of assistive technology can help them in school. One of the projects, which is financed by the Swedish Government, will end in September and then we will be able to present for instance quantitative and qualitative data from about 400 - 500 students, evaluation of the experience of the occupational therapist's competence in school and a socio-economic analysis.

Keywords. Assistive Technology, pupils with disability, cognitive disability, occupational therapist, user perspective, employment, socio-economic analysis

Introduction

Every fifth person in Sweden has a disability that affects their daily lives. Among these people, unemployment is twice as high compared to the general population.[2] In the summer of 2012, more than 31,000 young adults received activity grant. The majority of these individuals received compensation due to some kind of disability.[3]

It is a major problem for the Swedish society that so many young people with disabilities are unemployed. We know that in many Swedish high school classes, there are pupils who will not get final grades because they can´t handle the school situation.

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According to the Swedish Employment Service, 50 percent of those who do not have final grades from high school will end up in unemployment.

Far from all pupils, especially those pupils with disabilities do not get the help and support they need to reach the grading goals of the school. We believe that the teachers don’t have enough knowledge about these pupils and it therefore requires a new competence in school; the occupational therapist.

1 Two Projects to Support Pupils with Disability

The Swedish Institute of Assistive Technology, SIAT, runs two projects which analyzes how technology can support pupils with different disabilities. The projects will follow the pupils and offer different kinds of support with the aim to prepare them for a future employment or further studies. The projects are located at five different high schools in Sweden and include pupils between the age of 16-20.

One of the projects is financed by the Swedish Government as a Government mission and the other project by the Swedish Inheritance Fund Commission. The total budget is 30 million SEK (approximately 3,6 million EUR). The same methodology are used in the two projects but the Government mission is only intended for pupils with cognitive disability such as ADHD, ADD and autism and runs for 1,5 year and will end in September this year. The project which is founded by the Swedish Inheritance Fund Commission lasts for a longer time period until June 2014.

1.1 The Aims of the Projects

Some of the aims are:

- identify pupils with different types of disability
- offer the pupils with disability access to adapted choice of technology support
- evaluate the importance of the use of new technology in school for pupils with disabilities
- disseminate the outcome to politicians and school principals.

2 The Methodology

To be able to identify the pupils and their disabilities, an instrument called the School Setting Interview (SSI) has been used. The SSI is an occupational therapy assessment developed by Helena Hemmingsson, Professor in occupational therapy at Linköping University in Sweden. The SSI is a client-centred instrument, and considers the pupils´ opportunities for participating in all possible settings, including the classroom, playground, gymnasium, corridors and field trips. The SSI contains 16 items (see table 1), with suggested follow-up questions that provide the occupational therapist with information about the student´s functioning and needs for adjustment within school.

Table 1. The School Setting Interview (SSI) items (Hemmingsson et al 2005).

1. Write	9. Do practical subjects
2. Read	10. Participate in the classroom
3. Speak	11. Participate in social activities during breaks
4. Remember things	12. Participate in practical activities during breaks
5. Do mathematics	13. Go on field trips
6. Do homework	14. Get assistance
7. Take exams	15. Access the school
8. Do sports activities	16. interact with staff

The SSI was initially developed especially for pupils who have some type of motor dysfunction. According to Swedish and Icelandic pilot studies (Volk 1998, Hauksdóttir and Júlíusdóttir 2007) it is also well designed for usage among pupils with other disabilities.

After the SSI is completed, the occupational therapist tries to find an appropriate technology support based on each pupil´s specific needs. After about a month a follow-up meeting takes place to see if the pupils can use its new assistive technology. A second SSI takes place after approximately six month to make sure if the new technology has been useful for them and if their school results have been improved. If the pupils still face difficulties new measures from the occupational therapist side might be needed.

2.1 The Occupational Therapist

The projects have employed occupational therapists to perform the interviews of the pupils. Occupational therapist is not a common profession in Swedish schools today. In the preparation of the projects it was needed to include this profession with the aim to expand the perspective of the pupils and their needs of support. It is perceived that the perspective of the occupational therapy helps to see the big picture and bring together the pedagogy with the use of technology for the pupils who are involved in the projects. This will be an ingredient in the evaluation of the projects.

3 The implementation

So far, approximately 400 pupils have been interviewed. The SSI instrument has been used. A majority of the interviewed pupils have a cognitive disability or dyslexia. More than 50 percent of these pupils had no earlier on documented diagnosis. The results so far indicate that the SSI instrument has made it possible for the pupils to explain their situation for the occupational therapists about their whole situation in school. The majority of the interviewed pupils have difficulties with writing, reading, remembering and structuring.

The most common technology support which have been distributed to the pupils in the projects are tablet computers and smartphones (such as iPad and iPhones) with different kind of applications, scanner mice, spelling programs and time-aids.

There are lots of different kinds of calendar applications which create an overview and structure for pupils who have difficulties to remember things as for instance homeworks and exams. There are also applications which allow pupils to record lectures, take picture of the blackboard and make notes. "Time Timer" is a watch which visualizes time for pupils who have difficulties with time perception. The pupils who have been identified as dyslexics have received speech synthesis and spelling programs to their computers or dictaphones and Daisy players.

Even more general supportive solutions to the classrooms have been purchased such as classroom audio systems and interactive whiteboards. Classroom audio system is used during lessons for pupils with difficulties to filter noise. It means that the teacher has a microphone and the pupils can hear the teacher's voice with the help of headphones or speakers.

4 Results and Follow-up

It is too early to draw general conclusions from the projects. However we have indications that the pupils perceive that different kind of assistive technology can help them. The fact that the technology support is modern and new has made it easier for pupils to accept the help and support the occupational therapists have offered them. Some of the pupils are graduating in June and the projects will evaluate if their grades have improved and if they get a job.

Linköping University will evaluate the results s from the both SSI number one and two. In September, at the Conference, it will be possible to show more specific statistics about the pupils from both projects. The project illustrates that there is a great lack of knowledge among teachers and other school staff about different kind of disabilities and new assistive technology.

The results from the projects will eventually include:

- quantitative and qualitative data from about 400 - 500 students (which will be used in future research at Linköping University).
- evaluation of the experience of the occupational therapist's competence in school.
- a socio-economic analysis about occupational therapists and assistive technology in schools.
- a training package about cognitive disabilities in school aimed for the teachers need for education about disabilities and assistive technology.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-970

Research on the Occupational Ability Evaluation Technique in the Group Work of Intellectually/Mentally Handicapped Persons by MODAPTS Method

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Abstract. The percentage of company employment as advance into society in the intellectually/mentally disabled is almost the same as that in the physically disabled, and moreover is getting higher every year. The first objective is to analyze the characteristics of the intellectually/mentally disabled more deeply in order to help the government and companies to understand them and the employment rate to increase.
The second objective is to review the work evaluation method of the intellectually/mentally disabled anew through this evaluation in order to trigger the research on the intellectually/mentally disabled to be activated. The result of the verification performed by this research has showed that the success or failure in a continuous company employment is more significantly related to the factors of "surrounding healthy persons" which are external factors than the factors arising from the disability of a disabled person. According to the result of this study, if they work with healthy persons in the same place, their job performance actually decreases.
This shows that disabled person's own willingness to work and job performance ability is not much influenced by individual disability characteristics, but they are very likely to be significantly influenced by whether the human environment around them in the workplace is good or not.

Keywords. Environment in the Workplace, Healthy Persons and Disabled Persons, Analysis of the Movement, Support of the Working.

Introduction

The percentage of company employment as advance into society in the intellectually/mentally disabled is almost the same as that in the physically disabled, and moreover is getting higher every year. [1)] The first objective is to analyze the characteristics of the intellectually/mentally disabled more deeply in order to help the government and companies to understand them and the employment rate to increase.

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The second objective is to review the work evaluation method of the intellectually/mentally disabled anew through this evaluation in order to trigger the research on the intellectually/mentally disabled to be activated.

1 Method of Study

As the research method, survey investigations in local working support institutions were conducted. The locations were set to be working support institutions in the urban and suburban areas in Table 1. The subjects were sampled from 26 persons in total consisting of 16 intellectually/mentally disabled persons in total in working support institutions and 10 healthy persons. In the work, they were asked to perform a menial labor of putting two mouthpieces and 5 containers into a bag for a packing work of bubble kits.

Table 1. Experiment facility information.

Target	Facilities division	Location	Details
Subjects	Employment support facility A	Osaka	Usually, the assembly of a used bicycle etc. is performed.
	Employment support facility B	Tokushima	Usually, the packing of accessories, foodstuff, etc. are performed.
Healthy persons	————	Tokushima	Young people in the early twenties (For a sampling, in a university laboratory)

Table 2. Environmental parameter information.

Parameter Info	Details
Parameter A	Usual works only by disabled persons
Parameter B	Works of disabled persons unfamiliar to work and skilled disabled persons
Parameter C	Works of healthy individuals and disabled persons
Parameter D	Works only by disabled persons and external constraints

Table 3. Three analytical method (MODAPTS/ timeline analysis, and rate of a poor process.

The process of bagging operations (example)	Left hand operation (MODAPTS)	Right-hand operation (MODAPTS)	MOD	MOD Time	Timeline (sec)	The number of completion	Number of defects
Grasp/place a bag	M3G1 M3P0		7	0.9	2	–	–
Open a bag	M2G1	M2G1	3	0.3	2	–	–
Grasp/put in yellow	Retainment	M4G1 M4P2	11	1.4	4	–	–
Grasp/put in green	Retainment	M4G1 M4P2	11	1.4	5	–	–
Grasp/put in blue	Retainment	M3G1 M3P2	9	1.1	4	–	–
Grasp/put in pink	Retainment	M3G1 M3P2	9	1.1	7	–	–
Grasp/put in orange	Retainment	M3G1 M3P2	9	1.1	3	–	–
Press a bag	M2G0	M2G0	2	0.2	2	–	–
Grasp an embouchure/put in	M4G1 M4G1 R2 M4P2	Retainment	18	2.3	9	–	–
Close a bag	M2G0	M2G0	2	0.2	1	–	–
Grasp a bag/put in	M3G1 M4P2	M3G1 M4P2	10	1.2	2	–	–
	↓			11.2	41	1	0

○ "Estimated time for performance of work (MODTime)" analyzed using MODAPTS
Estimated time (MODTime) = work index calculation MODx0.129

○ Record real-time and an event at that time using timeline
The rate of creation = time / number of sets

○ Evaluate not only work process but also work quality
Defect rate= the number of defects/completion

In view of the possibility to affect the mental and physical health of the intellectually/mentally disabled, the extended usual works as shown in Table 2 were evaluated. I asked the staff member concerned with the facilities to sit with a disabled person in consideration of too much burden etc., so that poor physical conditions might not be induced by these contents.[2-5]

Three techniques (Table 3) were used as analytical method. The reason for employing these techniques here is that I wanted to grasp the characteristics from work observation without giving any physical pressure to a subject. Usually, although only MODAPTS[6] is sufficient, the preliminary experiment showed that only the motion evaluation was insufficient, and therefore irregular actions at the working time were also recorded by using a timeline analysis.

2 Analysis

2.1 Analysis 1: Time-Line Analysis and Calculated Results of the Poor Process Rate

From the time-line analysis and calculated results of the poor process rate, we could get the rate of creation in Figure 1 and the defect rates in Figure 2. The rate of creation in Figure 1 is the time to complete one set and The defect rates in Figure 2 are numbers and proportion of products which were not able to be created as the standard sample.

As a result of comparison with the environmental parameter A (mean value at the usual time of subjects), the rate of creation got worse particularly in the mentally handicapped person group among the environmental parameter C (mixed group with healthy persons) .The defect rate got worse in the whole of environmental parameter B (mixed group of unfamiliar persons with proficients) and the environmental parameter C (mixed group with healthy persons), particularly in the mentally handicapped person group sharply.

Moreover, in the environmental parameter D (two institutions, two kinds of work), the creation rate and the defect rate got worse a little in the employment supports facility A (bicycle assembly work) , on the other hand, the creation rate and the defect rate were improved conversely in the employment supports facility B (food packaging work).

2.2 Analysis 2: The Total Result of MODAPTS

Table 4 and Figure 3 was able to be obtained from the total result of MODAPTS.

The work rate in Table 4 is the one in which the point obtained from each action actually recorded in MODAPTS is further turned into time, and the average value and standard deviation of all samples are found here.

Moreover, the net work rate in Figure 3 is a sorted model sample on the timeline approximated to the presumed basic value (MOD Time) by MODAPTS among all samples based on the observed data (picture recording) accumulated separately. As with the work rate, the average value and standard deviation of all samples were found for this work.

The value in which the net work rate (2.) was deducted simply from this work rate (1.) was deemed to be the group with the factor in which usual work operation was not completed due to any disturbance (element for work stop) during the work and was quantified as a poor operation difference. It is estimated that in the environmental parameter (group) with high average value of this value, the work accuracy tends to be affected by external factors.

From the first, the parameter in disturbance factors is also prepared for the action analysis by MODAPTS. However, for the work of the disabled persons, the state which cannot be analyzed by the usual parameter may appear. Therefore, in order to think as important the degree of influence of the work environment on the workability, in this research, numerical evaluation was tried individually.

From the view point of environmental parameter A (average value at the usual time of subjects), since there is no difference between healthy persons in 1. (work rates) and 2. (net work rates), it is found that the difference of a creation rate is due to work ability (when becoming skillful in applicable work, there is almost no work difference) originally.

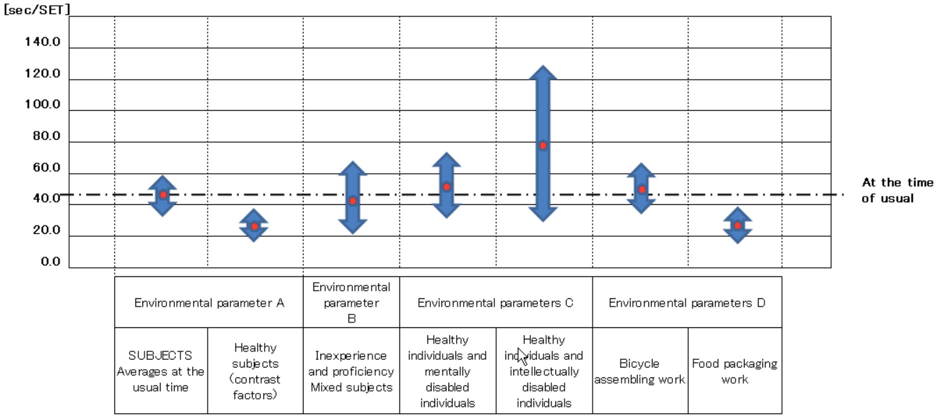

Fig. 1. The result of calculating timeline analysis and process defect rates (creation rate).

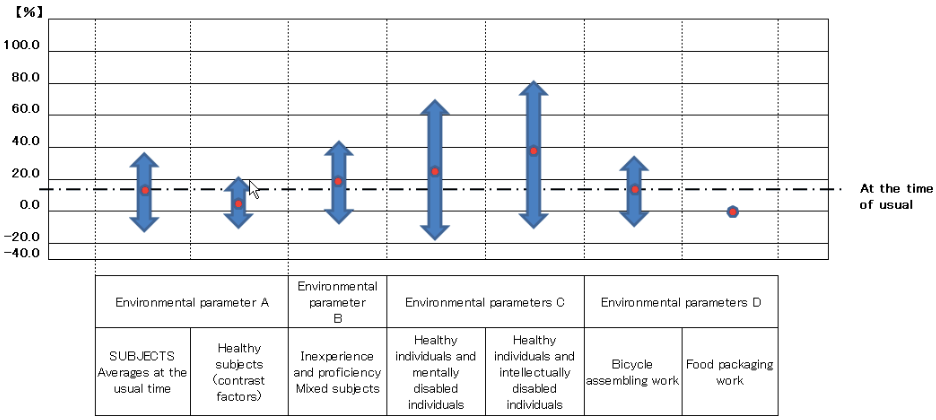

Fig. 2. The result of calculating timeline analysis and process defect rates (defect rate).

Table 4. Result analyzed employing MODAPTS method (power and pure power).

			1. power	2. Pure Power	1−2 Difference (Poor operation difference)
Environmental parameter A (comparison factors)	Intellectually and mentally disable individuals	Mean	13.2	12.3	0.9
		Standard deviation	1.5	1.4	
	Healthy individuals	Mean	12.5	12	0.5
		Standard deviation	0.5	0.7	
Environmental parameters B (inexperience/proficiency mixture)	Intellectually and mentally disable individuals	Mean	15.1	14.3	0.8
		Standard deviation	1.5	1.5	
Environmental parameters C (cooperation with a healthy individuals)	Mentally disable individuals and healthy indicividuals	Mean	13.7	11.6	2.1
		Standard deviation	2.3	2.5	
	Intellectually disable individuals and healthy indicividuals	Mean	18.2	14.8	3.4
		Standard deviation	4.9	2.9	
Environmental parameters D (2 institutions and 2 work classifications)	Bicycle assembly operation facilities	Mean	15.5	13.77	1.7
		Standard deviation	0	0.01	
	Food packaging works facilities	Mean	12.85	12.01	0.8
		Standard deviation	0.03	0.63	

Comparing with this environmental parameter A (average value at the usual time of subjects), it is found that the value got worse slightly in the environmental parameter B (mixed group of unfamiliar persons with proficients), the same in the environmental parameter C (mixed group with healthy persons), and the mentally handicapped person group got worse considerably and the mentally handicapped person group got worse slightly.

Moreover, it was found that while in the environmental parameter D (two institutions, two kinds of work), the employment supports facility A (bicycle assembly operations) got worse a little, the employment supports facilities B (food packaging work) was improved a little.

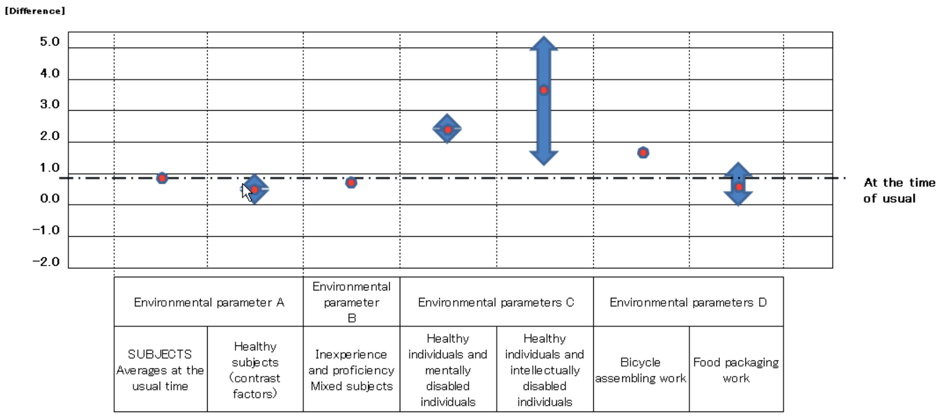

Fig.3. Poor operation diferrence computed employing MODAPTS method (Time to be under the influence of a disturbance factor).

3 Results and Discussion

The result of analysis by three techniques used in Figure 1,2,3 and Table 4 has shown the followings.

1) Comparing simply the workability at the usual time between healthy persons and disabled persons, there is no big difference in the creation rate and the defective rate (MODAPTS).
2) The disabled persons are easier to demonstrate their powers in the group classified by equivalent work level of skill mutually and in the environment consisting of only them than in the environment that was not the case.
3) Especially, mentally disabled persons tend to have lowered workability in the presence of healthy persons (They correspond to the welfare-facilities personals generally.) in the group.
4) Comparing with intellectual disabled persons, the mentally disabled person tend not to be affected by the presence of healthy persons (correspond to a group leader or the welfare-facilities personals) comparatively (MODAPTS).
5) Since the rate of creation and the rate of a defect change by institution environment or work classification, the workability (the degree of work execution) is likely to be affected by the surrounding environment and the work classification (what the works educational materials are) to work.

From these discussions from 1 to 5, it was found that the disabled persons are not necessarily inferior in the healthy person's workability. The workability is estimated to be affected significantly by surrounding environment (also including human environment).

Moreover, in the disabled classification, it was thought that the intellectual disabled persons are likely to be affected by the surrounding environment. Especially, we could found as a analysis result that the apparent lowered workability of disabled person is due to the competitive mind against healthy persons or the higher level of reliance on the corresponding healthy person for the part that the disabled person must consider theoretically.

Usually, the group activities taken by welfare service as the form are divided into the side receiving services (user) and the side providing the services (administration side). Usually, receiving services is often considered to be the need for the services, that is, considered that the services provided can not be achieved by one-self without being taught. Therefore, the "work instructors" are arranged, certainly in the workplace, and based on the instructions, the user learns the way of proceeding of the field work itself.

In this verification, we could estimate anew that the basis is not enough, but especially on analysis, the intellectual disabled persons were affected significantly by the disturbance factors occurring in the environment and thus the person in charge who provides services had large influence on the actions and the words of the service user. That is, since it is estimated that a service user always observe with very high concern the service technique and its person in charge itself, it can be confirmed that in order to improve the skill of service users, the side for instruction requires the degree of proficiency.

Moreover, the awareness on self-repair is in each human originally. There is no evidence that it is out of the question that disabled persons themselves devise in order to improve group working efficiency. Usually, even if it is a category or a field that is not specialized in the group of welfare, everyone always should be aware of an organization group with the strong cohesiveness within the group being dynamic in the universal portion.

In this evaluation, it did not necessarily result in that a healthy person is an instructor, but even if the thought of "healthy person = instructor" does not exist possible voluntary group consisting of only the users with high level of group consciousness will generate the high level of workability and improvement there.

We think that this give a deeper suggestion to the way of providing working-based social-welfare-services more than ever for future service providers and those who are interested in the service provision.

For these detailed analysis, it is necessary to increase the number of subjects and to expand and re-verify the various factors of required environmental parameters from now on. However, at least, it could be said to show that the important issue of how the way of supports on employment support is from now on.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-976

CAPKOM: A Wizard to Facilitate the Web Experience of Users with Cognitive Disabilities

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Abstract. Adaptable and adaptive user interfaces for both, software and (mobile) web applications are an extensively researched area for mainstream users as well as users with disabilities. The "sticking point" in developing adaptable and adaptive user interfaces for people with cognitive disability is the lack of appropriate, reliable and stable recommendations, guidelines, techniques and tools as well as evaluation methods and techniques [1], especially for people with cognitive disabilities (e.g. persons with unknown reading capabilities using a web site or service), measuring how well user interaction paradigms and content is understood and used. In this paper, we present initial work carried out in this field within the project CAPKOM that aims at developing a "Wizard" that supports the definition of requirements for people with cognitive disabilities when accessing the web, means to evaluate necessary adaptations to ease reading and understanding, compile individual user profiles out of it and hand them to the browser to adapt websites following the gained profile. Within the presented project CAPKOM, the Wizard works with a specifically designed website (online-atelier.com) but can be adapted and implemented to other use cases to allow profile based adaptations and the definition of support functionalities when accessing mainstream web pages.

Keywords. eAccessibility, Cognitive Disabilities, web 2.0, Adaptable and Adaptive User Interfaces.

Introduction and Research Idea

Following developments and progress made in providing affordable and stable internet access, ICT / AT development as well as concerning policies, accessibility recommendations, guidelines, tools and efforts in Design for All, everyone with a basic willingness should be able to be self-dependent part of our information society. In practice, the picture is considerably different: Studies [2] show that even easy realizable accessibility adaptations like alternative textual descriptions of pictures displayed on a website are not satisfyingly implemented – suggesting a general low take-up of eAccessibility [3] – not to even think about a comprehensive (more elaborate and less quantitatively measurable) facilitation of "Easy to Read". The needs of people with cognitive disabilities are first of all oriented towards the content, its structure and usability (navigation, consistency) of a website. Furthermore, the "Internet" developed to a most dynamic and interactive "web 2.0" for (and to be more precise also by) everyone asking all content providers to publish accessibly in order to be understood and used by the biggest possible and most diverse user group.

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This should lead on the one hand to the development of authoring tools supporting accessible content provision (with included possibilities to check the framework and content) and on the other hand to adaptable and adaptive user interfaces providing accessible annotation, adaptation, enrichment and conversion when technical accessibility doesn´t go far enough and personal assistance would be too much and not yet necessary

1 State of the Art, Methodology and Contributions to the Field

Studies show that extensive research is done in the domain of adaptive user interfaces [1] and using it for people with disabilities (e.g. AEGIS project). When looking into research activities for our target group, there is still a lack as research in web and software accessibility focuses on people with physical or sensory disabilities [4]. The reasons for this absence are [5]:

- "Myths" – People with learning disabilities would not belong to the target group of web services and creating the required web content would be an insurmountable task.
- "False understanding of web accessibility" – Accessibility is often seen as merely providing an additionally text version ignoring aspects like design, structure and navigation.
- "Priorities of the WCAG" – Requirements especially essential for the target group got a very low priority [6] and in addition, web accessibility still is very much focused on technical foundations and not on content.
- "Unclear priorities of the sector" – It is often unclear where general accessibility requirements end and specialized services (e.g. translation into easy to read language) should start.

The results of an initial survey amongst peers and institutions / care givers for people with cognitive disabilities confirmed these findings. Through an accessible online – survey amongst 31 carers of people with cognitive disabilities, we got information on their experiences with the target group and necessary ICT / AT, adaptations needed for using ICT, browsing behavior and barriers faced when using computers and the web. The following issues were raised for browsing the web [4]:

- High text complexity (19 %)
- Confusing advertisements (18 %)
- Inconsistent menu as well as navigation structures (16 %)
- Overloaded pages / websites (12 %)

It also became apparent that the target group would use accessible websites the web more often and more independently: 46 % of the persons taking part use the Internet without any help, 39 % mentioned to need personal assistance [7], [8].

The user studies resulted also in a set of "personas" outlining end user needs and supporting the design and development work (not only) within the CAPKOM project.

2 Methodology

We developed and implemented a virtual, agent based "Wizard" to involve our users, get in touch with them and conquer the most influencing difficulties for people with cognitive disabilities in dealing with the computer and the internet [9]. This wizard measures the activities and skills of individual users with a cognitive disability to provide an adapted web experience. The (cloud based) wizard supports the:

- Identification and management of individual users, in particular a symbol/picture based registration and login is provided.
- Administration of the different individual language space and preference (e.g. photos, graphics, "Easy to Read" **Error! Reference source not found.**, "Plain Language" [11]). The wizard, by carrying out different games / questions, supports the selection of specific words, icons, or language levels.
- Selection of the appropriate interface elements and characteristics (e.g. character size, color schemes, icon size, line/character spacing) by playing simple games which allow measuring skills like speed, accuracy and precision.
- Provision of a generalized profile of the user's preferences in accessing web pages which can be included in adaptive design of specific applications for the target group (e.g. the online-atelier) or for the adaptation by mainstream web applications be it by personal support of by (future) tools.
- Output of an easy to evaluate JSON file displaying e.g. the time needed to react and move and the number of (in)correct tries to be computed to a user profile.

The wizard itself has also been developed as a web application to facilitate an easy to use and quickly implemented testing and evaluation framework. The wizard appears as "buddy", assessing the needs of our target group and their competences (reading, symbol understanding, accurateness and reliability of mouse control) and needs (symbol size, contrast settings, language level, and additional speech output). Additionally – and planned for a future development, this wizard can survey the users behavior, notice phases of inactivity and needed help (e.g. with finding a special page or navigation item. In the moment, the evaluation of the users' competencies and needs is done with low threshold, "mini game like" applications that also support generally needed abilities. E.g. the "dog - feeding" game presented below measures the ideal symbol size but also the user´s general mouse control.

3 R&D Work and First Solutions

The wizard checks the following issues with low threshold, empowering mini game like applications to make sure that the target group doesn´t feel tested nor observed (and get stressed because of this fact) what was stated from target group as well as their carers as huge barrier when evaluating user needs and capabilities **Error! Reference source not found.**. After assessing these issues the wizard includes the result and corresponding adaptations in the users´ individual profiles to be saved and retrieved for different web applications:

- Type and size of the symbols used (with a possibility to upload own symbols)
- Font size
- Symbol understanding (Colored "CapKom symbols / B&W pictographs)
- Reading proficiency
- Design template (different contrast and color settings)

Below is an example of such a game helping to find the ideal symbol size for our users. In the “dog – feeding” game the mouse pointer turns into a food bowl that has to be moved to the dog (without clicking or "drag & drop" action). When successful, the position of the dog changes and the size of the dog and the bowl shrink with a given percentage. The user has to feed the dog successfully five times in up to seven increasingly difficult rounds with both pictures getting smaller. If more than 3 out of the five attempts in every round were not successful, the wizard stores the last manageable (symbol) size and the time needed to identify the symbol for the dog, the symbol for the bowl, the time needed for moving the bowl to the dog and the efficiency (length) of the way taken. Out of these values, the ideal symbol size is stored and displayed for further activities. As there is of course a learning / training effect and users get more accurate and skilled using mouse and cursor, the necessary symbol size might get smaller (in case the user´s problem is not the result of a vision constraint). Therefore those games can be used on a regular basis. Some carers gave feedback that their users like the game very much and got far more proficient in a quite short time – also in general mouse control just by practicing their skills in a playful manner.

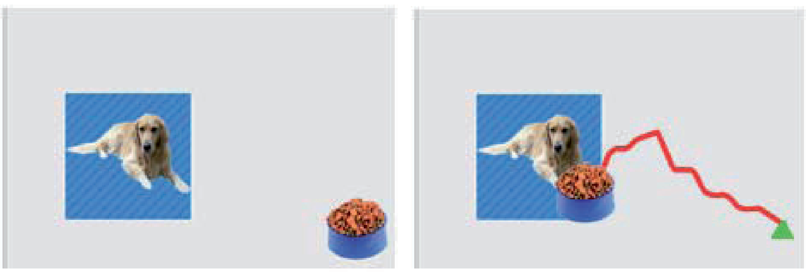

Fig. 1. Dog feeding game – start position (left) end position and way taken (right).

Furthermore we developed a game to check the users´ reading proficiency by picking the right symbol / picture to a displayed word out of three possibilities. The wizard (behind the scene) "measured" how many tries were needed and how many time was necessary to identify the right solution (from starting to move over the time and efficiency to reach the right solution and click on it). Another game displayed a symbol or picture and showed three words from which the users again had to pick the right one.

The evaluations showed that 19 of the 31 persons matched the right combination without any mistake and it took them around 7 seconds for their answer.

Another mini game like application (run through automatically or by pressing the corresponding button in the navigation part of the wizard) evaluated the users´ ability to understand and interpret symbols.

In this game, a symbol is displayed and the users pick the right (corresponding) symbol from a row of three placed below. For example the displayed symbol "dog" corresponds to the symbol "bowl with food" (that they already got to know in another game) below. The other symbols displayed (Popsicle and apple) don´t correspond and are wrong solutions. 13 people (out of 31) managed this game without retries (mistakes). It took them from 2.5 to 54 seconds to choose an answer, so we were able to assume the diversity of our test population. These findings underpin the diversity and difference within our target population, their capabilities and skills (carers reported states from ICD-10 F.81.0 – ICD-10 F.72.0).

Evaluations showed and carers stated that the target group enjoyed the game-like atmosphere and did not feel tested even if they were told that they are part of an evaluation activity. This way, we gained over the wizard the data to individually adapt the view (in terms of contrast set used, symbol and font size needed), handling (language level preferred, speech output to be toggled) and look and feel (in terms of the symbol set used. When rolled out, the system enables the user to choose from black and white pictograph like over specially designed "CapKom symbols" to own photos) of our sample – web application (an online community art portal, the "online-atelier" – www.online-atelier.com) to the needs of the users and bring them closer to the internet and its opportunities by stimulating interest and curiosity and training general abilities needed when using computers and accessing the web.

4 Evaluation and next Steps

Two waves of peer user evaluation were carried out to ensure a) the usability and attractiveness of the wizard for users and b) an optimal definition of the user profile. Results show that users are pleased with the games and handling of the wizard. Some usability problems as well as suggestions from our user group will be implemented like the following issues:

- Users were confused of some phrases and afraid of "automatic" voice used for the speech output. We changed the messages and re-recorded them with a human reader
- Some games went for too long, resulting in early tiring and not focused users that communicated to get bored. We reduced the necessary amount of "successful" rounds to be played (what resulted in a slight but afterwards statistically negligible decrease in the computed level of significance of the results)
- Problems with perceiving and noticing all important and needed items on one screen (without scrolling), especially when using the largest possible font and symbol sizes. We deleted the four biggest font and symbol sizes as the need for those font and symbol sizes would anyway ask for using screen enlargement software and were added for testing purposes in the very beginning of the project.
- When entering the "Wizard", users were automatically told how to use and play the first game. After this explanation, it was necessary to press a "Start Button" but our users often overlooked this and got stuck. We implemented an automated start of the first game after an idle time of 15 seconds but left the "Start Button" for users preferring a quick start.

Acknowledgements

The project CAPKOM is supported by the Austrian Research Fund (FFG - Forschungsförderungsgesellschaft) through its COIN Programme.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-982

Verification of LED Blocks Used at Crosswalk Entrances for Persons with Visually Impairment

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Abstract. A person with low visual capacity's eyesight might decrease remarkably under low-light conditions such as the morning, evening, and nighttime, decreasing their opportunities to go out. Research and development underway to ensure safe walking for visually impaired persons examined a walking guidance system in which LED blocks are embedded into the road at edges of warning blocks installed at crosswalk entrances. The LED block used in the experiment is 120mm wide and 300mm long. The LED block is a flat-topped bar made from transparent acrylic fiber. The solar panel and LED are embedded in the ground. The LED block is set adjacent to the warning block at crosswalk entrances. The LED block can be detected with the visually impaired person's residual vision. Blind persons can also detect this block through the soles of their shoes. The detectability of this LED block was evaluated by subjective experiments performed by visually impaired and blind persons. The function of the temporary stop can be strengthened in the sight or the sense of touch. Installing LED blocks at crosswalk entrances was found to be useful for guiding visually impaired persons.

Keywords. Tactile Walking Surface Indicators (TWSIs), LED block, Blind, Person with Low Visual Capacity (LV).

Introduction

The eyesight of a person with low visual capacity (hereafter referred to as "LV") might decrease remarkably under low-light conditions such as the morning, evening, and nighttime, decreasing their opportunities to go out. Research and development underway to ensure safe walking for LVs examined a walking guidance system in which LED blocks are embedded into the road at edges of warning blocks installed at crosswalk entrances. The LED block can be detected with the LVs residual vision. Blind persons can also detect this block through the soles of their shoes. The detectability of this LED block was evaluated by subjective experiments performed by visually impaired and blind persons.

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1 LED Blocks used at Crosswalk Entrances

Figure 1 illustrates the LED block used for crosswalk entrances. It is a flat-topped bar made from transparent acrylic fiber. The solar panel and LED are embedded in the ground. The light emitted by the LED is made yellow by passing through a transparent yellow acrylic board. Figure 2 presents the shape and size of the LED block. The flat-topped elongated bars are 17mm wide at the top, 27mm wide at the bottom, 5mm high, and 300mm long. Only this umbo sticks out from the floor surface. Blind people can detect the block through the soles of their shoes, and LVs can detect the LED light. The LED block is set adjacent to the warning block at crosswalk entrances. The function of the temporary stop can be strengthened in the sight or the sense of touch. Experiments have also been conducted on many electronic travel aids such as Talking Signs[1]-[4]. However, no research has examined the interrelation of the TWSIs and the LED blocks at intersections.

2 Experiment Outline

Crosswalks are generally laid straight across, but some crosswalks are oriented diagonally. Figure 3 presents an example of a diagonal crosswalk. Diagonal crossing was assumed, and an experiment with a 30-degree crossing was added. Figure 4 outlines the experiment. The center of the guiding pattern in the direction of travel was assumed to be the centerline. The y axis was assumed to be in the direction of travel of the crosswalk; the x axis was assumed to be orthogonal to the direction of travel of the crosswalk. The approach for law maintenance is a pressing need. Five speakers arranged to the left of the direction of travel at intervals of 1.5m reproduced environmental noise of 60dB. Two speakers installed 5m from the warning block at the crosswalk entrance generated environmental noise when the subject was trying to decide the direction at the crosswalk entrance. The experiment employed patterns crossing at a right angle and crossing at a diagonal of 30 degrees. The experiment was conducted with LED blocks in each pattern and without LED blocks. The influence of the LED blocks on the direction was considered using these four patterns. The subject determines the direction by the LED block that is adjacent to the attention pattern block and the attention pattern block. Next, the subject walks straight in the determined direction. Figure 5 presents the photograph of experiment both at a right angle and a diagonal of 30 degrees.

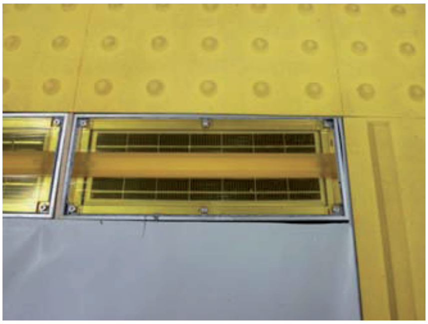


Figure 1. LED block installed in floor.

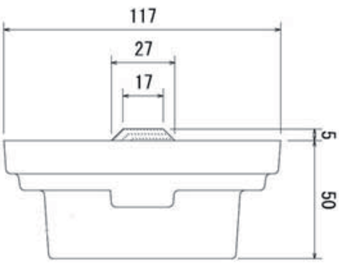
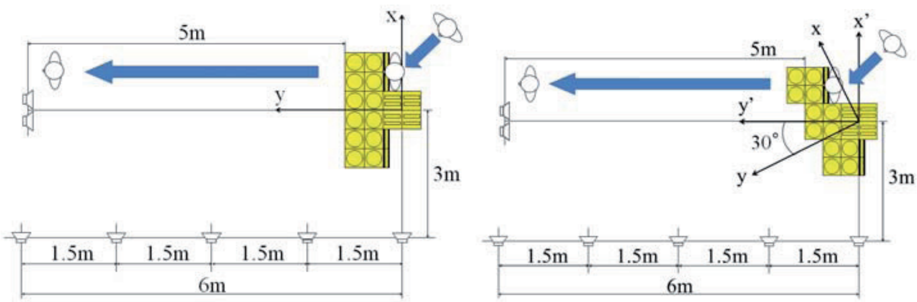


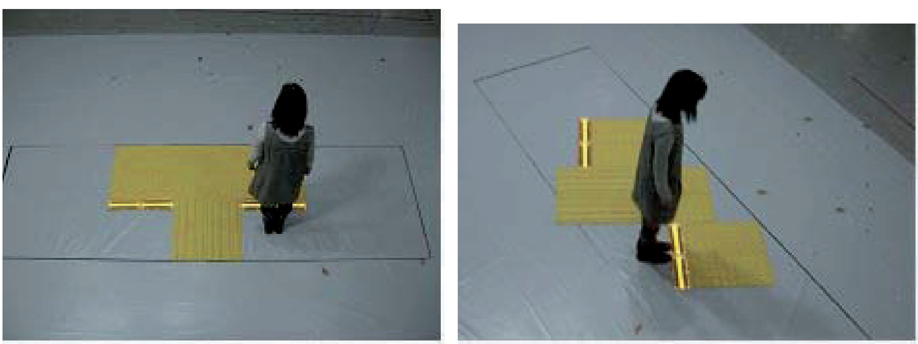
Figure 2. Shape and size of LED block.

Figure 3. Example of diagonal crosswalk.



(a) 0 degrees (b) 30 degrees

Figure 4. Experiment layout.



(a) 0 degrees (b) 30 degrees

Figure 5. Photograph of experiment.

3 Experiment Method

The experiment was conducted in the indoor laboratory of The University of Tokushima. This laboratory can adjust the illuminance to accommodate an person whose eyesight is extremely degraded in a dim environment. To reproduce the low-illuminance environment of the morning, evening, and nighttime, the illuminance on the surface of the floor was adjusted to 10 Lux in an experiment with an LV person.

Table 1. Number of people according to LV's grade in Japan.

Class	1	2	3	4	5	6	Total
number of people	14	17	6	1	2	8	48

The experiment procedure is as follows.

(1) The experimenter guides the subject to the starting point from a position separated from the crosswalk entrance. Here, the experimenter orients the LV subject in an arbitrary direction. The subject then finds the LED block using his/her residual vision. The experimenter orients blind subjects in the direction of the TWSIs.

(2) The subject moves to the Tactile Walking Surface Indicators (hereafter referred to as "TWSIs") or the LED block of the crosswalk entrance. Here, the LV subject uses his/her residual vision, while the blind subject senses the TWSIs through the soles of the shoes.

(3) The subject decides the direction of travel from the detected TWSIs and LED block.

(4) The subject walks about 4m after deciding the direction of travel.

The above procedure was repeated 16 times for each pattern. The coordinates where the subject stopped at the crosswalk entrance and the position where the subject stopped after walking 4m were recorded. The deviation from the centerline can be derived from the coordinates of these two points. The time required from leaving the starting point to detection of the direction from the TWSIs or the LED block was also measured.

There were 20 blind subjects (11 men and 9 women, 58.2±10.3 years old) and 48 LV subjects (30 men and 18 women, 59.6±11.4 years old). LV persons legally registered in Japan as having Class 1 or 2 Visual Disability were chosen as subjects. Table 1 presents the number of people according to LV grade in Japan. Class 1 or 2 LV people can see about 2m forward. Class 1 or 2 LV subjects comprised 65% of the total subjects.

4 Experiment Results

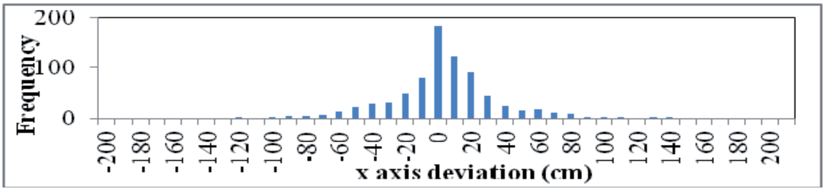
Figures 6(a) and (b) present examples of histograms of the axial deviation x after an LV subject walks 5m along a 0-degree crosswalk with and without an LED block. Figures 7(a) and (b) are examples of histograms of the axial deviation x after a blind subject walks 5m along a 0-degree crosswalk with and without an LED block.

Table 2 indicates the average axial deviation x after walking 5m. For LV subjects, the average deviation was less with the LED block than without it. A significant difference ($p<0.01$) was observed with and without the block. However, no significant difference was observed in the average deviation, though a significant difference was observed in the variance among blind subjects.

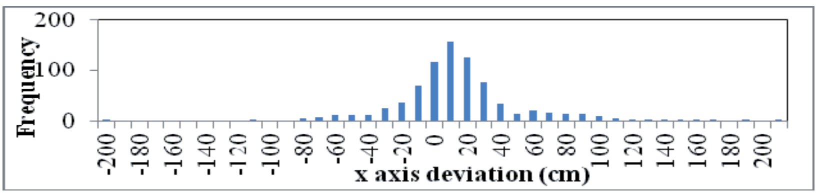
Table 3 indicates the time required from the starting point to detecting the direction. Both LVs and blind people were able to locate the LED block in a short time when crossing the roadway at a 0-degree angle. There was a significant difference ($p<0.01$) for both LV and blind subjects. In addition, a significant difference was observed at 30 degrees for the LV subjects. However, no significant difference was observed in the average deviation for a 30-degree crosswalk, though a significant difference was observed in variance among blind subjects. Fifty-eight percent of the subjects saw an LED block 10m away were able to find it.

5 Conclusions

We developed a walking guidance system in which a LED block was embedded in the road. Both visually impaired persons and blind persons found the LED block to be effective at a 0-degree crossing angle. Moreover, locating with the luminescence block was a short time in the time required. Orientation using the LED block used less of the required time. Significant differences (p<0.01) were observed among blind persons. The LED block was observed to have an orientation accuracy equivalent to that of TWSIs. Moreover, subjects expressed opinions such as "It was easy to locate" and "There is a sense of security when going straight" in an interview after the experiment. Installing LED blocks at crosswalk entrances was found to be useful for guiding visually impaired persons. Research [5]-[7] on the eyesight of LV people can be expected to be applied to this field in the future.

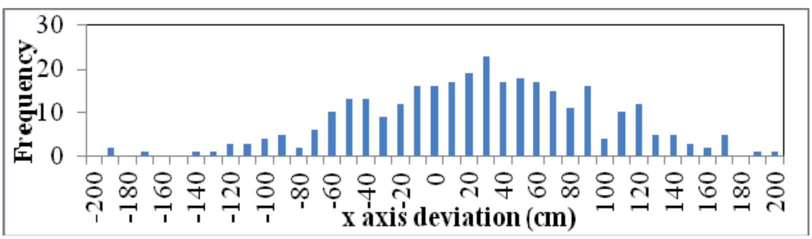


(a) 0 degrees, with LED blocks

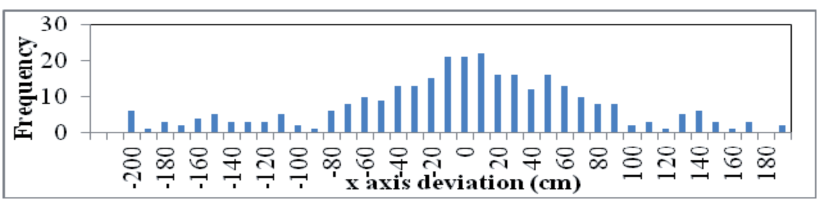


(b) 0 degrees, without LED blocks

Figure 6. Example of histogram of x axis deviation in the LVs.



(a) 0 degrees, with LED blocks



(b) 0 degrees, without LED blocks

Figure 7. Example of histogram of x axis deviation in the blind people.

Table 2. Average error distance.

	Direction (degrees)	LED block	Average deviation distance (cm)	t-test	Variance	F-test
LVs	0	Without	7.61	p<0.01	1274	p<0.01
		With	-3.39		906	
	30	Without	-30.28	p<0.01	6567	p<0.01
		With	-6.65		3575	
Blind	0	Without	19.62	-	19132	p<0.01
		With	11.51		5140	
	30	Without	10.59	- -	18326	p<0.01
		With	35.48		7331	

Table 3. Average time to orientation.

	Direction (degrees)	LED block	Average time (s)	t-test	Variance	F-test
LVs	0	Without	5.71	p<0.01	16.78	p<0.01
		With	4.11		12.70	
	30	Without	6.41	p<0.01	52.26	p<0.01
		With	4.19		3.01	
Blind	0	Without	12.42	p<0.01	5.48	p<0.01
		With	10.35		2.25	
	30	Without	11.81	-	6.51	p<0.01
		With	11.14		7.48	

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-988

Difference in Road Surface Recognition by Disease and Grades of the Low Vision

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Abstract. In our previous studies, Lateral Bands that were placed in both side of Tactile Walking Surface Indicators, and the result of clinical testing of Lateral Bands indicated the effectiveness for the Low Vision to show walking way. However, it was also indicated that Lateral band could be seen as holes or ditches in specific condition of luminance contrast and illumination. In this paper, relation between visibility and miss-recognition was studied from the different point of view in date of the previous study. Influence both by the difference in visual impairment and by the difference in grades of disability was also studied. As the results, it was suggested that 30% of luminance contrast was the optimum value for both keeping visibility of Tactile Walking Surface Indicators with Lateral Bands and producing no miss-recognition.

Keywords. Low Vision, Miss-recognition, Tactile Walking Surface Indicators, Lateral Bands, Different Type of the Low Vision.

Introduction

Human beings live while receiving a lot of information. The most important information for human being is visual one. The visually impaired has handicap in the vision which is one of the sensory organs for getting visual information. It is well known that about 90% of the visual impaired are Low Visions (hereafter, referred to as LVs [1]) and the rest is the blind. For the visually impaired, many kinds of assistive products have been developed. For example, Braille and equipment for enlargement have been developed to assist their communication by letters.

Tactile Walking Surface Indicators (hereafter, referred to as TWSIs) is one of assistive products for visually impaired and widely used in the world. Also TWSIs is originally developed for the blind. It is well known that TWSIs is also useful for LVs. It is observed that some of LVs confirm the position of TWSIs not only tactually but also visually. So, effectiveness of TWSIs for LVs depends on visibility. Therefore, increment of visibility of TWSIs is one of important issues independent walk for LVs.

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1 The Previous Study

1.1 Effectiveness of S to TWSIs

To increase visibility of TWSIs, the authors have proposed to use lateral bands (hereafter, referred to as LBs) which is placed in both sides of TWSIs (Figure 1) [2]. In own previous study, effectiveness of LBs was experientially evaluated at first. In this experiment, relation between width of LBs and visibility and illumination and relation between contrast of LBs and visibility were tested respectively.

From this experiment, two results were indicated. The first was that TWSIs with LBs could be recognized more clearly than those without LBs. The second was that LBs could be recognized most clearly when the luminance contrast was 30% and the width of LBs was150mm [3] [4]. On the other hand, it was indicated from subject's opinions after the experiment that they sometimes miss-recognized shadow on road as holes or ditches (Figure 2). It was considered from these results that farther experiments would be necessary to find the reason to produce the miss-recognition.

Fig. 1. TWSIs and lateral bands.

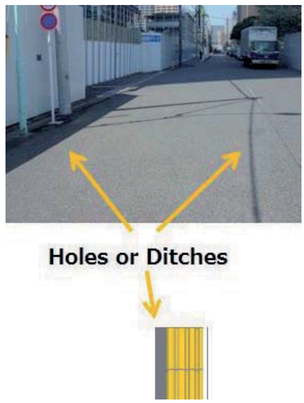

Fig. 2. Miss-recognized shadow on road surface.

1.2 Visibility of Lines

As the next step of our study, visibility of a line which is one of LBs on roads was experimentally evaluated. From this experiment, three results were indicated as follows[5].

(A)Rate of miss-recognition increases with increase in luminance contrast.
(B)There was no relation between the width of each line and ratio of miss-recognition.
(C)There was no relation between illumination and rate of miss-recognition.

2 Objectives

In the previous study, effectiveness of LBs and proportion relation of miss-recognition rate and luminance contrast were indicated. Then, it was also indicated that LBs could be recognized most clearly when the luminance contrast was 30% and the width of LBs was150mm[3] [4]. However, it was indicated that LVs sometimes miss-recognized shadow on road as holes or ditches (Figure 2). Then, it was observed that visibility in each subject was different for each other.

In this paper, relation between visibility and difference of physical condition such as kind of impairment and grade of disability was studied.

3 Methodology

3.1 Method

The subjects were asked to watch lines in each parameter at first. The lines were shown to each subject by two ways. These ways were showing one by one (Figure 3), and showing eight lines together (Figure 4). Parameters were different luminance contrast, illumination, and width as shown in Table 1. Then, they were asked their impression when they had watched lines in different parameters. The impression were whether they could see lines or not, whether they could feel safety at lines or not, and whether they could recognize lines correctly or not.

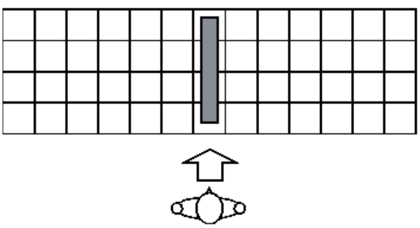

Fig. 3. Experiment that shows a line.

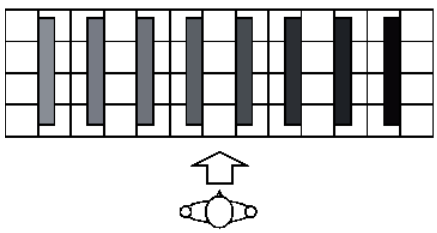

Fig. 4. Experiment that shows eight lines.

Table 1. Parameters of experiment.

Parameter	1st experiment	2nd experiment
	Value or range	
Width of line	150mm	100, 150 and 300 mm
Luminance contrasts of line and background based on Michelson Contrast	10 - 80%	
Color of line	Neutral	
Illumination	5, 10, and 500Lux	
Background color	Munsell N8	
Visual distance	2 m	
Experiment frequency	once	

3.2 Subjects

All subjects were fifty-nine LVs. And, all subjects were the visually impaired and had the certificate of the visually disabled. They did not have other disabilities such as physical and mental disabilities. In the certificate (each booklet), the grade of each subject's disability was indicated officially from grade 1 (the most heavy) to grade 6 (the most light). Figure 5 is the distribution map of these grades, and diseases that had caused their visual impairment were shown in Figure 6.

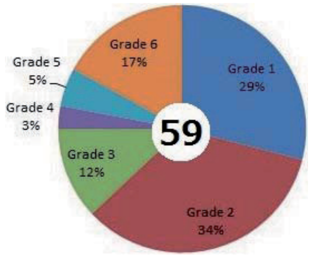

Fig. 5. Disability's grade of subjects.

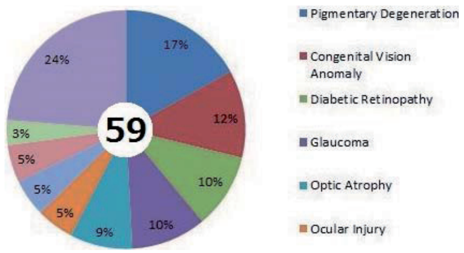

Fig. 6. Distribution of diseases in subjects.

4 Results and Discussions

4.1 Whether Subjects Could See Lines or Not

In each grade, difficulty of seeing each line increases according to decrease of luminance contrast. In addition, it is difficult for subjects in both grade 1 and grade 2 to see each line at five lux (minimum value). The illumination of five lux is generally defined as the one that a book is not readable. So it is supposed that LVs has much difficulty to see a object on road at very low illumination. Although it was thought that illumination had nothing to do with miss-recognition in previous study, above result shows the possibility of miss-recognition by illumination.

Subjects could see lines more clearly according to increase of luminance contrast. Depending on a kind of diseases, it is considered that there is a difference whether a subject can see clearly. This result indicates that difficulty of seeing lines clearly due to diseases affects the accuracy of seeing road surface.

4.2 Whether Subjects Could Feel Safety at Lines or Not

Increase of number of subjects who had answered lines safe was proportional to increase of luminance contrast of lines (Figure 7), regardless the difference of disability grades. Increase of number of subjects in each disease showed as same feature as in different grades of disability. However, subjects with different disease had their own characteristics for each other. In Figure 8, the most subjects in the diabetic retinopathy showed that they had felt lines dangerous in each luminance contrast. On the other hand, subjects in the glaucoma showed constant percentage in luminance contrast over 30 %.

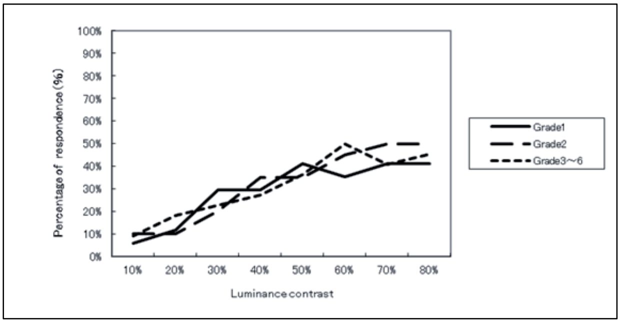

Fig. 7. Luminance contrast and ratio of incorrect recognition in deferent grades of disability.

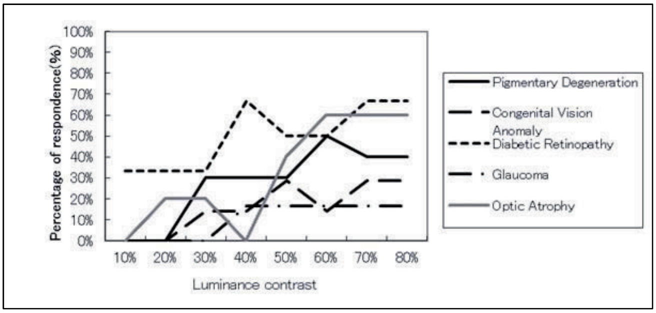

Fig. 8. Luminance contrast and ratio of incorrect recognition in different visual diseases.

4.3 Whether Subject Could Recognize Lines Correctly or Not

Rate of miss-recognition by subjects was proportional to increase of lines' illumination on roads surface, regardless of grade of disability. Rate of miss-recognition by subjects was proportional to increase of lines' illumination on roads surface, regardless of difference of visual impairment. From these results, it is suggested that increase of luminance contrast is proportional to the increase in miss-recognition.

4.4 Comparison between Visibility and Miss-Recognition

Figure 9 shows the result of previous study. It indicates relation between luminance contrast and number (percentage) of subjects who could see lines. In the previous study, range of luminance contrast was from 10% to 80% (10% distance). As other parameters, illumination was 10lux, and the width of each line was 150mm. As shown in "1.1 Effectiveness of s to TWSIs", rate of miss-recognition was 10% when luminance contrast was over 30%. Therefore, it was considered that more than 90% of subjects could see lines correctly when luminance contrast was more than 30%. On the other hand, rate of miss-recognition decreased when luminance contrast was under 40% as shown in "1.2 Visibility of lines". From above results, it was suggested that 30% of luminance contrast was the optimum value for both keeping visibility of TWSIs with LBs and producing no miss-recognition.

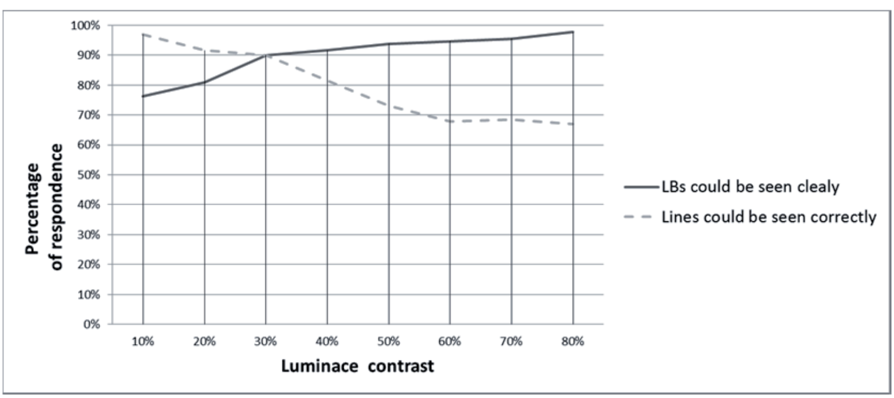

Fig. 9. Comparison between data of visibility and miss-recognition.

5 Conclusions

The following results were obtained from this study. It is possible to get the value of illumination to secure safety walk LVs can find the position of TWSIs on roads by seeing LBs. As some kind of LVs with heavy grade of impairment or disability has high possibility of miss-recognition, it is considered that illumination in road surface is very helpful for these. Therefore, it will be necessary to repair the road surface, to complement LVs' visual capability, or to arrange other support for LVs. It is expected that the result shown in this paper will be some of help for LVs independent walk on road in future.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-994

Audiopulse: Democratizing the Newborn Hearing Screening in Brazil

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Abstract. It is estimated that globally 588 million people have a hearing loss. It is estimated that 5.7 million of Brazilians have some degree of hearing loss. The situation for children is worse, 6% have hearing loss by age 4, and 6 in 1000 have hearing loss from birth. In Brazil, there is a federal law (number 2794/01) that obligates every baby to have the hearing test done during the first week of birth. Although a federal law exists, not all government hospitals and clinics provide the hearing test, due the high cost of equipment's, and the poor populations cannot afford the test. A child who suffers from hearing loss faces many challenges throughout life, including: delayed speech and language development, learning disabilities, social problems and stigmas. Later in life, they struggle with staying in school and unemployment due to their disabilities. Even though the World Health Organization recommends universal neonatal screening, many babies miss their chance to be screened due to unavailability, high costs, or long wait times. Current systems are so inflexible and expensive that can't easily be scaled to rural clinics. The specific aim of this work is to create a battery of hearing screening tests that can be performed efficiently through a cell phone. The software uses Sana technology and data is securely transmitted wirelessly to a centralized medical database for validation by a trained audiologist and storage in a medical record database. Also a new screening based on fractal analysis and intelligent systems of the recorded ear sound will also be developed and investigated. If successful, this new diagnostic tool will be merged into the mobile hearing screening software, simplifying the objective screening by decreasing the requirements in calibration and computer resources. Sana AudioPulse has developed a mobile telemedicine platform, using cellphones interfacing with specialized hardware to screen hearing impairment in newborns with a suite of hearing screening tests. This mobile technology allows wide-spread deployment of hearing screenings across abroad span of rural and urban communities. Sana AudioPulse provides a scalable, low-cost solution.

Keywords. Hearing Screening, otoacoustic emissions, rehabilitation.

Introduction

The evolution of the Information and Communication Technologies (ICT) have provided significant changes to modern society. Health is among the areas that has most sought innovation through ICT's constantly searching for processes, methods, equipment and / or devices that may improve service to society. Hearing loss is an issue that requires attention, especially in children, for moderate and mild loss of hearing can suffer imbalances in behavior disorders of oral and written language, and poor school performance. All these difficulties can be avoided or mitigated by making an early diagnosis, allowing appropriate treatment for each situation [1]. In Brazil, according to the Census 2010 of the Brazilian Institute of Geography and Statistics [2], 9.7 million people have some form of hearing impairment, and 6% of this group are children up to four years. There are some neonatal clinical exams to diagnose possible problems that compromise children's development. One test that has gained great prominence in the world and especially in Brazil was the test Evoked Otoacoustic Emissions (OAE), better known as the OAE test, a process of initial assessment of infant hearing that allows early detection of possible hearing. Currently, this test is done with the aid of a device reader Portable and otoacoustic emissions with a firmware or software that analyzes the received signals from the ear of the newborn. Unfortunately, in Brazil montly equipments are imported, thus with high cost and the technology is concentrated in the hands of foreign companies, making the hearing screening unavailable to the majority of the population. Thus arises the need for a reliable and cost effective for neonatal hearing screening and graphical analysis of otoacoustic emissions testing. The objective of this work is the development of an application that performs the protocol for Neonatal otoacoustic emissions entitled AudioPulse. This application will assist the audiologist in the search for possible risk factors and data partners that may influence, directly or indirectly, in the hearing loss in the newborn, offering an improvement in data acquisition capability of hearing screening, as well as providing a way of viewing the results of otoacoustic emissions testing to obtain a more accurate diagnosis. Since the system is developed in a cellphone, the screening can be preformed anywhere, building the capability of taking the newborn screening to remote areas, where is very difficult to find experts and health infrastructure is very restrict.

The paper is organized as follows: section two gives a insight how M-Health and Assitive Technology are linked in our work, section three described how the system is developed, section four shows our first results and conclusions are given in section five.

1 M-Health and Assistive Technology

The World Health Organization (WHO) recommends the use of telemedicine as a political and strategic in planning and executing actions in health [3]. As [4] the term telemedicine was the first to be used to the practices of health care at a distance. Several definitions have been proposed by several authors and have been used, such as telemedicine, telehealth, e-health. But all dealing with the same situation: medical care that breaks the barriers of the office, ie, that everything is M-Health (Mobile Health). In [5] the term M-Health is described as emerging mobile communications and network technologies for healthcare." In The [6] states that M-Health is the integration of information from medical records and software aid clinical decision using mobile devices like cell phones. Its purpose is to facilitate, improve and facilitate clinical care by providing an effective service, skilled and wide, and to survey and data storage. And, from these you can get information about health, conduct research on groups (age, sex, cities or regions, among others) and / or pathologies. Assistive Technology (AT) is recently area with great focus on business applications of Engineering and Computing. The term TA was created in 1988 as a legal element of the North American laws and is related to the rights of citizens with deficiencies. The Specialized Center for Child

Development (CEDI) still considers this term new and is used to refer to all the features and services that contribute to provide or enhance the functional abilities of people with deficiencies, promoting their independence. According [7], assistive technologies have built on the concept of resources and services. The resources are all and any item, equipment, or system manufactured in series or tailor, used to increase, maintain or improve the functional capabilities of people with disability. The services are defined as those who directly assist a person with a disability to select, buy and use the resources previously defined. However, one can not restrict the use of TA only in cases where the subject needs service or equipment to adapt or to have their autonomy. In this work, the AudioPulse and presented as a tool for assistive technology aimed to prevent disability hearing and give the possibility of the hearing loss to be early detected avoinding neurological demage. Assistive technology is side by side with the otoacoustic emissions testing aiming early diagnosis of any hearing deficiency, helping children which have any hearing problem to be early detected, therefor promoting quality of life for these individuals.

2 Telemedicina System for Hearing Loss Screening

2.1 Sana Platform

The SANA platform was developed by MIT [8], and its main goal is to bring medical care to areas where medical assistance is scarce, mainly providing remote medical diagnosis. The system provides an instant end-to-end infrastructure for media-centric remote decision support by experts. The SANA platform has revolutionized healthcare delivery in remote areas through innovative mobile information services that improve patient access to medical specialists for faster, higher quality, and more cost effective diagnosis and intervention.

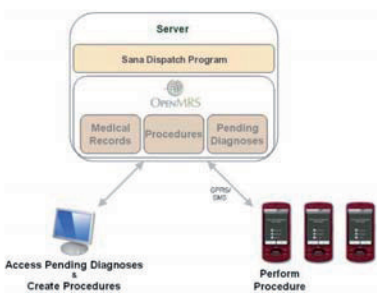

Figure 1. Sana Infrastructure [8].

Then, healthcare workers collect patient data using the Sana application. Next, these data will send to OpenMRS (Open Medical Record System), where one or more doctor will review. Finally, doctors will notify the health worker of the diagnosis by sending results to Sana application. The Figure 1, designed by [8], presents the Sana infrastructure.

2.2 Hearing Screening through a Mobile System: AudioPulse

The AudioPulse was developed to perform newborn hearing screening [9,10] based on a mobile platform. The system is based on the anamnesis analysis of the patient (Universal Neonatal Hearing Screening - UNHS protocol [11]) and acquisition of EOA signals with the ER-10C equipment connected to the cellphone. The cellphone application is responsible to produce the stimulus and record the hearing response. The hearing response is pre-processed in the cellphone by signal processing algorithms using time-frequency analysis. The cellphone application is embedded in the Sana telemedicine plataform. The Sana platform is already used in several projects to provide medical care to areas where medical care is scarce, providing remote medical diagnosis and getting consequently greater speed, quality and effectiveness for diagnostics. The protocol is based on the Universal Neonatal Hearing Screening, the socio-economic factors and all the risk factors related to the mother and the baby's birth. The factors that leads to hearing loss is not all defined in Brazilian population. The protocol and some questions where inserted into the questionary to help identified conditions related to hearing loss that are not yet identified.

The system will bring the possiblility to perform a screening in real time, assisting the final diagnosis of hearing aid. In addition, the system presented as the first step toward knowledge of a possible hearing loss. Given the context, such facts led to the main objective, which is to develop an alternative to the test of the OAE, as described below.

In Figure 2 one can observe the architecture of the system. The ER-10C is connected to the mobile device. The ER-10C probe is inserted into the newborn ear, and the stimulus is played by the earphones, is captured by the microphone and amplified by the ER-10C. The captured signal is processed by the Audiopulse application and embedded into the Sana plataform, which is responsible to send and receive the data from the server. In the server (OpenMRS) the audiologist have access to the patient data and hearing signals.

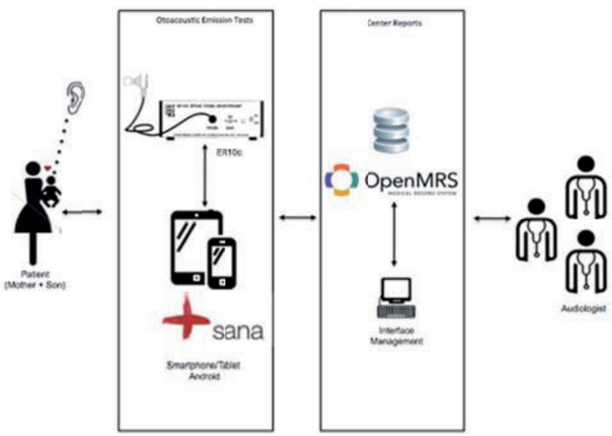

Figure 2. AudioPulse System Architecture. The anamnesis of the patient and the hearing screening test is performed by the mobile device and the ER-10C module connected to the mobile device. The data is sent to the OpenMRS through the internet, and the audiologist have the access to the data and response of the exam.

3 Experiments and Results

The system has two important data acquisition parts: first the anamnesis of the patient, and second the acquisition of the hearing screening test. Until now, all the patient history and the questions that the audiologist request from the system is already implemented into the Sana Platform as is shown in Figure 3 and 4. The second part of the hearing born screening the DPOAE tests are already working.

For the DPOAE tests, a database for the 4KHz was created with 4 patients, following the paper of Gorga, P. Michael (1993). The stimulus were produced on the following frequencies: f1 = 3.255 KHz and f2 = 3.906 KHz. The expected response will be on 2*f1 – f2 = 2.604 KHz. The expected response is shown between the margent lines in the plot (Figure 5).

Figure 3. Screenshot of the first three screens of the exam.

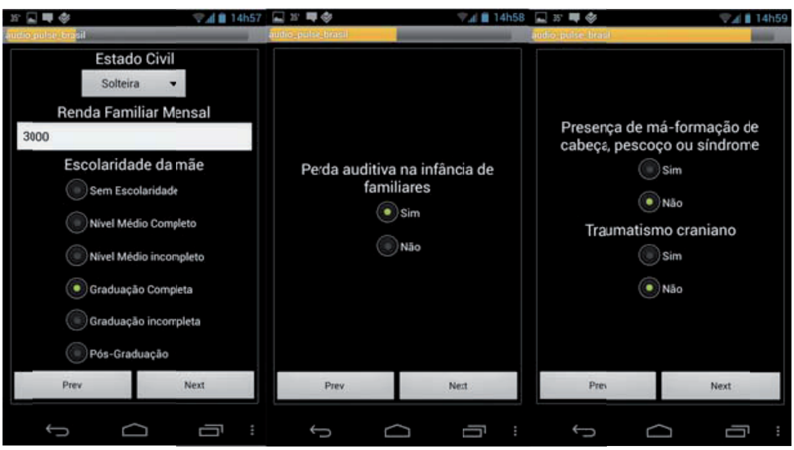

Figure 4. Screenshot of the questions that are important for the anamnesis of the patient as family history and newborn conditions.

4 Conclusions

Otoacoustic emissions were first observed by Englishman David Kemp, in 1978 [12,13], which defined them as energy release sound originates in the cochlea, which propagates the middle ear to reach the external auditory canal. He was able to

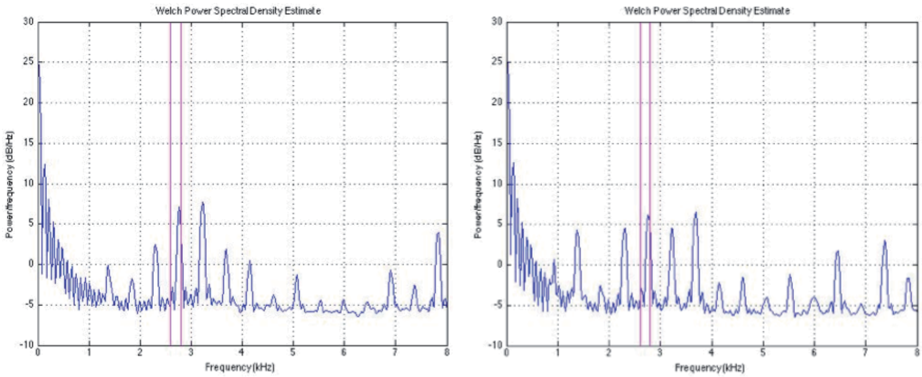

Figure 5. A plot of the periodogram with 250 averages using Welch window, for two different patients. The expected response is shown between the margent line in the Matlab graphic.

demonstrate that OAEs are present in all ears functionally normal [14]. There are some importants hearing screening test specially for newborns as the DPOAEs analysis. This paper provides a way of performing the anamnesis of the patient and the hearing screening tests with a low cost equipament, and can be done anywhere and anytime. The system uses Sana Plataform that is well stablished as a telemedicine plataform that can be used helping health care in restrict and low income areas. The results shows that is possible to prefome the DPOAE test with the system and more efforts has to be done to extend to other types of tests, as the transient otoacustic emissions tests, too. The use of this application will result in changes in everyday speech, as it provides the possibility of reaching patients who previously had no access to this type of examination, as well as medical care, in addition, provide a new form of information storage in an structured, easy and with online access.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1001

An Integrated Fall Detection System with GSM Module

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Abstract. Accidental falls in a domestic environment are the main cause of casualty among older people. A very important problem is represented by the fact that, after a fall, the person is seldom capable to call for help, and delays in assistance lead to the worsening of fall consequences, which also result in psychological insecurity and the need of continue assistance. For this reason a wearable fall detection system is presented in this work. A small sized and low power consumption board with a microcontroller, an accelerometer and a GSM module was designed, allowing the use also in outdoor scenarios, everywhere the GSM signal is available. A particular algorithm is used to distinguish a fall from activities of daily living (ADLs), that present an acceleration pattern similar to a fall, and to therefore reduce the probability of false alarms.

Keywords. AAL, Fall Detection, Older People.

Introduction

Nowadays many older people live alone and the main risk of injuries is due to accidental falls. This fact represent an important social problem, because it is estimated that 40% of people that are more than 65 years old and live at home fall once a year, and 1/40 of them are hospitalized [1]. Of those people admitted to hospital after a fall, only about an half will be alive a year later. Additionally, 43.7% of all domestic accidents are caused by accidental falls [2], which are the main cause of hospitalization and death. The relevance of this problem can be easily understood especially because, with the increase of life expectancy, many people suffer from degenerative diseases, like the Parkinson's disease. The psychological aspect must be considered, too, because people getting ambulation problems due to a fall may not trust anymore to move alone, and this leads to depression, social isolation, the necessity of a continue assistance.

The main problem of an accidental fall is represented by the fact that the person may not be able to call for help and might rest on the ground for a lot of time, with the worsening of his/her physical conditions. For this reason, many systems that can monitor and detect an accidental fall are described in literature.

Different approaches to the fall detection are commonly used: camera-based systems, ambient-device or wearable-device approaches. In the first case, cameras in the visible or infrared spectrum monitor the environment and particular algorithms analyze the captured video to recognize a fall event. In the second case, a network of ambient sensors detect and analyze the movements of the person to identify a fall. Both these approaches are not invasive for the person, but systems based on them can work only in an environment where sensors or cameras are installed, preferably an indoor domestic environment. With the third approach, which is also the one adopted in the present work, a wearable device is used. The main advantages of this approach are represented by the fact that the wearable device can be utilized without any setup and in every environment, potentially also in outdoor situations, and it can be integrated in a more complex system able to monitor also other parameters, like the physical activity of the person, the blood pressure and the heartbeat.

The Shimmer [3] is a small wireless sensor platform that can record and transmit physiological and kinematic data in real-time and can be used to develop applications like fall detection. The device transmits data through a Bluetooth connection to a base station or a smartphone. The total cost of the device is quite high and the battery life short.

Other similar devices are the ActiGraph [4], the Nuvant [5] and the Sensium [6]. They use a Wi-Fi connection to a base station, so that their use is limited to the range of the wireless connection.

In this work a device developed to specifically perform fall detection , is presented, having no other measuring functionalities of physiological parameters. The system was specifically designed to have a small size and a long battery life. A GSM module is used to launch an alarm after a fall recognition, so that there is no necessity for a base station and for the user to remain within the communication range from it. Concerning the use in outdoor scenarios, the only limit of the proposed system is the lack of a GPS receiver, so that when the alarm is launched, it cannot be integrated with information on user's position.

1 Fall detection algorithm

The majority of the actual fall detection algorithms uses a threshold detection scheme that may result in a high level of false positives. Inertial sensors are used to detect the movements of the person: when a threshold in some kinematic parameter is overcome, e.g. acceleration, a fall is considered to have occurred.

The fall detection algorithm used in this work uses a particular approach to reduce the presence of false positives. An accelerometer is used to sense the movements of the person. A class of movements represented by normal activities of daily living (ADLs) present acceleration patterns similar to those of a fall, and can therefore lead to a false fall detection. The original algorithm identifying a fall, starting from acceleration data, was developed in [7]. Our algorithm applies a filtering on the accelerometer data in a time interval around the exceeding of the threshold in order to try detecting ADLs. If an ADL is not detected after the threshold exceeding, a fall is considered to have occurred and the alarm is raised. Three ADLs can be detected by our algorithm:

A) Sit down and lie down quickly on a soft surface;
B) Sit down on a rigid surface;
C) Jump and run.

On the developed device, the microcontroller receives acceleration data from a triaxial accelerometer at a 50 Hz sampling rate. A potential fall is identified when:

1) The acceleration has a peak greater than 3 g;
2) This peak is followed by a time interval of 1200 ms without any other peak exceeding the threshold.

Our tests with volunteers showed that the first condition allows having a 100% fall detection sensibility, while the second condition is introduced to consider that an older person does not perform any significant movement immediately after the fall.

2 Hardware Implementation

The algorithm was initially developed and optimized on a PC using accelerometer data previously acquired. Subsequently, the algorithm was implemented in firmware on the microcontroller embedded on the iNEMO development board and it was tested in real time using some volunteers, see Table 1, performing ADLs and falls. Test description and results are reported in Table 2, and were performed with a prototype board constituted by the iNEMO development board interfaced with the SIM900 GSM module [8].

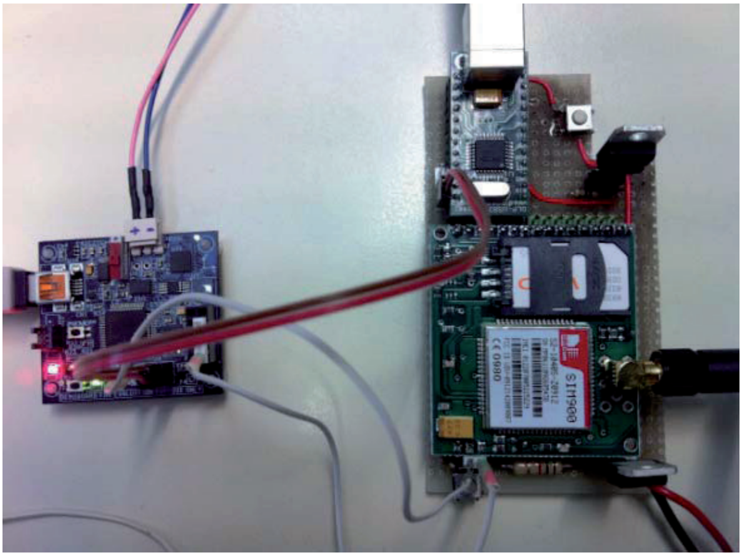

Fig. 1. The first prototype with the iNemo board (left) and the GSM module (right).

During the present work, an integrated board with only the accelerometer, the microcontroller, the GSM module and the needed electronics was designed. Special attention was paid in order to design a small form factor board with low power consumption to maximize wearing comfort and battery life. The board has a STM32 ARM Cortex-M3 microcontroller, the same used on the iNEMO board, so that the same firmware can be used. A LIS3DH triaxial accelerometer is used. The SIM900 GSM/GPRS module is interfaced with the microcontroller through the UART interface. A power regulator and a battery management system are added to the board to allow the use of a Li-Po battery. The board size is 40 mm x 50 mm and the current consumption is about 5 mA.

3 Experimentation and test results

Figure 2 shows a typical acceleration path of a fall.

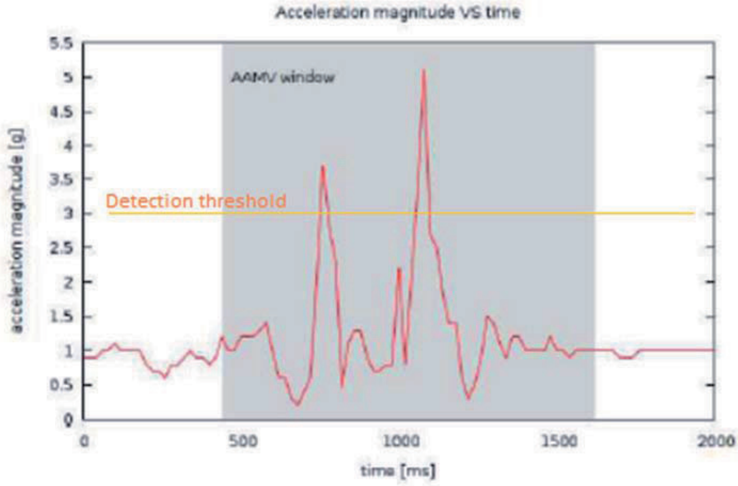

Fig. 2. Acceleration magnitude for a fall.

The iNemo prototype board was tested with three different volunteers, see Table I, that performed each action reported in Table 2. Each action was performed 40 times. The prototype board was fixed on the chest, simulating a future use in combination with an electronic patch. The results of the experimentation are summarized in Table 2, which shows the overall results for all the actions done by the three volunteers. All the falls were correctly detected, while there were a 5% of false positives, which were not identified as ADLs and therefore misinterpreted as falls.

The current consumption design allow for the fall detection system to be used for several days without the need to recharge the battery.

Table 1. Identity of the volunteers used for the experimentation.

User	Sex	Age	Height	Weight
U1	Male	24	185 cm	73 kg
U2	Female	49	155 cm	49 kg
U3	Male	51	170 cm	82 kg

Table 2. Result of the experimentations with three volunteers.

Activity	Number of executions	Correct detections	Error type
Quick sit on a chair	120	118	Fall detected
Quick sit on a sofa	120	119	Fall detected
Lie down on a bed	120	118	Fall detected
Jump	120	117	Fall detected
Fall	120	120	No errors

4 Conclusions

In this work a new fall detection system is presented. An integrated board with a microcontroller, an accelerometer and a GSM module was designed to implement a new algorithmic approach to fall detection. The algorithm identifies the ADLs that present an acceleration pattern similar to a fall. A fall alarm is launched only when, in case of a threshold exceeding, an ADL is not recognized. The integrated board with the GSM module allows for a small wearable device having low power consumption and a long battery life. Thanks to the GSM module, the device can be used also in outdoor scenarios, wherever a GSM signal is present.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1006

Developing the „Birdie" Game for Stroke Patients' Rehabilitation

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Abstract. This study introduces a rehabilitation game, which is part of a special set of games planned and developed within the "StrokeBack" project. These games aim to support the rehabilitation process of stroke patients who have upper limb impairments and damaged psychomotor abilities. In this paper the user interface and relevance feedback of the "Birdie" game is presented.

Keywords. Stroke, rehabilitation, virtual reality, game.

Introduction

Within 'StrokeBack', which is a running project partly funded by the EU, the goal is to improve the speed and quality of stroke recovery [1, 2] by the development of a telemedicine system which supports ambulant rehabilitation at home settings for stroke patients with minimal human intervention [1].

Changes in clinical practice cause that most patients are discharged from hospital within a very short time, so the research and development are mostly concentrate on home-based rehabilitation. This approach has various advantages; for example new skills are automatically transferred into daily life, improving motivation and morale. In addition, home-based therapy is less expensive, more motivating and –, because of the familiar environment – more comfortable too.

The researcher and developer team at the University of Pannonia's role in the 'StrokeBack' project is to create games which can be used during the home rehabilitation process by the patients or to replace clinical rehabilitation and speed up the process of recovery. This paper shows the development process of one of the rehabilitation games. The main idea of the games is to train the patients with repetitive movements and exercises.

1. The State of the Art in Rehabilitation using Games

Every year more than 700,000 people suffer stroke in the United States, making it the third most common cause of death, especially for elderly people [3]. The occurrence in

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Europe is very similar; it's about 2 million people per year. According to the World Health Organization's data 15 million people suffer stroke worldwide in a year. Although survival rate is improving, 5 million die and another 5 million remain permanently disabled yearly [4].

Virtual reality (VR) technology [5] is currently being explored in several areas of rehabilitation [6].The potential benefits of training in VR would be the ability to increase the duration, frequency, and intensity of therapy that could be provided to patients by using semi-automated programs.

The Internet can be used for data transfer, allowing a therapist to monitor progress remotely and to modify the patient's therapy program [7]. The rate at which patients can regain their motor skills, the extent of improvement, and the environment in which they are treated affect the duration, effectiveness, and cost of patient care. Therefore, developing new methods to accelerate and improve the level of motor retraining is a very important societal consideration.

VR-based rehabilitation systems have several other advantages as well. VR rehabilitation exercises can be made to be engaging, so that the patient feels immersed in the simulated world. This is extremely important in terms of the patient's motivation, which, in turn, is key to the recovery. VR sensor technology can also be used to fully quantify any progress made by the patient, especially in terms of motor-control improvement. The literature investigating virtual reality as a tool for rehabilitation training does indicate potential benefits. These should be more extensively explored in order to ascertain the use of VR as an enhancement to traditional therapy.

2. The Methodology used

The Qt programming framework, based on the C++ programming language, was used, because of platform independency. The development was realised with object oriented programming (OOP), using both the Qt's built-in features and libraries and our own developed components too. Also the graphical user interface (GUI) got a significant role.

During the development the V-model was used. [8] It completes the V model by processing the test results, or rather debugging and mistake correction.

For the testing questionnaires and observation were the tools.

3. The Research and Development Work

The Birdie Game was developed in two different versions, under the guidance of the Brandenburg Clinic's therapists. Both of the two versions can be fully personalised. The therapists can do this personalising with a special module in the games. They can set up the level of difficulty for each level in the games. The therapists are able to set the necessary movements up to control the games, and they can plan individual levels for each patient.

The patient (user) and/or their assisting person can apply some modifiers on the game, for example they can set the game's background, and they are able to change the graphics of the levels. These settings only affect the appearance of the game, not the functions. The user can set their own favourite pictures as a background picture, but there is a limitation for the size of used images: image size must be exactly 1200 x 700 pixels. With this background manipulating ability the game is more stimulating for patients. In the Birdie game the user plays with a little bird. The user has to help the birdie. The bird is flying home, but there are some barriers: woods, bushes, etc. (see figure 1.) The user shall keep birdie flying, and with his/her movement intensity can navigate the birdie to fly higher.

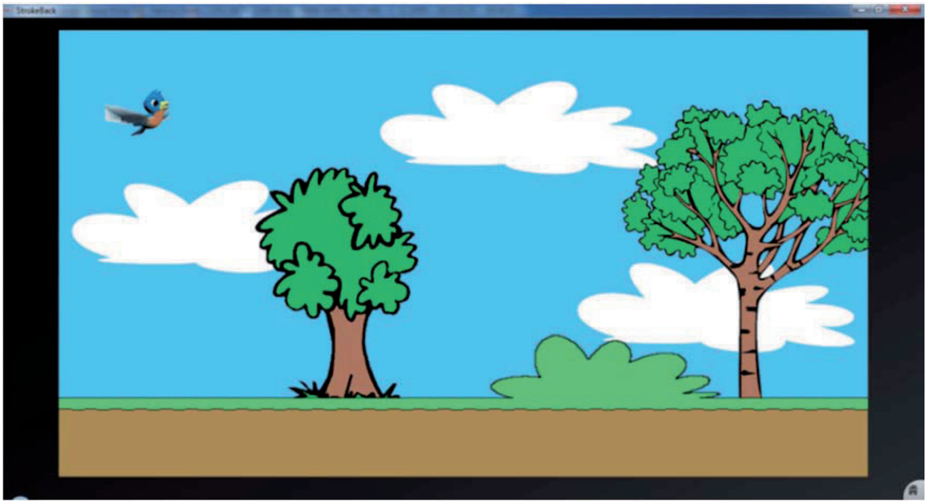

Figure 1. A screenshot from the Birdie game: birdie over a field.

We have planned more scenery for the game. In the second scenario the goal is to make a seagull fly (see figure 2), similarly to the previous scene.

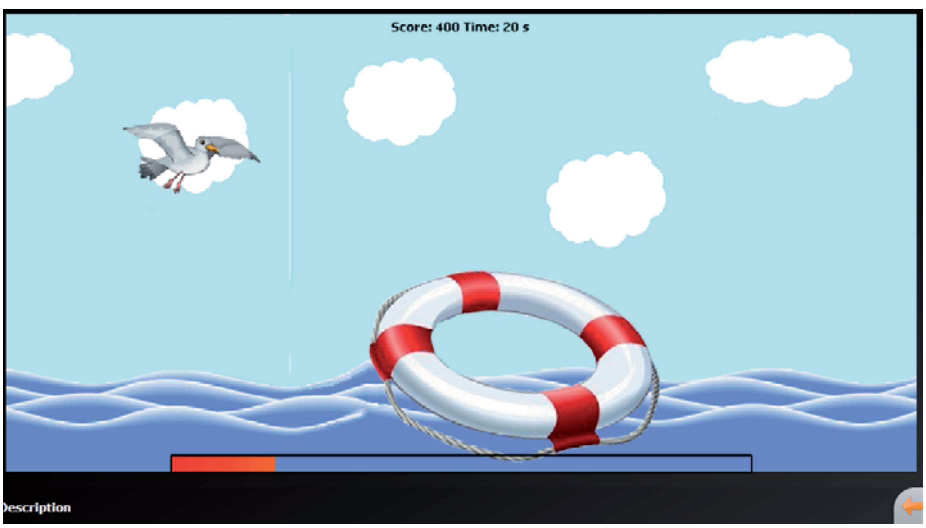

Figure 2. A screenshot from the Birdie game: birdie over a sea.

In the first version of the Birdie game, the background moves, and the patient has to keep the bird in the air. If the bird falls down, it will get into a cage. The user can control the game with keyboard, touchpad, Kinect sensor or mobile device too. With the bird, the patient has to dodge obstacles during the flight. If there is an assigned resting point (like a branch of a tree), the patient can keep a short break with about 5 to 10 sec. duration. After the break, the birdie lifts up, and the user has to keep it up in the air again, until the next stop or the end of the level. This break time can be set to meet personal needs by the therapist. The helper of the patient can also participate in the game by using the standard input devices like a keyboard or a mouse. The main goal of the game is to exercise a repetitive movement for at least 5 minutes.

In the second version the patient has to control the bird in four directions: up to increase, down to decrease, right to go forward on the course, and left to slow down and move a bit backward on the track. In this version, the birdie will stop automatically at an assigned resting point for 5 to 10 sec., but the patient has to lift it up after the end of the break.

The software saves the following data: the time of completing the whole course, the time spent between two "stops" (from resting point to resting point, etc.), the time elapsed until reaching each breakpoints, the time difference between each stages of the course, and the time spent with resting on each breakpoints.

4. Testing the "Birdie" Game

The usability test of this game was made by 30healthy adult people (age group 20-25 years). The clinical test was made by 9 stroke patients in the Brandenburg Clinic in Bernau (Berlin) early May 2013.

The questionnaire contained 11 questions, and 5 points could be given at maximum.

- Q1: The loading of the games were not problematic.
- Q2: I could easily acquire the usage of the game.
- Q3: The game is understandable, easily usable.
- Q4: The game was impulsive, amusing, I would like to play with it more.
- Q5: The audio effects used during the game were disturbing for me.
- Q6: The levels inside the games were getting hard too suddenly, they were hardly feasible.
- Q7: At the start and when I got stuck, I got enough help from the Users' Guide of the game.
- Q8: The intermission of the game (pause, quit) was not problematic.
- Q9: The appearance of the game is pleasing/ I like it.
- Q10: The game, according to the feedback (game scores, time-check), is easily traceable.
- Q11: I could easily manage the levels of the game.
- Open questions for remarks and suggestions

Other scenery and reward animations at the end of the game will be created based on these opinions. The results of the tests can be seen on figure 3, for both healthy youth and stroke patients.

Table 1. Test result.

Questions	1	2	3	4	5	6	7	8	9	10	11
Healthy control group	4.80	3.83	3.77	2.20	1.07	1.77	2.83	3.37	3.77	3.37	4.43
Stroke patients	5.00	5.00	4.67	3.78	1.00	0.89	-	4.33	4.00	3.67	-

It can be concluded that if the stroke patients can use the game with ease and satisfaction, then another disabled person will be able use it as well.

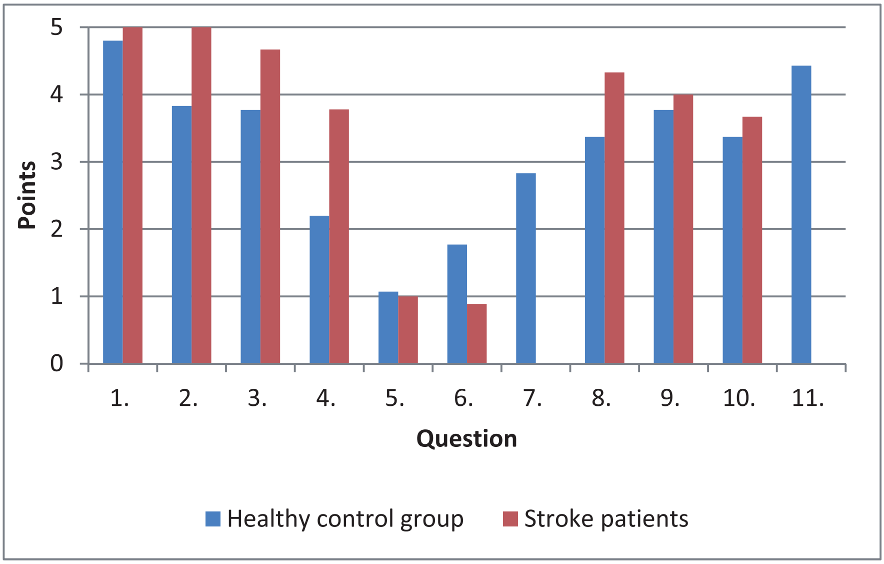

Figure 3. The test results.

As it can be seen from the results of the survey, the stroke patients gave more points (table 1 and figure 3), than the university students whom the control group is consisted of. The reason of this is likely to be: most of the university students in the control group will be software engineers, and their point of view is more critical. Where the stroke patients didn't give point is because that question didn't concern them, for example they didn't try the different levels of the game. And the 5th question was a negative one. Obviously everyone gave low points because the sound effects did not bother them.

5. The impact or Contributions to the field

The Birdie game is only one of the games in the 'StrokeBack' project. The system will be a new innovative tool in future rehabilitation. The results give quantitative, specific information for the therapists about the improvement of patient's motoric coordination. The therapists can follow the way the patient does exercises at home day by day, independently or with the help of an assisting family member. This information may help to assess the effectiveness of the therapy, the difference between the traditional rehabilitation process and the new, telemedicine system, and they can judge if this difference is enough for the rehabilitation aims. During the designing of the games we took into account that they should be accessible and everyone should be able to use them.

According to Burke, VR games were indeed usable and playable by people with stroke. Further, games seemed to stimulate a high level of interest and enjoyment for the participants [9].

Older people and new technologies are principal research and development areas [10]. Improving the quality of life for elderly people is an emerging issue within our information society. Most of the stroke patients are in the older generations – their physical and emotional needs must be supported [11].

The recovery of the voluntary motor control is improved by many repetitions of functional exercises including fine finger and whole arm movements. By using serious games, patients are more motivated and willing to do more exercises.

6. Conclusion and Planned Activities

This paper showed the newly developed "Birdie" game. During the development of the games we took into consideration both the advices of the therapists and the needs of the future users. This is how the actual version of the Birdie game was created. The game was tested with stroke patients and a control group consisted of healthy university students.

Our future plans include the testing of the game with Kinect sensor according to the original plans, as well as making further scenarios and motivational videos.

Acknowledgements

The StrokeBack research project is supported by the European Commission under the 7th Framework Programme through Call (part) identifier FP7-ICT-2011-7, grant agreement no: 288692.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1013

Stakeholder Perspectives on Assistive Technology to Aid People with Visual Impairment to Move Safely

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Abstract. In relation to visually impaired people moving safely, an exploration of stakeholders' perspectives in the context of the current status of need, practice and experience of use of assistive technologies is presented. Rapid acquisition of domain knowledge through consultative non-research processes, is reported as a prelude to researching stakeholder perspectives. It is noted that while the small numbers who volunteered would not be expected to generate authoritative generalisable findings, in fact in relation to the design goal and the depth of analysis, they actually reflect well the current state-of-the-art understanding. Other findings of import include : the apparent hostility of professionals and some end users to new electronic assistive technology - apparently underpinned by poor historical experiences; the potential inference is that haptic and other electronic aids for safe movement have to deliver simple-to-use solutions that really offer significant advantages over the use of a white canes or guide dogs.

Keywords. Visual, Impairment, Blind, Safe, Movement, Walk, Assistive, Technology.

Introduction

The World Health Organisation reports that prevalence of blindness and visual impairments is reducing due to concerted public action. However, where there are increasing numbers of older people, age-related visual impairment results in more cases [1]. Most people with such impairments use low-vision aids such as spectacles; but a significant minority, have congenital blindness or through diseases like age related macular degeneration, have such poor eyesight that they are partially sighted or blind, therefore requiring additional support to live independently. Support comes in many forms of tailored services and technology. One axiom of independent living is being able to move around within the home and outdoors.

As in all good design approaches [2] the authors were tasked to elicit current stakeholders' views in the first stage of an applied programme of research and development. Future studies ultimately aiming at more sophisticated and appropriate technology for partially sighted or blind people based on the use of haptic perception. The project also included interdisciplinary work as follows: reviewing the literature reporting inventions of relevant AT; reviewing recent and current relevant AT available on the market; and, examining the literature on training needs of end users for the AT being considered (i.e. haptic related). The literature reviews are the subject of separate

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publications and so are not presented here, not least for space considerations. However, several published surveys were highly influential to this work [3-7].

The purpose of this paper is to establish a current snapshot of the status of and desire for electronic AT for safe movement for people with visual impairment. This includes what end users' and users' needs are in relation to moving around safely indoors and outdoors, and the usage of current technological solutions.

1 The Main Issues from the Literature

The literature identifies problems involved in moving around safely for people with visual impairments despite use of current aids including: collisions with obstacles such as shop signs, wheelie bins, and bollards at ground height; and above waist height, low hanging branches and lamp posts [3]. Injuries resulting from tripping or walking into obstacles are common [8]. The surveys [3-7] consistently report the vast majority of people with a visual impairment use traditional methods to aid movement, i.e. a guide dog and/or long cane, despite the above problems and availability of alternative or secondary technological solutions. So either people are unaware of these alternatives, the alternatives are too expensive, practitioners do not know how to support their use, or these alternatives are not what people with visual impairments need.

While there are many technologies innovated to aid safe movement [9] there are very few that become commercially available products. However many papers about the products' design do not describe any user consultation [9], hence suggesting stakeholder perspectives are not often considered and an explanation for lack of take up of new forms of AT. If this 'gap' between the ideas of those developing the new technology and the practical needs of the end-user still exist, this would be somewhat surprising given the state of the art of well-established good AT design practice [10].

2 The Methodology

A range of methods for eliciting stakeholder perspectives were thoroughly considered. Time constraints dictated that desk work with stakeholder consultation, qualitative and online surveying were the most suitable pragmatic choices. Whilst reviewing literature and online information is a useful first step in understanding the issues, a dialogue with the community itself is also essential [10].

The project employed Public and Patient Involvement[11] to obtain a user informed research protocol. To incorporate user centred design research participants were interviewed. An online questionnaire was chosen as the method of eliciting experts' views nationally (i.e. from professionals or others who have a broad knowledge of the needs of people with visual impairment). University ethical approval was a requirement for the latter two methods. This approach conforms to good practice in AT research and development, such as suggested by the Fortune guide [12].

2.1 Perspective Gathering

Consultations with a cross section of professionals were conducted to gain expert knowledge in an efficient way, and explore their perspectives on current solutions, including AT, for safe movement. This process was intended to also specifically inform the design of the subsequent questionnaires to experts and interviews of end users.

Online questionnaires were chosen to reach experts from any geographical location in the UK involved in providing services or AT. The aim was particularly to gain a broader knowledge on these stakeholder perspectives at a national level. In 26 questions, the respondents were briefly profiled, asked about reported difficulties people with visual impairment experience when moving around, the range of AT used within their service, and opinions on key features of any better future device. Recruiting via advertising the study and questionnaire through a national knowledge exchange organisations' database of contacts and relevant events [13] was attempted.

Semi-structured focus groups, or individual interviews if preferred by volunteer participants, were planned to address the formerly identified key issues and to allow the people participating the flexibility to report other issues. The topic guide covered movement difficulties, their (end user) attitudes towards assistive technology, and experience of using devices. These topic areas were devised to explore the nature of the gap between the ideas of those designing technology to aid movement, and the practical needs of the end-user. A local non-governmental organisation providing services for people with visual impairments [14] offered to help find participants.

3 The Results

As the data gathering research only attracted small numbers of respondents and volunteers the results from this study have to be considered more consultative/qualitative than generalisable to the whole populations of stakeholders (including the professionals).

3.1 Expert Consultations

Extant use of haptic electronic AT by national and some international providers of AT were openly explored through the online ASSISTECH email distribution list [15]. There were just three responses, suggesting that very little provision of haptic solutions was occurring in the UK. None reported anything overtly aimed at assistance with safe movement, but one innovation was related to haptic perception. In the end one respondent stated "*it may be a solution in want of a problem and there isn't enough proof of concept or sufficient reasons yet to take it forward as an AT*". Meanwhile more detailed consultations with professionals were conducted. This involved an individual network of professionals specific to a nearby large town, a rehabilitation officer in another location and the manager of the local society of the blind. The network included a clinical ophthalmologist, a rehabilitation officer, a low vision expert, and a commissioner of services for visual impaired people. The following topics were discussed: common assistive interventions, activities of daily living, and navigation – all in terms of solutions and problems; and, what is needed in new products/services and their adoption.

A key informant in the professional consultation was the network rehabilitation officer whose own views on technology were coloured by the lack of training she had received on new technologies, and her poor first impressions of some of the technologies to help with safe movement. She reported that her clients varied in their response to technology, but younger clients were more likely to choose a technological solution. Another professional in a similar role emphasised the need to consider the impact of the trauma of becoming blind and changes in life when also trying to learn to use unfamiliar AT – of any kind. Consultation with the manager of the local society for the blind highlighted that many people with a visual impairment have negative attitudes towards using alternative AT (other than the long cane and guide dog) to aid safe movement, because of issues of reliability, durability, and practicality.

3.2 Expert Questionnaire

The online questionnaire only generated one response. After five weeks, individual recruitment with potential participants who had provided their contact details was tried and was marginally more successful with three occupational therapists and three rehabilitation officers responding. Only three of the respondents answered questions relating to the frequency of use of solutions/technologies and what influences this distribution; and, just one considered alternatives to white canes and guide dogs in their service and another singleton expressed their opinion about key features that should be included in a newly designed technology. They stated "*If it was discrete, easy to use without complicated instructions and need for regular maintenance. Also that it was flexible and could be adapted to exactly what the person needed.*"

3.3 End User Interviews

Originally focus group discussions were planned but all but two volunteers preferred the idea of individual interviews which meant just ten older people with varied levels and types of visual impairments were recruited. It was evident from the participant accounts of movement with a sight impairment that the extent and range of difficulties related to the degree of sight loss, age of the participant, the availability of family support, and the amount of independent travel. The participants with the fewest reported difficulties either had residual sight which enabled them to avoid collisions by slow, careful movement; or in the case of more elderly participants, accidents were avoided by reliance on sighted companions to guide them. In both cases there was little interest in the idea of technology to aid safe movement, e.g. *"No, I don't think it would be much use to me."* But where there was the oldest participants in particular emphasized the requirement for aids to movement to be simple and easy to use.

Younger participants in their fifties were generally more active and independent. With this freedom came a price; with home accidents caused by encountering unexpected objects, and once outside, accidents became an everyday occurrence with potential sources of collision at ground, waist, and head height, *"...you go oh I have fell again, let's get up, hope no one is looking."* However, the openness to seeking technological solutions to these everyday movement difficulties varied, with some keen and others totally uninterested. In most cases participants were unaware of the range of available devices to aid movement, and therefore their views on technology were informed by their own perceptions rather than the reality.

4 Discussion

The methods employed were a valid choice in the circumstances of a short timeframe. The professional consultation was an excellent way to initiate the activities and inform data gathering. The expert questionnaire was less successful in that it only elicited 6 responses. Speculation for the low response rate from the context of the study are, lack of time when on top of busy schedules national re-allocation of care services was also occurring, or, negativism about technological solutions. The even smaller response relating to technology and the features needed may have many explanations, acting individually or in concert: current solutions are viewed as sufficient; professional resistance to innovation/change; negative attitudes to electronic AT; uncertainty about how technology can address any gaps; and/or, concerns about integration into services.

Individuals with visual impairment who journey alone recounted collisions with a wide range of hazardous objects, the extent of which is surprising. In contrast, those who relied mostly on sighted companions to guide them, reported no problems suggesting best mobility is achieved with a human carer. Inherently the latter seems to imply a loss of real independence. Is technology a panacea solution for this? It can't be as not all end users are keen to find out about and use new devices. This complex web of needs and attitudes therefore forms the user perspective on assistive technology as reported elsewhere recently [16].

At the time of writing most safe movement designs for people with visual impairment, i.e. either published electronic AT inventions or products, are failing to be widely adopted. The following list has suggestions to improve design and development of future safe movement technology for people with a visual impairment:-

- User needs should be at the centre of design. Past unsupported and/or inappropriate technology has prejudiced many end users and professionals alike. Thus the legacy of disinterest and even hostility needs to be considered.
- Solutions should be intuitive and reactive. Essentially be simple, respond/activate appropriately and be reliable for the end user.
- Solutions should be based around individual wants and needs that arise from personal levels of impairment, preferences and circumstances.
- Developers need to consider the user and prescribing service adoption of their technology. Training and support is needed that is non-threatening to people with visual impairment and easily available to those delivering the services.
- A consequence of the previous principle is that, user trials will have to incorporate consideration of evidence based training of the participants.

5 Conclusions

It would seem at present that technology push has led to the development of devices that are by inference not fit for purpose. Consequently there is a need to put users – i.e. people with visual impairments and people who provide services or AT for them - at the forefront saying what is needed and in informing the design of AT for safe movement. Resulting appropriate designs should have enhanced likelihood of adoption and commercial success. Nonetheless to get stakeholders to consider electronic movement aids the legacy of disappointment from past innovations need to be addressed in user engagement. The principles of development outlined above are not significantly different from those in use for the development of other types of ATs for a long time, so it is surprising that these were not being followed.

Acknowledgements

The authors would like to thank all those who volunteered and our colleagues from the Department of Psychology (Tony Prescott. Tom Stafford and Craig Bertram) and Department of Mechanical Engineering (Matt Carré and James Clark) at the University of Sheffield.

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Special Session on Alternative Human Computer Interfaces for People with Motor Disorders

Special Session on Alternative Human Computer Interfaces for People with Motor Disorders

This Special Session collects publications about the newest advances and trends in Human Computer Interfaces (HCI) for people with motor disorders. The objective is to present the most recent technologies used in the context of HCI and discuss potential users that may benefit from these Assistive Technologies, concerning applications for communication and other fundamental daily activities as mobility, manipulation or cognition. HCI are important for people with complex communication needs caused, in most cases, by motor and cognitive disorders. These devices intend to reduce the gap caused by the disability, connecting the user with his/her both physical and social contexts. This session is also aimed at assessing potential users including those with progressive neuromuscular diseases and severe motor dysfunctions (e.g. locked-in syndrome, traumatic brain injury, stroke and cerebral palsy). It encourages authors working on emerging systems that play an important role in augmentative and alternative communication and that will include eye-tracking systems, biosensors (e.g. Electromyography, Inertial Sensor, Brain-Computer Interfaces) and multimodal interfaces. Nowadays, the Human Computer Interfaces are not only used for communication purposes. Besides communication, users with motor disorders can benefit from HCI for performing rehabilitation tasks. The combination of HCI with virtual environments (e.g. videogames) is a new trend in the rehabilitation of people who suffer cognitive and motor disorders. Finally, this Special Session will also present papers focused on designing and validating strategies to reduce the effect of the motor disorder on the control of the devices (e.g. filtering techniques or adaptive software).

Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1021

A Novel Depth-based Head Tracking and Gesture Recognition System

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Abstract. This paper presents the architecture for a novel RGB-D based assistive device that incorporates depth as well as RGB data to enhance head tracking and facial gesture based control for severely disabled users. Using depth information it is possible to remove background clutter and therefore achieve a more accurate and robust performance. The system is compared with the CameraMouse, SmartNav and our previous 2D head tracking system. For the RGB-D system, the effective throughput of dwell clicking increased by a third (from 0.21 to 0.30 bits per second) and that of blink clicking doubled (from 0.15 to 0.28 bits per second) compared to the 2D system.

Keywords. Fitts' law; assistive devices; human factors; disability; Human Computer Interface.

Introduction

The motivation for the work reported in this paper is the need for low-cost, reliable head tracking and automatic facial gesture recognition systems to help severely disabled users to access electronic assistive technologies e.g. communication devices and environmental controls. Approximately 10 million people in UK have disabilities with a neurological diagnosis, such as Traumatic Brain Injury and Motor Neurone Disease, resulting with an impact on their quality of life as well as that of their carers. The value of assistive technology to enable patients to improve their quality of life and also reduce carer stress is emphasized in a recent National Guidelines by Royal College of Physicians report [1]. The cost of caring for neuro-disabled persons in Europe has been estimated as 795 Billion Euro[2]. The system is designed for individuals with neuro-disabilities such as Traumatic Brain injury (TBI), Stroke, Motor Neurone Disease (MND), Cerebral Palsy (CP) and Multiple Sclerosis (MS).

For the most severely disabled user the only means of access to this technology may be via head movement or facial gesture such as eye blinks and/or eyebrow movements. Therefore, the reliable detection of such movement is vital if a useful system is to be implemented. Two key aspects of this system are the development of robust algorithms for the tracking of head movements and the detection of facial gestures by adding depth information to RGB data. Depth information is obtained using a single camera with structured illumination rather than a stereoscopic system.

The rest of the paper is organized as follows. A brief review of head tracking and evaluation methods is presented in Section 1. In Section 2, our approach using both

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depth and RGB images is discussed. In Section 3, the experimental method is presented. In Section 4, the results are analysed and discussed. Finally, Section 5 contains the conclusions of our investigation and future plans.

1. Background

Over the years, a number of different techniques have been used for head tracking. These techniques could be classified as template-based approaches [3]; 3D systems using stereo cameras [4]; vision-based systems [5]; and using wearable markers [6].

In Kim et al [3], a dual template based tracking system was proposed. The templates are used for tracking the nose and the tip of the nose. Gorodnichy & Roth [4] presented a system for tracking the nose both in 2D and 3D with low resolution images. The nose was selected as the facial feature to track because it is the most prominent feature of the face; it is always visible even with different head orientations.

CameraMouse [5] is a vision based tracking system. The system can track features selected by the user present on the user's body. To track the movement of the head, facial features such as the nose are selected. Once a facial feature has been selected, optical flow is used to track the movement of the feature. Two groups of participants were used in the experiments. The first group consisted of twenty healthy volunteers and the second group consisted of twelve volunteers with disabilities - ten users had Cerebral Palsy (CP) and two suffered from Traumatic Brain Injury (TBI). The study shows that in the first group with the healthy volunteers, the users performed significantly better with a regular mouse. In the second group, only nine participants were able to use CameraMouse whereas three participants did not have sufficient neck/head muscle control to use the system.

In Cloud et al [7], the performance of CameraMouse was evaluated for different users. The experiments were carried out with ten healthy individuals and one individual with disability. This study highlighted the need for customizable interfaces for users with disabilities, as the user had difficulties in the typing task because the keys were too small and close together. The study also showed that for the healthy volunteers, the nose was the best feature to track where as for the individual with disabilities the area above the nose bridge, between the eyes was the best spot to track.

In Pereira et al [6], a head tracking system using a low cost infrared source and camera with a reflective dot is presented. The proposed system required the user to wear a reflective dot either on their forehead or on the brim of a cap. The reflective dot can be easily segmented and tracked as the user moves his head. This data is processed to move the cursor on the screen. The system was validated with ten individuals with cervical spinal cord injury performing twenty four tasks at two different index of difficulty (2 bit and 5 bit). The study found that after four sets of test, the Movement Times (MT) of the participants were constant i.e. the learning curve was fast and also the device was easy to use.

For evaluation and comparison of a range of Human Computer Interface devices (HCI), the method proposed by MacKenzie et al [8], based on Fitts' Law [9] was applied. The guidelines set forward by the International Organization for Standardization (ISO) for evaluating the performance, comfort and effort required to use a non-keyboard input device was followed [10] in designing these evaluations.

In our proposed system, the Kinect for Windows sensor is used [11]. The sensor provides both an RGB and depth image. Our novel proposed system based on RGB-D enables us to use both the RGB data and depth to make a more robust system by removing noise from the data The sensor consists of a structured light based depth sensor and an RGB sensor.

2. Methodology

In the proposed system, it is assumed that the head would be the nearest object to the sensor. The depth image is used to find the point nearest to the sensor which in our case is the nose. The contour of the nearest object in the depth image is extracted and used to create a mask for the region where the face was detected. The depth mask generated enables us to segment the RGB image and remove the background and thus reduces the search area for facial features using a Haar-Cascade [12]. The data from the RGB-D sensor is used to segment, detect and track the movement of the head. The system is non-invasive i.e. no reflective surface would be used. The depth data together with the RGB data is used to capture facial gestures such as eye blink and eyebrows movement and used as a switching mechanism.

The index of difficult (ID) is the amount of effort required to complete a task.

$$\mathrm{ID} = \log_2\left({}^{D}/_{W} + 1\right) \tag{1}$$

Devices are usually compared by calculating the effective throughput ($\mathrm{TP_e}$) using Eq. (2) in bits/second [9].

$$\mathrm{TP_e} = \mathrm{ID_e}/\mathrm{MT} \tag{2}$$

where MT is the mean movement time(i.e. time take to complete a task), in seconds, for all trials within the same condition, and $\mathrm{ID_e}$ is the effective index of difficulty given by Eq.(3).

$$\mathrm{ID_e} = \log_2\left({}^{\mathrm{D}}/_{\mathrm{W_e}} + 1\right) \tag{3}$$

$\mathrm{ID_e}$ is calculated from the ratio of the distance (D) from the starting point to the target and the effective width of the target ($\mathrm{W_e}$). $\mathrm{W_e}$ is calculated from the observed distribution of selection coordinates in the test carried out (assuming 4% error rate and circular targets)[13].

$$\mathrm{W_e} = 4.133 \text{ x } \mathrm{SD} \tag{4}$$

where SD is the endpoint deviation i.e. standard deviation of the selection coordinates. SD is calculated using Eq.(5).

$$SD = \sqrt{\frac{\sum_{i=1}^{N}\left(\sqrt{(x_i-\bar{x})^2+(y_i-\bar{y})^2}\right)^2}{N-1}} \tag{5}$$

where x_i and y_i are the coordinates where the cursor was clicked; $\bar{x}$ and $\bar{y}$ are the expected endpoint which in our case is considered as the midpoint of the target area. Using effective width incorporates the variability observed of human performance and includes both speed and accuracy ([13], [14]).

3. Experimentation

Table 1. Index of Difficulty of Test.

Target Width (W) (pixels)	Target Distance from Centre (D) (pixels)	Index of Difficulty(ID)
25	50	1.59
50	200	2.32
50	400	3.17
25	400	4.09

For the experiment, the sensor is mounted centrally on the monitor. The Kinect, web-camera and SmartNav [15] are placed centrally and next to each other. CameraMouse [5] uses the web-camera and SmartNav has its own sensor. Fitts' Test [9] is carried out in blocks of 5 sequences each having 8 different orientations for each device being evaluated. The evaluation is based on the procedure detailed in [16]. The activation time of mouse click generated by dwell, eye blink and eyebrows movement was set to 1 second.

4. Result

As can be seen from **Figure 1**, the Kinect-based head tracker (khtdwell) is better than the 2D head tracker (htdwell). The TP_e of the Kinect head tracker (0.30 bits per second) is nearly a third better as that of the vision based head tracker (0.21 bits per second). And in **Figure 2**, the Kinect-based dwell click (khtdwell-fit) and blink (khtblink-fit) is better than the dwell clicking of the vision-based head tracker (ht-dwell-fit). The TP_e of the Kinect head tracker with blink clicking (0.28 bits per second) has doubled compared to the effective throughput of the 2D head tracker (0.15 bits per second).

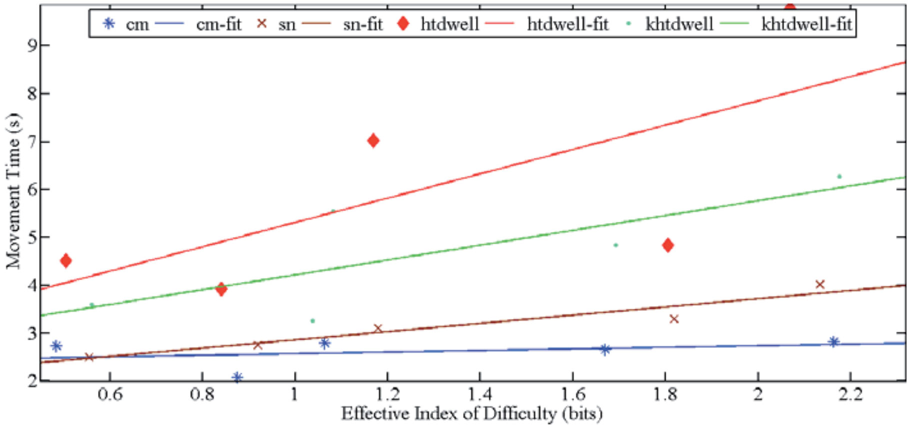

Figure 1. Device comparison using dwell click.

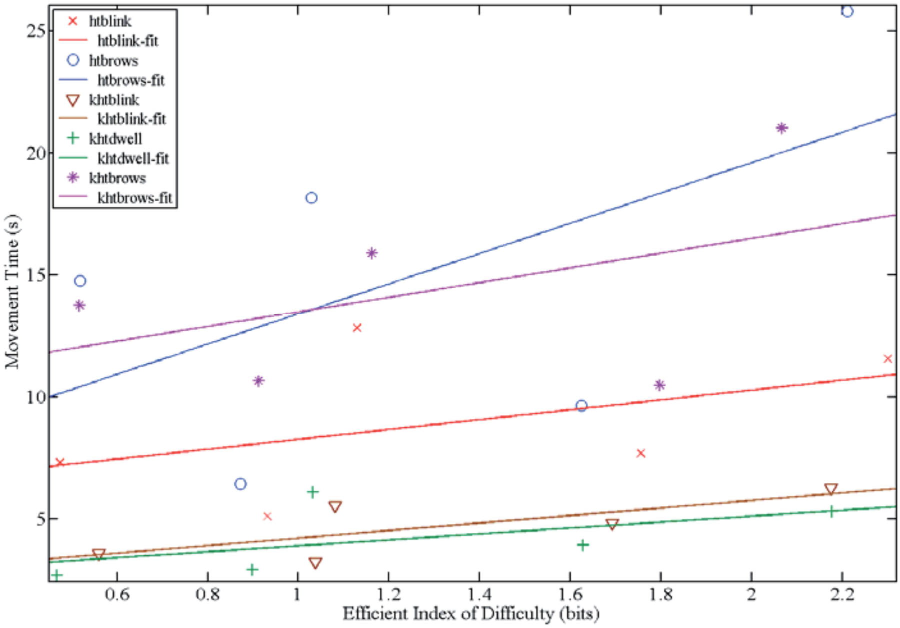

Figure 2. Device comparison using facial gesture as switching mechanism.

5. Conclusion

This paper has shown that the addition of the depth data to the RGB image enables the removal of the background distractions (based on the distance to the sensor) and thus reduces the noise in the data. The inclusion of a sensor capable of measuring depth information from structured illumination (such as Kinect for Windows [10]) is shown to have potential to enhance assistive device performance. From our RGB-D system, the effective throughput of dwell clicking increased by a third (from 0.21 to 0.30 bits per second) and that of blink clicking doubled (from 0.15 to 0.28 bits per second) compared to our 2D system. The eyebrows detection algorithm has the worst performance as it can be seen from the increased Movement Time (MT). The eye blink detection algorithm performance is quite near to the performance of the dwell click switch using depth. The proposed system should also be tested in varying illumination condition to further test the robustness of the system. The next planned step is to conduct translational research with people who are neurologically disabled to varying degrees in order to validate the system, its efficacy and utility.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1027

Development of a Driving Simulator with Joystick Steering for Persons with Reduced Mobility: A Technology Transfer Project in Spain

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Abstract. This paper presents the process of a Technology Transfer project. The project aim is to develop a driving simulator which meets the appropriate interface configuration to be controled by a person with reduced mobility.
The process of innovation in the field of disability and assistive technologies have not been taken into account sufficiently. However, interactions between partners in a technology project presents how the process works, and these data are needed in order to achieve a broader understanding of innovation issues.
Two business have been working with a university under the direction of a not-for-profit organization. therefore, the current case study illustrates the collaboration between partners, sharing knowledge in a technology transfer project, and showing the insights of the process of innovation.

Keywords. Technology Collaboration, Knowledge Exchange, Innovation Process, Physical Disability, Assistive Technology.

Introduction

This paper describes the process of a Technology Transfer project. The project aim is to develop a driving simulator which meets the appropriate interface configuration to be controled by a person with reduced mobility regarding their physical and sensorial abilities.

A driving simulator is a tool that recreates different contexts similar to real environments and allows to generate test scenarios[1]. Physical disabilities can be very diverse [2], and it is difficult to find an unique method to evaluate different abilities. One way to identify different physical abilities and improve driving skills is the use of driving simulators. Previous work has shown how the results in several areas, such as assessment, training and rehabilitation are achieved through this kind of tools [3].

This project is developed by three partners:

- A private company specialized in accessibility consulting and assistive products;

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Via Libre™.
- A company provider of adapted car for people with disabilities; Caradap™.
- A Design and Manufacturing Institute specialized on driving simulators that belongs to Universitat Politècnica de València.

The largest Spanish organization representing people with disabilities, ONCE Foundation, supports and engages the innovation process of all stakeholders.

Both private companies turn out to be related to ONCE Foundation enterprises group, therefore the economic aim is always shared with a social purpose; in others wors, belonging both companies to the third sector.

This work remarks processes and relationships between partners and shows the insights of the collaboration, where a question arises: How do organizations within third sector work with a university in a technology transfer project?
It is assumed that the general knowledge of technology transfer is valid in this field. However, the commitment and open dissemination of results are likely different to general practice.

1 R & D or Application Idea

The process of innovation in the field of disability and assistive technologies have not been taken into account sufficiently. However, interactions between partners in a technology project presents how the process works, and these data are needed in order to achieve a broader understanding of innovation issues.

Hence, the current case study illustrates the collaboration between partners, sharing knowledge in a technology transfer project.

Moreover, an innovative idea behind this technological work is adapting a driving simulator to someone with low mobility of the upper extremities, such as people with quadriplegia.

2 State of the Art in This Area

Technology transfer is a multifaceted topic [4], however there is a consensus on the benefits of closer collaboration between business and universities as open innovation model [5].

On the other hand, literature about joystick steering is quite large [6], but the application of this technology is limited. In Sweden there were 20 vehicles adapted with these devices in 2005 [7].

In the Spanish case there are no precise data on the implementation, and technical staff does not have the tools to assess joystick steering driving [8].

3 Methodology

Methodology followed[9] is divided in three phases:
- desk analysis.
- collecting evidences from innovation process from records generated during project as well as experience.

- Contrasting findings with state-of-the-art.

In the first phase, literature review is divided into two sections. Firstly, Technology transfer knowledge, and secondly publications and projects about joystick steering, driving simulators and physical disability data.

The second phase seeks to gather all key information throughout lifetime of the project, 18 months in total. Although each partner develops their labor in their facilities, six workshops, have been held in where researchers shared all comments on minutes. Workshops were held in partners' headquarters (Madrid, Barcelona and Valencia).

Communication was conducted primarily through email and electronic media but also informal communication was produced via phone calls.

Finally, all process was analyzed retrospectively and compared with other conclusions in published studies. .

4 The R & D Work and Results

Starting point of project is the lack of Spanish assessment on joystick steering driving when potential drivers have low mobility on their upper extremity.

ONCE Foundation accordingly to its strategic line: "Promotion of research, development and innovation in design for all, universal accessibility and assistive products for people with disabilities", created a technical group that prepared a proposal.

Researchers from the companies prepared a contract to formalize the relationship between the stakeholders, by subcontracting university and managing intellectual property rights.

University background included a national patent and software control. Adaptation requirements and include simulator joystick function have been set by companies.

The result was the driving simulator named J4D (Joystick-For-Driving). J4D has been designed in two parts. One supports the full weight of the computer equipment and structure of the monitors, the other consists of a ramp that enables the driver to get into simulator platform with four restraint systems for driver wheelchair.

Ergonomics considerations implemented are an adjustable mounting Joystick system –in both sides of driving position-, and an adjustable arm-rest platform. Moreover, J4D can be managed also with steering wheel and pedals (figure 1).

Fig. 1. Layout of Driving Simulator "J4D" (Joystick-for-Driving).

The initial validation of the prototype confirmed us how neurological learning process needs training and rehabilitation [10].

Fig. 2. User validation of driving simulator named J4D.

Knowledge exchange varies from a procedure to optimize the use of J4D, valuation of these kind of tools on rehabilitation and leisure market, and personal contacts interchange among others.

5 The Impact or Contributions to the Field

Social organizations should be part in projects related to actions that can affect their activities. On doing, so the technological results will meet their needs. This case offers an example of collaboration in which a social organization takes the risk of innovation action.

From a business point of view, acquisition and adsorptive knowledge [11] are fundamental to go on increasing quality of products and services to client and collaboration reported goes beyond a simple technology transfer.

Regarding potential users, A Spanish survey on disabilities conducted by National Statistics Institute [12], estimated that 1.06% of population have problems to drive (448,400 persons), and this number was related to ageing. Therefore, J4D prototype has an important target for training physical and psychological abilities as well as a rehabilitation tool.

Finally, the prototype developed confirms how a flexible interface configuration facilitates the best adaptation to individual requirements. So, this tool allows learning new interfaces to drive through practice.

6 Conclusions and Planned Activities

The technology transfer project analyzed explains how Social organizations follow the common rules on the collaboration with university.

The evidence of disability organization commitment pushing the market promoted this action demonstrates social motivation from beginning. Also, open dissemination is a different practice by this organizations.

User tests and improve the driving simulator jointly manufacturers of assistive products will be next steps on this research topic.

Acknowledgements

The research described in this paper has been promoted and funded by "ONCE Foundation for cooperation and inclusion of People with disability" under the direction of Mr. Jesus Hernandez Galan, PhD, director of Universal Accessibility.
http://www.fundaciononce.es/EN/AmbitosActuacion/Accesibilidad/Pages/Inicio.aspx
The opinions expressed in this paper are those of the authors and are not necessarily those of the ONCE Foundation.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1033

ABC System: A New Communicator Concept for People with Cerebral Palsy

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Abstract. ABC introduces the development of a new concept of communicator that holistically manages interaction of user with the environment. This project has enhanced user involvement (people with dyskinetic cerebral palsy) from early stages of the design process. The inclusion of users has allowed to identify new features not covered so far in augmentative and alternative communication systems. The possibilities offered by the communicator are access to Internet resources, leisure management, learning, emotion management, and environmental control. These demands should have not been identified without the direct inclusion of users in the design.

Keywords. Alternative and Augmentative Communication, User Perspective, Cerebral Palsy, Driving People Innovation, Inclusive Design, Role of Networking.

Introduction

ABC project aims to develop a novel modular and interoperable system, based on smart processing of Brain-Neural Computer Interface (BNCI) signals to provide augmented communication, emotions management and environment control to persons with Dyskinetic Cerebral Palsy (DCP), which will enhance their interaction capabilities of This will substantially improve their social inclusion, independent living and quality of life.

Cerebral Palsy (CP) is a population with posture and motor disorders, which affects children from when they are born. These motor disorders are often accompanied by epilepsy and by disturbances of sensation, perception, cognition, communication and/or behavior. Although, 78 % of DCP population has a "normal" intelligence, their limitations of motor control and the lack of communicative abilities can mask this, hampering their learning possibilities and their development process and limiting their physical and social activity, even affecting their health.

In fact, their life expectancy and quality of life have considerably increased thanks to being able to communicate with their environment; solving their motor, speech and written language limitations by leaning on Augmentative and Alternative Communications (ACC). AAC have three components: language (e.g. Minspeak or Bliss), support system to implement language (from static supports such as physical

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boards, to dynamic supports such as tablets) and input interface (from third person support, scanning systems combined with switches, to use of systems that record head or gaze movement).

User Centered Design Methodologies are not frequently applied with Cerebral Palsy population (Dahlman, 2011). However, prospective techniques have not been used with people with severe cognitive problems. Some researchers have gathered opinion of children with brain injury by interviews (Van Tol, 2011), but most of data were obtained from parents or teachers. When parents provide information about their child's worries or expectations can interpret questions in a different way, hence introducing bias (Prigatano, 2007; Forsyth, 2002). Therefore, it is important to involve all user profiles, including the point of view of CP children and not only the point of view of parents and professionals.

The objective of this article is to detail the needs, demands and expectations of people with cerebral palsy to develop a new communicator based on Brain Neural Computer Interface (BNCI). To achieve the active inclusion of DCP users in the project, current people driven innovation methodologies have been adapted to DCP characteristics (Bühler, 1998) to allow their direct participation and not only through the voice of professionals and family members.

1 Methodology

The project has developed and adapted a set of user centered design methodologies to involve DCP users along the chain of communicator design and development. These methodologies will enable extracting user preferences or opinions independently of the level of motor control, writing and speech.

It has been defined the key criteria to adapt each methodology from the elicitation of needs and expectative, the selection of conceptual designs, to the validation of prototypes.

In most cases, needs of cerebral palsy users are provided by their relatives or professionals. Proposed approach allows to comprehensively address the assessment of their needs by considering the different points of view, including CP population

1.1 How Do Inclusive Design?

The involvement of DCP people in the project has required a justified choice of the most appropriate user centered design methodologies and the adaptation to users capabilities and skills (Poveda and López-Vicente, 2003). This adaptation has been achieved by the participation of experts in DCP, which have characterized and identified the key issues to take into account when applying each technique.

Main features to adapt methodologies are:

- Anticipate the contents of the techniques to allow reflection and active participation.
- Send session planning (objectives, action steps, timeline, etc.) with enough time to solve any doubts and ensure that all users understand the objective of the session and their role.
- Write simple and very descriptive questions and provide exercises.
- Use examples to explain the requested information.

- Apply the technique along several stages, providing time to think about the exercise/task.
- Use different formats (e.g. paper or computer).
- Make a final session to provide the opportunity to contrast the views of different users.
- Reduce the final session to 1 hour to avoid users overload and boredom situations. This can be done because the contents are worked through the preliminary tasks several days before.

1.2 What Techniques Do We Use?

The techniques proposed in the first stages of the project to involve persons with cerebral palsy are interviews, context-mapping and affinity diagrams (Table 1).

Table 1. Description techniques.

Technique	Description
INTERVIEW	• It is suitable to individually identify needs and demands, making easier user participation. • It allows to get in deep because there is not time limits for o answering.
CONTEXT-MAPPING and AFFINITY DIAGRAMS	• Context Mapping is suitable to generate new ideas and expectations regarding the product. It is individually performed, facilitating user participation. • Affinity Diagrams is suitable for the user to organize information according to their individual criteria, which facilitates user participation. • Both allow the continuous monitoring because the exercises are sent to the researcher and the changes can be iteratively requested. • Both support and promote the use of images and visual elements to make easier user communication.

2 Results

On the one hand, we have identified the specifications of the main features of the new communicator:

- Communication features: Normalized speech, translator, use of Information and Communication Technologies (ICT) (phone and internet communication features).
- Learning features: Tutorials, improve communication (feedback), increase vocabulary, etc.
- Emotional features: Identify emotions, emotional messages, and emotional management tools.
- Usability: Multimodal control using user movements (e.g. head) and physiological signals (electromyography or electroencephalography), adapt interaction to user capabilities and enhance aesthetic issues and portability.

On the other hand, with the inclusion of users, new features (Figure 1) not covered so far in augmentative and alternative communication systems have been identified. ABC system is perceived by users as an ICT tool that must consider other features as far as the initially proposed ones (communication, learning and self-regulation of emotions). The identified features are:

- Access to leisure, information and culture: reading newspapers, thematic forums, access to cultural events, etc.
- Access to Internet resources(phone, social networks, watch movies, read, play online, listening to music, etc.).
- Environment control to provide greater autonomy at home and at the centre.
- Support to perform advanced Activities of Daily Living (ADL): access to shopping, bank operations, etc. through Internet

Fig. 1. Example of expectative and interpretation of communication.

Error! Reference source not found. provides a summary of the key demands and expectative of DCP users.

We have identified that current AAC systems are suitable to communicate into familiar environments. Nevertheless, the users' expectative goes beyond these environments because they need to use it by themselves in non familiar environments.

Finally, ABC system must be a tool to increase their:

- Opportunities of making relationships beyond familiar environment.
- Self-satisfaction and well-being. through enhancing self-improvement, reaching new goals, overcoming current problems and limitations, and social integration.
- Social image, freedom, autonomy and experiences.

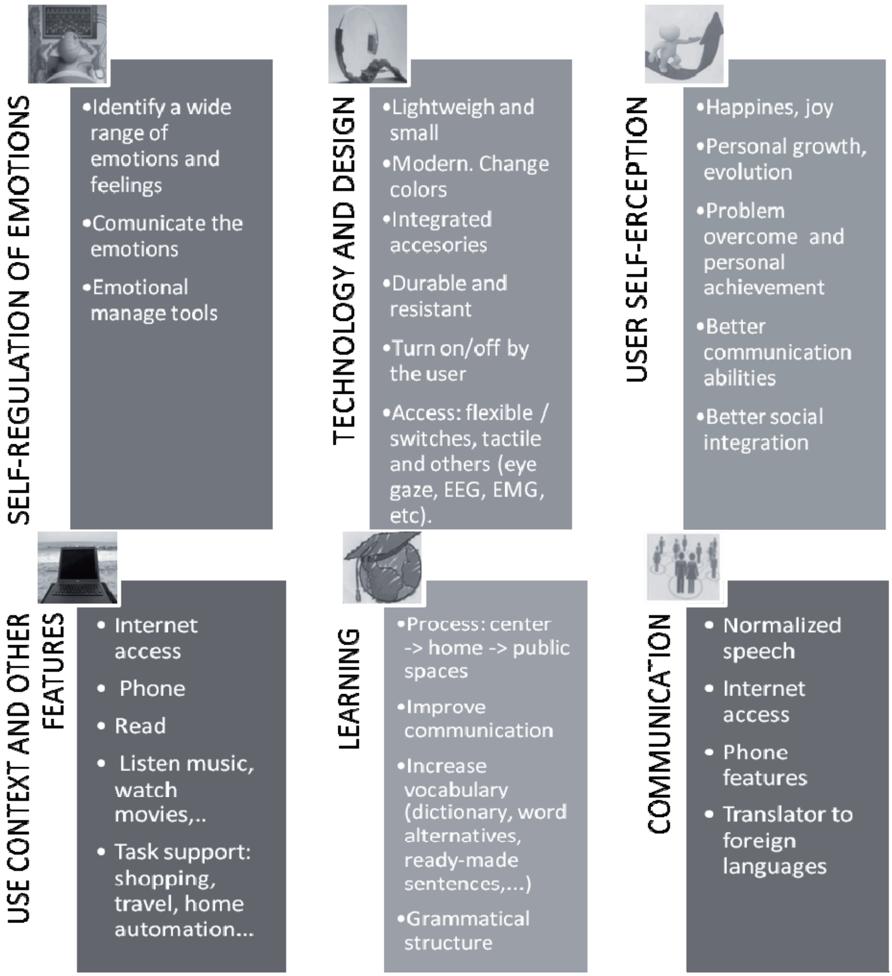

Fig. 2. Key demands and expectative.

3 Conclusions

The inclusive design has allowed DCP users to feel the center the project.DCP people has had the possibility to provide their needs by themselves. Moreover, the information provided by DCP has been different and complementary from the information provided by relatives and professionals.

DCP users have in mind a communicator concept further than a tool for augmentative and alternative communication. It is considered as a social development tool that must be autonomously used by themselves.

DCP users want that the ABC system was support tool not only for face to face communication but also for other many activities. They expect that ABC system was a portable computer (e.g. laptop or tablet) that allows them to access to Internet to learn, meet and communicate with non-familiar people, but it should also serve as support for leisure access (listening to music, watch videos, photos, etc.) and environment control.

Nowadays, we are including users in the design process of the new communicator, such as the selection of the conceptual design and the prototypes testing.

Acknowledgements

This study is part of the European Project 287774: ABC "Advanced BNCI Communication" financed Seventh Framework Programme, corresponding to the FP7-ICT-2011-7 call.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1039

Design of Input/Output Mapping for a Head-Mounted Interface According to Motor Signs Caused by Cerebral Palsy

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Abstract. Cerebral palsy (CP) is one of the most severe disabilities in childhood and it is a disorder of posture and movement due to a defect or lesion in the immature brain. People with CP are unable to control standard human-computer interfaces (e.g. mouse). Therefore, they need advanced devices, which reduce their limitations and empower their capabilities. This paper presents a wearable head-mounted interface based on inertial technology. Firstly, we present a study of relevant head motor signs for 14 users with CP. Secondly; we discuss the different methods of mapping between the human activity (input) and the command transmitted to the computer (output). According to the results, negative signs (insufficient muscle activity, as weakness or hypotonia) are more significant contributors to disability than positive signs (increased frequency of movements, as tremor, chorea or tics). This fact suggests that control modes based on velocity or acceleration might be more useful that control modes based on head posture. Nevertheless, since positive and negative motor signs are often simultaneously present, the interface should include different control modes in order to be usable for different types of users with CP.

Keywords. Cerebral Palsy, human-computer interface, inertial, mapping, control.

Introduction

Cerebral palsy (CP) is one of the most severe disabilities in childhood. The most frequently cited definition of CP is a disorder of posture and movement due to a defect or lesion in the immature brain, [1]. The prevalence of CP is internationally 1.5-2.8 cases per 1000 births. Only in the United States 500,000 infants are affected by CP, [2]. In Europe these figures are even higher, [3]. The "Surveillance of cerebral palsy in Europe: a collaboration of cerebral palsy surveys and registers" presented a consensus that was reached on definition of CP, classification and description, [4]. This classification divides CP into three types: spastic, ataxic and dyskinetic.

One general classification of motor signs distinguishes 2 basic categories: positive signs and negative signs, [5]. Positive motor signs can be defined as those that lead to involuntarily increased frequency or magnitude of muscle activity, movement, or movement patterns. Examples include hypertonia, chorea, tics, and tremor. Negative motor signs describe insufficient muscle activity or insufficient control of muscle activity. Examples include weakness, impaired selective motor control, ataxia, and apraxia, [6], [7].

Disorders of posture and movement cause activity limitation. People with severe disability are unable to control standard interfaces (e.g. mouse or keyboard). This fact reduces the possibilities to control assistive technologies, such as a wheelchair or computer. Many people with speech disorders use the computer as communication tool.

Davies *et al*. presented a systematic review of the development, use and effectiveness of devices and technologies that enable or enhance self-directed computer access by individuals with CP, [8]. They divided HCI into five categories:

_ pointing devices,
_ keyboard modifications,
_ screen interface options,
_ speech and gesture recognition software and
_ algorithms and filtering mechanisms

Authors affirm that access solutions for individuals with CP are in the early stages of development and future work should include assessment of end-user comfort, effort and performance, as well as design features. Although there is a wide diversity of solutions, authors frequently assert that usability decreases dramatically when users have a severe motor disability, [8]. Therefore, it is essential to reduce the barriers between user and computer to empower the user's autonomy.

The work presented in this paper is based on the ENLAZA interface, a head mounted human computer interface. This device has been validated for healthy and some subtypes of CP. This study extends the current research analyzing more number of users and different subtypes of CP. The main objective of this paper is to increase the usability of the interface analyzing the user's needs. This paper analyzes the motor signs of 14 people with CP and discusses the design of the optimum control mode (input/output mapping) accordingly. The input is the human activity, that means, head movement/posture in our study. The output is the command transmitted to the computer, that means, mouse pointer locations.

1 Methodology

1.1 Equipment

The inertial HCI (Fig. 1) consists of a headset with a commercial helmet and an inertial measurement unit (IMU). The IMU (Technaid S.L.) integrates a three-axis gyroscope, accelerometer and magnetometer. The 3D IMU is based on MEMS technology and is available in a package measuring 27x35x13mm and its weight is 27 grams. The 3D IMU has an angular resolution of 0.05º, a static accuracy less than one degree and a dynamic accuracy about 2º RMS.

The mapping between head posture and pointer position is one-to-one (absolute), meaning that each head posture corresponds to a unique pointer position. The sample frequency for data acquisition is 50Hz. The signals from accelerometer, gyroscope and magnetometer are fused to obtain IMU orientation. The three Euler angles α, β, γ are calculated from the orientation and they are the frontal, sagittal and transverse planes respectively.

Figure 1. User with CP (left) and the inertial interface (right).

1.2 Analysis of Motor Signs

We present two metrics to quantify positive and negative motor signs of people with CP. The objective of these metrics is to find quantitative measurement tools, which support the definitions described above. Concretely, we propose to analyze the frequency and the range of motion (ROM) of user's head. The frequency of the movements allows identifying whether involuntary movements of participants present positive motor signs. We will measure the frequency at the maximum spectral density of the mouse pointer movements.

Fourteen subjects participated in these experiments (age 33.75+/-10). They are included in the level IV and V of the Gross Motor Function Classification System (GMFCS). Moreover, one healthy subject (age 29+/-2) participated in order to extract the voluntary patterns. Some of users with CP use alternative interface with low usability level. Tests took place at AVAPACE (Valencia, Spain) a center specialized in CP and similar disorders.

The methodology is based on a goal-oriented task. Participants were instructed to locate the cursor over the target as quickly as possible using head motion. The target changed its position when a click was performed, following a sequential order. The click was performed holding the pointer in a certain area (50 pixels) for a length of time (3 seconds). One session consisted of reaching 11 targets, 3 for practicing and the remaining 8 for assessment. Number of sessions varied according to the user's motivation and fatigue. The target size was adapted according to user's skills from 50 to 300 pixels (screen resolution 1280x768).

1.3 Human-Machine Mapping

Most devices sense linear position, motion, or force; rotary devices sense angle, change in angle, and torque ([9]). For example, tablets sense position of a pen, mice sense motion (change in position), and isometric joysticks sense force. The property sensed determines the mapping from input to output, or transfer function, that is most appropriate for the device. Position sensing devices are absolute input devices, whereas motion-sensing devices are relative input devices. A relative device, such as the mouse, requires visual feedback in the form of a cursor to indicate a screen location. With absolute devices, the nulling problem arises if the position of a physical intermediary, such as a slider on a mixing console, is not in agreement with a value set in software. This problem cannot occur with relative devices, but users may waste time clutching: the user must occasionally lift a mouse to reposition it.

The inertial interface designed uses the absolute control mode. We hypothesize that CP causes movement disorders, which make difficult to control the velocity of the movement, meaning that the relative control is more challenging for people with CP.

The following sections describe the analysis of motor signs and discuss whether the absolute mapping is the optimum mode for all cases.

2 Results

Figure II shows the results of frequency analysis. The peak for the voluntary movement (healthy subject, user 1) occurs at very low frequency (0.1Hz). In all the cases of user with CP analyzed, the frequency is really similar to the voluntary frequency. That implies that involuntary movements share the bandwidth with voluntary movements. This result suggests that positive motor signs (involuntarily increased frequency or magnitude of muscle activity) do not affect the control of the device. User 4 and 11 were not able to finish the task.

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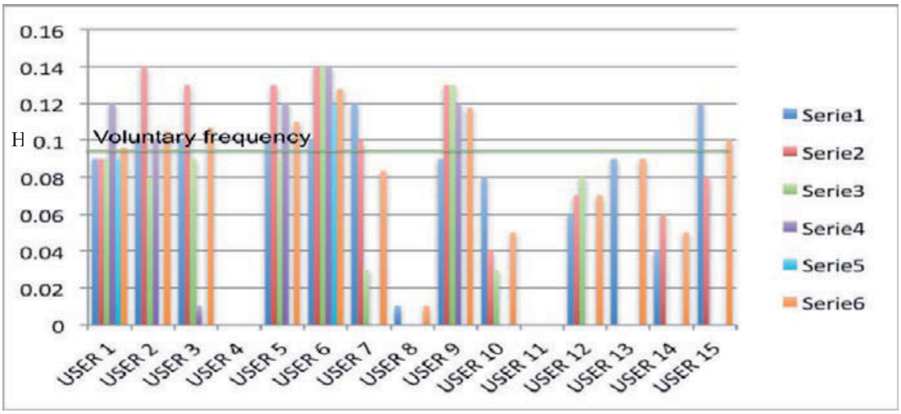

Figure 2. Frequency analysis for every user (DFT of the horizontal coordinate of the mouse pointer).

Figure III shows the result of the ROM analysis. For the healthy subject (user 1), the ROM is balanced for all the axes, which implies a good head posture. For some users with CP, control limitations seem to be more related to head posture due to the difference respect to voluntary ranges. Figure IV and V depict the difference between the ROM for a healthy subject respect to a user with CP. Although balanced control exists for some cases, other users present important difficulties to maintain the right posture to perform the task. This fact implies that negative motor signs (insufficient muscle activity that leads to poor posture control) appear during the task.

3 Conclusions and Discussion

This paper aims to design a human computer interface for people with CP. The first goal is to characterize the user’s limitations and capabilities. According to the CP classification, motor signs can be divided into positive and negative. Positive motor signs refer involuntarily increased frequency or magnitude of muscle activity and

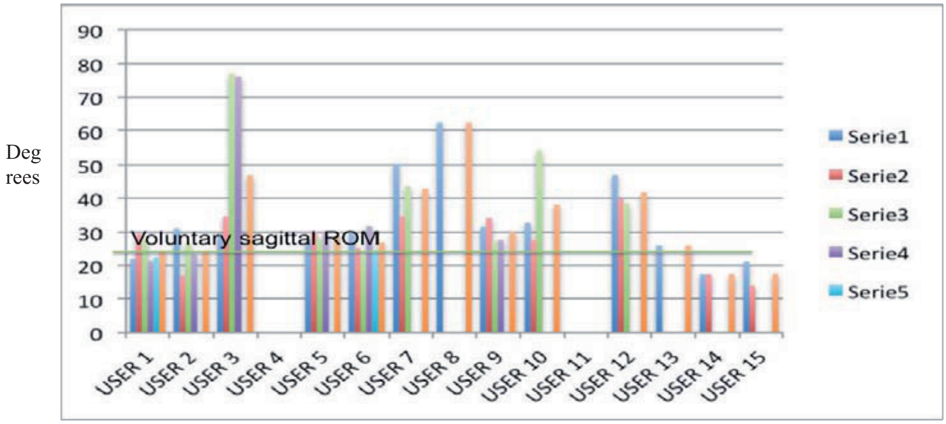

Figure 3. Sagittal ROM analysis for every user.

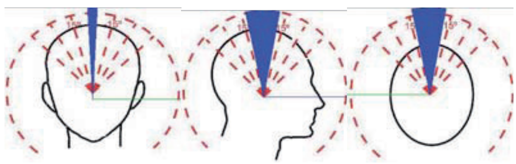

Figure 4. Frontal, Sagittal and Transverse ROM for a healthy subject.

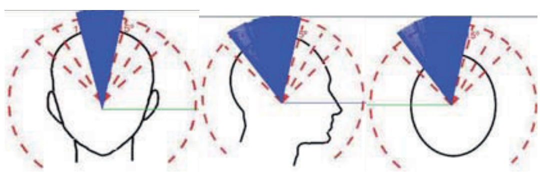

Figure 5. Range of motion (ROM) for an user with CP. Frontal, sagittal and transverse rotations.

negative motor signs refer to muscle weakness. The experiments showed that negative motor signs affect the control more than positive motor signs.

The property sensed was the angular orientation of the user's head, thus, the inertial interface is an absolute input device. This mode was selected as the most appropriate for the device considering the involuntary movements caused by CP. However, according to the results, negative motor signs are more frequent than positive motor signs. The presence of negative motor signs implies that users have more difficulties to maintain the posture. Therefore, the assumption of a control modality based on absolute positioning might not be optimum.

Additionally, the absolute control strongly depends on the calibration position, which requires maintaining the head posture within a certain range. This requirement may be very challenging for some users with difficulties to maintain the posture. The relative mode would allow users to reach any location from any head orientation. This study will help to implement a relative mapping controlling the mouse pointer with velocity or acceleration instead of orientation. This design will provide more versatility to the interface contributing to increase its usability.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1045

From Touch to Brain Control: Augmenting Communication in Persons with ALS

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Abstract. Brain Computer Interface (BCI) systems aim to provide people with severe motor impairment with an additional/alternative channel to communicate and interact with the external world. At the state of the art there are several custom computer programs specifically developed to be controlled through a BCI. However from the end users' point of view it is important to become familiar with their own assistive device before the BCI represents the only way to access it. The Brindisys project aims at designing and developing a general assistive technology to support communication and autonomy in people with Amyotrophic Lateral Sclerosis (ALS) from the onset of the disease to the locked-in phase. The prototype consists of a specific interface allowing for communication and environmental control that can be managed both with conventional/assistive input devices and with a P300-based BCI. This work describes the system functionalities and reports the results of a preliminary assessment with end users and healthy control subjects.

Keywords. ALS, Brain Computer Interface, AAC, domotics.

Introduction

Brain Computer Interface (BCI) systems aim to restore communication and interaction with the external world in people suffering from severe motor impairments. In fact, non-invasive BCIs rely on the detection of voluntary or involuntary modulations of the Electroencephalographic (EEG) signal which are translated in a control signal for an external device [1]. Among the EEG features that can be used as input signal for a BCI, using the P300 event related potential (ERP) allows direct selection of a single item (for instance a character or an icon) among a group of possible choices presented to the user. The P300 ERP is a positive deflection which occurs about 250-500 ms after the

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subject receives a stimulus that he/she identifies as a Target (or rare stimulus) between a train of Non-Target stimuli (frequent stimuli [2]).

The Brindisys project (*Brain-computer interface devices to support individual autonomy in locked-in individuals*) aims at developing a new assistive system designed to be operated with several input devices, ranging from conventional/assistive input devices to a P300-based BCI. The target users are people with Amyotrophic Lateral Sclerosis (ALS) since they experience a progressive loss of muscle strength that eventually prevents any movement. In this course, independence and communication ability are increasingly impaired. In each phase of the disease, this condition can be temporarily compensated by adopting an assistive device, tailored to the current functional deficit. When muscular contraction is eventually impossible, BCIs may represent a solution, allowing communication and interaction with the external world with no use of the conventional output pathways of central nervous system (muscle and nerves).

1 System Overview

The Brindisys system consists of two main components: a tablet PC which features several visual interfaces (see examples in Figure 1.a-c) for communication and environmental control and an application that can overlay visual stimuli (grids or dots) on the user interface [3]. The stimuli are used to implement a P300-based BCI paradigm: they flash in a pseudo-random configuration above the icons (see Figure 1.d), and the subject is required to focus on the stimulus appearing on the item he/she desires to select. All stimuli must be considered Non Target, except the one that overlays the attended item (Target stimulus) which elicits a P300 ERP. Since the P300 ERP amplitude is comparable with the amplitude of the spontaneous EEG signal, an average of several stimulus repetitions (usually from 5 to 10 depending on the subject's EEG features) is required to detect the Target item (Figure 1).

In contrast to existing BCI systems, which only allow the control of dedicated applications, in the Brindisys system the applications available on the tablet PC are accessible with both several input devices relying on the current user's residual motor abilities (touch screen, mouse, keyboard, joystick, buttons and head tracker) and a P300-based BCI (Figure 2). The user can adopt the aid in an early stage of the disease, and familiarize with it using the touch screen when his/her motor abilities are still intact. When muscle strength decreases options for assistive access are available: for instance if fingers movements are preserved the user can access the prototype functionalities by means of scanning input modes (automatic or self-paced modalities with one or more buttons); if the user can reliably control even subtle head movements he/she can use the dwelling function by means of an head tracker to emulate the mouse operations. Given the complexity and the heterogeneity of the ALS progression, a system that meets the needs of this particular type of users could also be very useful for people suffering from other types of motor disabilities (stroke outcomes, multiple sclerosis, etc).

Currently, a few demonstrations of BCI as possible assistive product have been given and some cases are reported in the literature of motor disabled users that can access to communication and environmental control through a BCI [4-7]. However BCI systems are still not widely used outside experimental contexts, for reasons including the complex configuration and calibration procedures and limited set of functions of BCI-controlled applications. To address these issues, in the Brindisys system all calibration and configuration procedures have been simplified, and new classification algorithms have been developed in order to increase system reliability and usability [8-10].

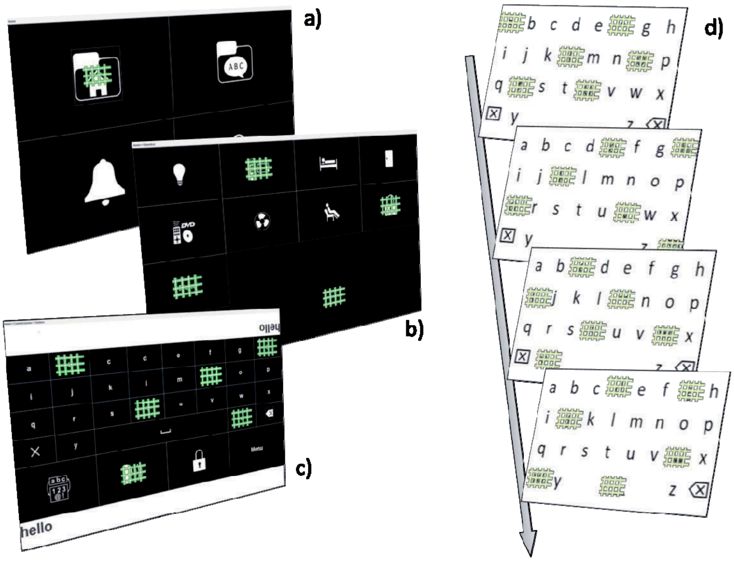

Fig. 1. Examples of visual interfaces available on the tablet PC with stimuli (green grids) overlapped to implement the P300-based BCI paradigm. a) System Home page; b) Environmental control menu; c) Virtual keyboard. d) overlaid stimuli are pseudo-randomly flashed every 250 ms; a stimulus appearing above the item attended by the subject elicits a P300 ERP.

1.1 The Role of End Users and System Functionalities

The Brindisys project focused on users through the planning, design and development of the system (User-centered design). At the beginning of the project, 7 end users, 13 caregivers and 20 stakeholders were interviewed about both communication and environment control needs of people with ALS, all of them recruited from the ALS Center (Department of Neurology and Psychiatry, University of Rome). Two focus groups about the potentialities of a BCI were carried out. This first phase allowed to define the system functionalities. As far as the communication is concerned, the system provides three main applications: *(i)* an alarm bell to draw the attention of the caregiver; *(ii)* a text writing function for both face to face and remote (e-mail, SMS) communication; and *(iii)* fixed sentences or keywords for quick communication. For the environmental control, simple functions have been required by users such as TV control, movement of armchair/bed, lights control and doors opening (Figure 2) [11]. These functions have been implemented using the KNX standard to control the devices available at the “Casa Agevole” premises (IRCSS Fondazione Santa Lucia, Rome), which is an apartment designed for people with limited mobility and where preliminary assessment took place.

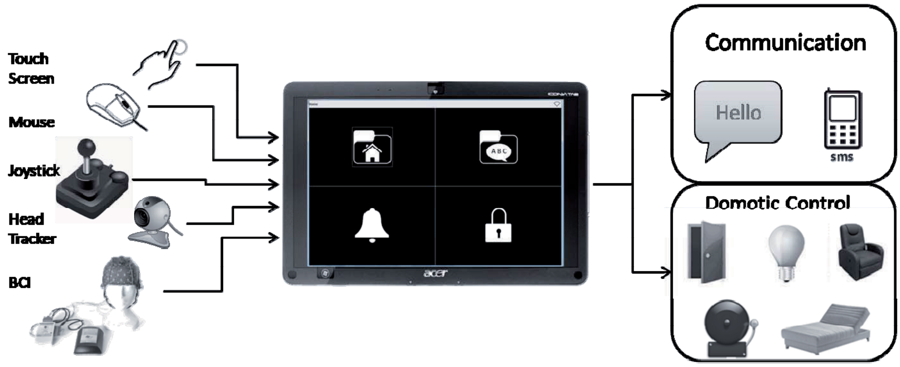

Fig. 2. Overview of the Brindisys system: on the left side the input devices supported by the prototype, and on the right side some of the applications provided for communication and environmental control. In the middle the tablet PC providing the user interface.

2 Evaluation

Usability of the Brindisys system was evaluated in terms of effectiveness (BCI accuracy of selection), efficiency (required workload - NASA-tlx [12]), and user satisfaction (Visual Analogue Scale – VAS for overall satisfaction and System Usability Scale – SUS for perceived satisfaction and usability) [3]. Three end users with ALS (EU, 2 male, 1 female; age= 56, 40, 80; ALSfrs-r =13, 31, 38[13]) and three healthy control subjects (CS, 2 male, 1, female; age = 52, 55, 68) were involved in the experimental protocol, which included two sessions: during the first one, subjects operated the prototype using the conventional input device (CONV) which best matched their motor abilities (one button with automatic scanning, two buttons with manual scanning, and touchscreen and keyboard for the three EU respectively and mouse for all CS), during the second session all of them operated the prototype by means of the P300-based BCI. For the BCI session scalp electroencephalographic (EEG) signals were recorded (g.MOBIlab, gTec, Austria) from 8 channels according to 10-10 standard (Fz, Cz, Pz, Oz, P3, P4, PO7 and PO8). The EEG signal was digitized at 256Hz, high pass and low pass filtered with cut off frequencies of 0.1 Hz and 30 Hz. Each channel was referenced to the right earlobe and grounded to the left mastoid The required tasks were the same for both sessions:*(i)* a communication task: access the virtual keyboard interface, write a specific word suggested by the experimenter and vocalize it using the text-to-speech function of the prototype and *(ii)* an environmental control task: performing specific actions suggested by the experimenter on the environment mimicking real-life situations. The word to write and vocalize and the sequence of actions on the environment were the same for all subjects in order to standardize data across subjects. During each session, subjects could also familiarize with the system in an ecological condition operating the prototype without constraints due to the experimental protocol.

3 Results

Both experimental groups successfully completed the protocol. Table I summarizes the results of the experimentation. On average the classification accuracy of the BCI device was between 90.5% and 94% for EU and CS respectively. The formers resulted completely satisfied of both the BCI-device (average 10) and conventional/assistive input devices (average 10). While CS exhibited a higher satisfaction with the BCI device (average 9.6) with respect to the conventional input device (average 8.6). The usability perceived by the EU (on average 82.5 for BCI and 73.83 for CONV) and measured by means of the SUS was lower than the usability perceived by CS (on average 93.3 for BCI and 91.25 for CONV). CS experienced an appreciably higher workload with the BCI (44.95 on average) with respect to the conventional input device (6.65 on average), on the contrary the required workload for EU was lower with BCI (21 on average) than with the CONV (36 on average).

Table 1. Result of the experimental protocol for both control subjects and end users.

	BCI accuracy	SUS (0-100)		Satisfaction (0-10)		Workload (0-100)	
		CONV.	BCI	CONV.	BCI	CONV.	BCI
Control 1	82%	91.2	87.5	8.6	10	8.3	51.6
Control 2	100%	85.0	92.5	7.2	9.0	5.0	38.3
Control 3	100%	97.5	100	10	10	11.6	27.6
Subject 1	89%	57.5	85.0	10	10	23	20
Subject 2	100%	100	92.5	10	10	29	11
Subject 3	82.5%	70.0	70.0	10	10	56	32

4 Conclusions

The Brindisys system was designed to support people with ALS in the different phases of the disease. This work provides an overview of the system and reports the preliminary results about the assessment with end users and healthy control subjects. While system usability was rated lower by end users than by control subjects, the formers stated that they were highly satisfied of the proposed system used in both the conditions. End users experienced a higher workload using the system with conventional/assistive input device than with the BCI input, and we speculate that since the latter does not require muscular activity, it requires a minor physical effort even if the users are not completely impaired.

Despite not conclusive, these results indicate the potential effectiveness and usability of the proposed system. Further tests involving end users in their own homes for long periods, will allow us to identify the weak/missing features of the system in order to improve system effectiveness, usability and reliability.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1051

Enhancing Interaction of Persons with Cerebral Palsy using Biosignals Detection

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Abstract. Cerebral Palsy (CP) is a disorder of posture and movement that results in permanent but no unchanging conditions. Interventions in rehabilitation therapies and health management are important to improve the quality of life of persons with CP. Moreover, intervention in Communication is of utmost importance, as disorders of movement impose severe limitations in the interaction with the environment. In this paper we describe four modules based on biosignal sensor technology, developed to augment the performance of CP users in the interaction with the environment. Our technology is focused on detection of multimodal physiological signals through wireless, miniaturized and wearable sensors to be placed in the body of persons with CP (EMG, ECG, EDA, BVP, respiration and accelerometry). The presented modules were developed to integrate a sensor framework for implementation of different assistive technologies with applications in the areas of computer access, affective computing, health monitoring, and biofeedback rehabilitation.

Keywords. Cerebral palsy, biosignals, augmented communication, rehabilitation, affective computing, health monitoring.

1. Introduction

Cerebral Palsy (CP) is a permanent disorder of posture and movement due to a defect or lesion in the immature brain. Disorders caused by CP (either physical or cognitive) are very heterogeneous, meaning that the interventions should be tailored to the individual skills of each person. Health treatments and rehabilitation increase the quality of life and may also extend life expectancy in CP [1, 2].

Movement impairments that people with CP have, impose severe limitations in communication and interaction with the environment. Lack of mobility and speech disorders increase dependency and social exclusion. Communication, as part of rehabilitation interventions in CP, is a very important factor in their quality of life [2]. Intervention in early stages is demonstrated as very important to develop communication skills for persons with CP. Assistive technologies can open opportunities in health and rehabilitation or in computer access, to better development of interaction and functional capabilities that will improve communication with the environment [3, 4].

Biosignals is a summarizing term, that is used to define all the signals related to

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body human, whether they are electrical, mechanical, chemical or physical. Some examples of these signals include the ECG, respiration, and motion signals such as acceleration. Biosignals provide us with powerful information about the human homeostasis, since we can extract several psychophysiological parameters. As such, these signals have been used for many purposes that include health monitoring, affective computing, human-computer interaction, among many others.

This paper presents a technology developed for augmenting interaction and communication of CP users with the environment. Our work is part of the development of a sensor framework designed to provide effective and efficient communication channels for people with Dyskinetic Cerebral Palsy (DCP) based on Brain/Neural Computer Interface (BNCI) technologies. Modules were designed to use biosignals as sources for generating control signals (computer access), improving motor control (biofeedback rehabilitation), detect emotional states (affective computing) and alert to changes in critical health parameters (health monitoring).

2. Modules Design

In this section we present the design requirements for the four modules that were developed to integrate sensors in applications used as Assistive Technologies. In all modules, biosignals are transmitted via Bluetooth and acquired in a computer or mobile phone (Android platform). Extended battery life enables signal acquisition for long term, and several wearability factors were considered and analyzed during the development of each module.

2.1. Computer Access

A miniaturized and wireless module integrating EMG sensors was developed for computer access. This module can be placed in any part of the body (Fig. 1). Concerning involuntary movements of the target group, we developed this module as a small and lightweight form factor, so that it can be easily adapted to each user with no constraints in positioning. This module can be placed in a bracelet or other garments. A software application allows the conversion of EMG signals into control signals. This module can be used as one or two switch interaction with any Augmentative and Alternative Communication (AAC) software.

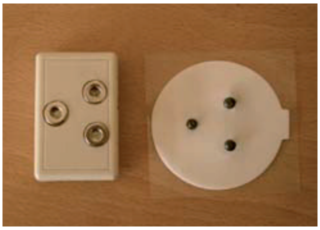

Figure 1. Module developed for computer access based on EMG wireless transmission.

2.2. Affective Module

A special bracelet was developed to integrate blood volume pulse (BVP) and skin conductance (EDA) (Fig.2). From an initial design based on a glove [5, 6] we developed a wristwatch-like configuration that would fit to CP users; contrary to a glove design, the current configuration is easier to setup and wear. The BVP and EDA signals are transmitted wirelessly to a computer or can be visualized and stored in a mobile platform (Android).

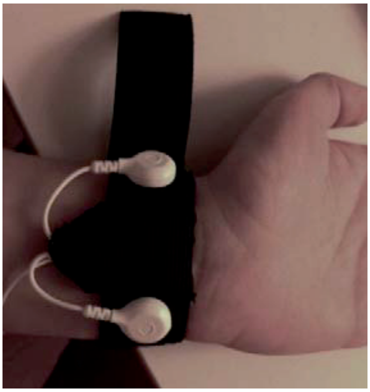

Figure 2. Module for acquisition of EDA and BVP.

2.3. Biofeedback Rehabilitation

For rehabilitation purposes, special protocols are being developed for CP children that use computer interaction and EMG biofeedback. Our rehabilitation module allows simultaneous acquisition of up to 8 channels, enabling the simultaneous acquisition of EMG data from different muscles. Some exploratory work on protocols for CP children, including games adapted to different ages, is being developed (Fig.3).

Figure 3. Biofeedback protocol.

2.4. Health Monitoring

A chest strap was developed to integrate different sensors that will collect physiological signals related with the health status in CP users (Fig.4). Our chest strap is designed to be integrated in a textile sleeve, confortable for the user, and which enables the device to be used in a continuous way. The Health Monitoring module includes three different sensors: electrocardiography (ECG), respiration and accelerometer.

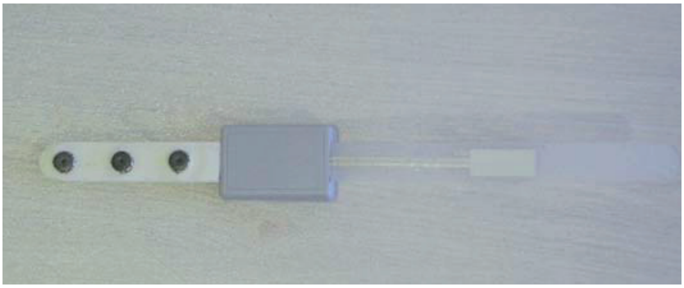

Figure 4. Health monitoring module

3. Results

Preliminary tests were conducted with children with cerebral palsy at two rehabilitation centers. A qualitative analysis of usability and collected biosignals were important to integrate further improvements in these modules. Namely, the Health Monitoring module is being further developed to improve the quality of the signals. Movements' artifacts were identified as a problem, when children are moving. These artifacts are more problematic in the Respiration sensor, which is very sensible to any kind of movement. We also verified that more accelerometers could be helpful and the integration of temperature sensor was also considered mandatory by the clinicians. Thus, next steps for our Health monitoring module will be focused on improving the quality of the signals, namely on the Respiration sensor, on the integration of two more accelerometers, and a temperature sensor. Artifacts were also identified in the Affective module, due to diskinetic movements of end-users.

4. Conclusion

Despite having motor disorders and problems with the speech, 78% of CP users (namely, diskinetic CP) are considered to have a normal IQ, however most of them (96%) are not able to learn [7,8]. This is due to the fact that the lack of communication affects the rehabilitation process, health diagnosis and social relationship, driving CP people to be dependent of a third person, to be socially excluded, and to see their quality of life decreased. Thus, improvements to the health and rehabilitation of the CP children are needed, mainly by developing new communication means to increase the quality and expectancy of life.

Currently, we are witnessing an increase of assistive technologies in order to improve the quality of life of the people with special needs. Regarding the CP children, existing technologies are mostly based on EEG systems. Still, the EEG as a standalone modality has been showing limitations due to its intrusiveness and sensitivity to artifacts that significantly decrease the quality of the EEG signals. As such, new research directions are being followed towards non-EEG signals.

In this paper, we have presented a set of four modules based on non-EEG signals, aiming to provide a sensor framework for helping the augmentative communication and health monitoring of CP user. For a Health Monitoring module, we present a chest strap that integrates three sensors, namely ECG, Respiration and Accelerometer, to support in the assessment of the heath status. For the affective module, a wristband was developed with EDA and BVP sensors; these sensors allows the acquisition of signals associated with the affective states of the user, enabling the system to help the CP users express their emotions. Another important aspect is the communication and computer interaction module; for this purpose we presented a solution based on EMG, which enables human-computer interaction triggered by voluntary muscle activations controlled by the user. Finally, since rehabilitation is also an important process for this population in order to improve motor capacity, we present an EMG biofeedback solution that allows the measurement of muscle activation ability and provides feedback about the muscle recruitment patterns of the patient during the exercise.

Considering future work, our next steps in this project will be to validate the developed modules in a real-world setting. Detailed experimental setups are being initiated in the Rehabilitation Centers, with CP end-users. We will further improve signals quality, namely for movements' artifacts removal.

Acknowledgements

This work was partially funded by the Seventh Framework Programme (FP7) under the "Augmentative BNCI Communication" project (ref. 287774), and by the Fundação para a Ciência e Tecnologia (FCT) under the grant SFRH/BD/65248/2009.

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Special Session on AT Centres and Service Delivery Issues

Special Session on AT Centres and Service Delivery Issues

Session promoted by the G3ICT Global Network of Leading Assistive Technology Centres.

The advancement of AT in the world is highly determined by effective service delivery systems and practices, able to cater for the needs of the various stakeholders involved: persons with disabilities, professionals, policy makers, etc. Worldwide AT centres, intended as specialised resource centres play an important role in furthering AT knowledge, skills and outcomes. Although there are important differences in the national or regional context in which they operate, the share many concerns: how to enhance the role of persons with disabilities in service delivery, how to keep models of service delivery up to date, how to boost AT outcomes, how to transfer experiences from one country to another, how to adapt and localise outcome measurement tools in different cultural contexts, etc. This session will address some of those issues. Although the session is interesting for all AT expert, in particular AT Centres are invited to participate.

Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1059

The Employment of KWAZO with Parents of Children with Disabilities in an Italian Region: Preliminary Data on Scale Adaptation and Validation

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Abstract. *Introduction*: The World Health Organization (WHO) recognizes the fundamental role of assistive technologies in overcoming functional limitations of people with disabilities. Users' satisfaction with the provision of assistive technology (AT) service is a fundamental aspect of the AT service outcome evaluation process. To this end, the employment of validated instruments is recommended. *Objective*: to provide data about a preliminary validation of the KWAZO scale in the Italian context with a sample of parents of children with disabilities who use AT solutions. *Methodology*: the translation of the scale was performed by AT professionals operating at the Centre for Assistive Technology (CAT) operating in Bologna, Italy. A survey was conducted involving parents of children assessed for AT at the CAT centre in the period 2007-2012. The validation of the scale was performed in terms of content and face validity in order to evaluate its comprehensibility and usability. Convergent validity was also assessed employing the Italian version of the QUEST 2.0. *Results*: 34 parents completed the questionnaires. From the results, the content and face validity was confirmed. Correlation between the KWAZO and the QUEST 2.0 resulted satisfactory (Spearman correlation .66; $p < .001$). *Conclusions*: The Italian version of the KWAZO scale is a valid instrument for assessing the satisfaction with the service delivery from a user perspective. Further investigations are planned in order to assess its validity and reliability with a broader sample of AT users.

Keywords. UN Convention, Service Delivery, Outcomes, User's Satisfaction, Instruments, Parents, Children With Disabilities.

Introduction

Although the Convention on the Rights of Persons with Disabilities (Articles 20 and 26) [11], the World Health Assembly resolution WHA 58.23 [12] and the United Nations Standard Rules on the Equalization of Opportunities for Persons with Disabilities all highlight the importance of assistive technology (AT) [9] in compensating the functional limitations of people with disabilities, Lenker and colleagues [14] note that "the effectiveness of AT solutions and the services involved in providing them (e.g., assessment, fitting, and training) is not well supported by rigorous research evidence" (p.59). To bridge this research gap, European AT professionals have recently been encouraged to employ shared and validated instruments for assessing the

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outcomes of AT solutions and the quality of AT related services [1]. Several instruments have been developed for the evaluation of changes produced by AT solutions in the lives of users and in their environments [10,13,16]. In contrast, few instruments are available for evaluating users' satisfaction with the quality of AT services [2].

The concept of user satisfaction is central in the assessment of quality of care. Research in the field of AT considers user satisfaction as a bidimensional construct [15], comprising a) the satisfaction with the AT solution, and b) services for AT provision [15]. In the present study we will focus on user satisfaction with AT related services.

The measurement of user satisfaction with AT services is hampered by a lack of well validated instruments [2]. The KWAZO ("Kwaliteit van Zorg"; "Quality of Care") [2] scale is becoming a widespread tool for measuring the level of satisfaction with the service provision. It measures the quality of the AT service delivery from a client's perspective. It has been validated both in Dutch [2] and Finnish [3] with an adult population. However, no data are available about its use with parents of children with disabilities who use AT devices and cannot answer the questionnaire autonomously.

The objective of this study is to provide data about a preliminary validation of the KWAZO scale in the Italian context with a sample of parents of children with disabilities.

Methodology

Instrument. KWAZO [2] is composed of seven questions, each addressing specific criteria for quality of care found in literature and in the Horizontal European Activities of Rehabilitation Technology (HEART) study [4]. The respondent is requested to rate his/her degree of satisfaction with each criterion on a scale from 1.00 to 3.00 ('insufficient', 'sufficient', and 'good').

Translation and adaptation of the scale. The translation and adaptation processes of the KWAZO scale followed a modified version of that described in [3]. In a first meeting, three AT professionals (one AT technician, one social educator, and one PT/OT) working at the CAT centre, all familiar with English, met in October 2012 and were introduced to the framework behind the development of the scale by the principal investigator (LD). The three AT professionals were requested to read and translate independently the English version of the KWAZO. The different translations were then matched and discussed by the group in order to develop a single Italian version of the KWAZO scale. A final discussion about the acceptability of wording in the Italian context was conducted and changes to the final version of the scale were made following the discussion.

Content, face and convergent validity. Once the final version of the scale was ready, a survey was conducted starting from November 2012. The participants were selected from the database of the Assistive Technology Centre (CAT), which operates in the municipality of Bologna, Italy, and the catchment area considered in this study covered the Emilia-Romagna region. Inclusion criteria were: parents of children with congenital disabilities (e.g., cerebral palsy, muscular dystrophy, spinal muscular atrophy), aged 0-17 and assessed by the CAT service in the period 2007-2012 for at least one of the following typologies of AT: access solutions for information and communication technology (ICT-AT); augmentative and alternative communication (AAC); literacy (adapted books); and toys adaptations. The principal investigator first contacted by phone the parents of selected children, to explain the aim of the research and ask for their willingness to participate in the study. The parents who accepted to participate were given the possibility to decide to fill the questionnaires either on a paper form sent through ordinary mail or through a web form sent by email. This mixed-mode design allowed to reduce the coverage bias and complete the survey at reasonable costs [4]. Content and face validation were assessed by asking the users to answer, at the end of the KWAZO scale, to two "yes-no" questions: "Did you find any difficulties in understanding the previous questions?" (content validity); "Do you think the questionnaire is suitable for exploring your satisfaction with the AT service?" (face validity). Respondents were given the possibility to explain their answers on blank spaces. Convergent validation was evaluated to assess whether the construct behind the Italian version of the KWAZO scale correlates with a well-validated tool assessing, partly, the same construct [6]. To this end, we asked the respondents to answer to the four questions of the Italian version of the QUEST 2.0 [7], which address the user's satisfaction with the AT related services, on a scale from 1.00 to 5.00 ('not at all satisfied', 'not satisfied', 'more or less satisfied', 'satisfied', and 'very satisfied').

Analyses

A Spearman correlation was calculated between the total score of KWAZO and the summed scores of the four items of the QUEST 2.0. The level of significance was set at 1%. Analyses were conducted with SPSS 17.0.

Results

Translation. Some changes were made to the original wording of the scale. The term "service delivery" in items 1 to 4 has been translated with the expression "Services related to the AT process" (Italian: "Servizi legati al percorso ausili") because the latter is more frequently used in common language. The term "application" in item 2 was exchanged with the term "AT process" (Italian: percorso ausili). The term "assistive device" in items 6 and 7 was exchanged with the more general "assistive solution" (Italian: "soluzione assistiva") which refers to a broader set of possible assistive interventions, not restricted to assistive devices only.

Content, face and convergent validity. A total of 62 questionnaires were sent and 34 (54%) were returned. The characteristics of the sample involved are illustrated in table 1. On average, the age of children at the time of the consultation was 10,7 (±4,3) and the time elapsed between the consultation and the survey was 3 years (± 2,2). Overall, content and face validity resulted satisfactory. None of the respondents reported any comprehension problem in reading the scale and none of them indicated an incomprehensible item wording. Only 2 of 34 respondents (6%) indicated that they found the questions not suitable for exploring their satisfaction with the AT service delivery process. Only one of the two left a comment, indicating that more space for writing personal comments and impressions below each item of the scale would be needed. Spearman correlation is .66 ($p < .001$).

Table 1. Characteristics of the sample recruited for the Italian validation of the KWAZO.

Sample (n=34)		n	%
Gender	male	15	44
	female	19	56
Survey version	paper	5	15
	web	29	85
Type of recommended device	ICT-AT	25	64
	AAC	10	26
	Adapted toys	3	8
	Adapted books	1	2
Geographic area	urban	27	80
	rural	7	20

Conclusions and Planned Activities

In this study we adapted the KWAZO scale for assessing the users' satisfaction with the AT service delivery process conducted in an Italian region. In particular, we focused on responses given by the parents of children with disability. From the results of the adaptation to the Italian context, some modifications were produced between the original version of the scale and the Italian version, although they did not impact the overall construct behind the scale. Overall, the Italian version of the KWAZO resulted comprehensible for the users and satisfying their understanding of the "AT service delivery" concept. The convergent validity appeared to be satisfactory, proving that the Italian version of the KWAZO assesses different aspects of the same construct as that of the QUEST 2.0. Taken together, these results demonstrate that the KWAZO is a valid tool for the Italian context also.

The AT service delivery is a complex and articulated process usually involving different actors as well as health and social agencies. A way to overcome differences in the AT service provision both between and within countries is to use validated and shared instruments in any aspect of the service delivery process [8].

The KWAZO scale is a valid, reliable and straightforward tool to be used in the AT service delivery outcome assessment, and in this study we provided preliminary data on the feasibility and validity of its employment in an Italian context. An extended investigation of the validity and reliability of the scale with different users' groups is planned.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1064

Individual Assessment for Assistive Technology Solutions: Reflections on a Thirty-Years Experience

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Abstract. Individual assessment for assistive technology solutions (AT) is often carried out as a specialist consultation in Assistive Technology Centres (ATCs). The SIVA service of the Don Gnocchi Foundation was the ATCs pioneer in Italy: over 30 year of activity it offered about 23.000 individual consultations to clients from all over the country, and developed methodologies and protocols for provision of this service. It also established a national AT information system – first as a local database, then as a web Portal (Portale SIVA) that later was the initiator of the European Assistive Technology Information Network (EASTIN) – and various educational initiatives including a Postgraduate Course and a permanent educational programme composed of monthly Seminars. These activities helped disseminate AT knowledge to end-users, health care professionals, industrialists and policy makers; contributed to the establishment of other ATCs throughout Italy; they also led to a gradual change in the profile of clients applying for individual consultation. As time evolved, the clients' requests tended to be more focused and complex, as answers to simpler problems could be more often found in their community services, or in local ATCs, or even online through the SIVA and the EASTIN portals. This article offers a retrospective look at this thirty-years experience, which in turn is divided into three ten-years phases: the "pioneer" age (1983-1992, in which the service gradually took shape), the "maturity" age (1993-2002, in which the service operated as a self-standing Unit with nation-wide scope) and the "integration" age (2003-2012, in which the service was up-taken by the clinical rehabilitation services of the Don Gnocchi Foundation). Evolutions in the clients' profiles, in the topics dealt with and in the organisational models, are discussed and correlated to the parallel evolution of the information system and the educational activities.

Keywords: AT assessment, AT Centres, AT Infomation Systems, AT education.

1. Background

In good practice, individual assessment for recommending appropriate assistive technology solutions is part of the rehabilitation treatment or of the educational programme: in health or social services it is often included in occupational therapy programs, whether in hospital or community care setting. However, it often needs to be carried out as a *specialist consultation* in an Assistive Technology Assessment Centre (ATC), especially for complex cases when inter-disciplinary competence and trial equipment are required [1]. Of course ATCs are useful also in simpler cases when a

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client needs orientation or assistance in choosing assistive solutions that are not directly linked to a rehabilitation or educational programme, or when professionals need specialist support or supervision in working for their clients. ATCs are often places where AT educational activities for professionals or users are held.

The SIVA service in Milano was the ATC pioneer in Italy. Over 30 year of activity it offered about 23.000 individual consultations to clients from all over Italy (***figure 1***), and developed specific methodologies and protocols for provision of this service. Looking back at its history, by and large SIVA's experience can be divided into three ten-years phases: the ***"pioneer" age*** (1983-1992, in which the service gradually took shape), the ***"maturity" age*** (1993-2002, in which the service operated as a self-standing Unit with nation-wide scope) and the ***"integration" age*** (2003-2012, in which the service was up-taken by the clinical rehabilitation services of the Don Gnocchi Foundation and eventually was integrated within the Occupational Therapy Service).

This article briefly discusses the evolutions over time in the clients' profiles and in the topics dealt with, along with the parallel evolution of the information system, of the educational activities and the public awareness of assistive technology.

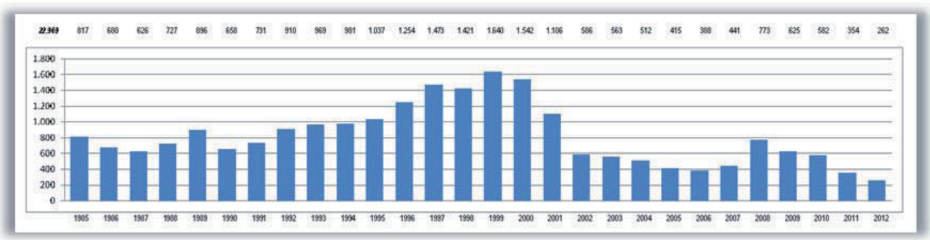

Figure 1: Overview of the number of consultations per year provided by SIVA from 1985 to 2012.

2. The "Pioneer" Age (1983-1992)

The SIVA concept was launched in 1981 by the Don Gnocchi Foundation, a major private non-for-profit Institution providing rehabilitation and care services to people with disability all over Italy. The initial idea was to just create a computer-based information system on assistive technology products (the first one worldwide, along with the US Abledata system that also took wing in that period [2]). However, soon it became evident that a database – also considering the computer technology available at that time – was not sufficient to meet the information needs of people with disabilities and of professionals working in the field. As soon as the rumour spread out that an AT database was being created, a lot of people in need of information showed up. After some time spent in learning from experiences abroad, the Foundation decided to establish an AT assessment service, equipped with qualified personnel and a permanent AT exhibition, which was officially opened at end 1982.

At that time, the database was running on a VAX mainframe computer, and the contents was kept up to date by the same team who responded to the clients' questions.

In 1985 the consultations started to be systematically registered in a database. This database clusters the consultations round six categories:

- phone consultations;
- mail consultations (of course, only by post at that time);
- on-site simple consultation (*simple* stands for *involving just one consultant*);

- on-site complex consultation (*complex* stands for *involving a multi-professional team*);
- home consultations;
- educational consultations (including visits to the exhibitions, consultancy to technicians, companies, researchers etc.)-

In this period, ***6040*** consultations were provided free-of-charge, most of them being “on-site simple” (about 40%), followed by “phone” (23%), “mail” (22%) and “on-site complex” (17%) (***figure 2***). The top four subjects were mobility (23%), appliances for home adaptations (16%), communication (14%) and general or legislation information (also 14%). Most clients were relatives or friends of persons with disabilities (26%), followed by therapists or medical-allied professionals (18%), social workers (11%) and persons with disabilities themselves (10%). Other clients included medical doctors, teachers, officers of public or private institutions, technicians, students, industrialists. The majority of the clients came on their own initiative (62%): only a minority were referred to by private Institutions such as user organisations or private rehabilitation services (12), or by public Health Institutions (10%).

Most clients (57%) came from the Region of Lombardy, where the service is located; however there was also a high number of clients from other regions (41%), as no other similar service existed in other parts of Italy (with the exception of Ausilioteca in Bologna, established in 1989).

Pionieer age (1983-1992)		
Phone consultations	1375	*22,76%*
Mail consultations	1307	*21,64%*
On-site simple consultations	2294	*37,98%*
On-site complex consultations	1004	*16,62%*
Home consultations	23	*0,38%*
Other consultations	37	*0,61%*
Totale	***6040***	

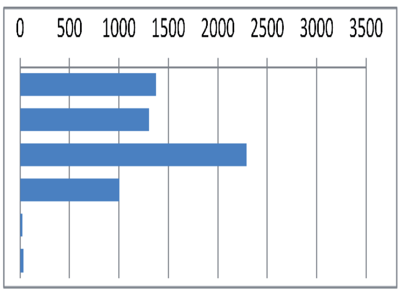

Figure 2: Overview of the consultations provided in the "pionieer age".

The increasing demand for AT information – a subject that was almost unknown at that time, even by rehabilitation professionals – suggested to initiate educational courses to disseminate AT knowledge nation-wide. The first Course (24 hours) was held in 1985; other courses followed every year with more extended duration. In 1992 the Course (titled “AT Fundamentals”) had reached 60 hours. Along with the migration of the database from the VAX mainframe to personal computer (DOS operating system) – which made it possible to copy out the database to other computers by means of floppy disks – this created the basis for the establishment of new ATCs by the Don Gnocchi Foundation in other regions of Italy: first in Torino, then in Salerno and Roma.

As time evolved, the team grew bigger and the service was moved to a new building. This gave the opportunity to re-design the new AT exhibition, taking advantage of the experience gained in the previous years. The exhibition was organised as a 130 m^2 open space, with flexible furniture and appliances that allowed simulation of all most common living environments.

3. The "Maturity" Age (1993-2002)

In this period, a structured methodology for AT assessment was gradually developed through a number of iterations, each including literature surveys, comparison with foreign experiences, retrospective analysis of "difficult" consultations carried out, and design / field trial / validation of new protocols. Besides improving the effectiveness of the service provided to clients, this provided further stuff for educational activities. In 1990 SIVA started a permanent educational programme composed of monthly Seminars held first in Milano, since 1995 duplicated in Milano and Roma, and since 1999 extended to other seats via audio conference. In 1999 an agreement with the Milano Catholic University was signed, that gave birth to the *Assistive Technology Postgraduate Course* featuring a 200 hours programme whose contents was somewhat similar to the US *AT Practitioner Certificate* [3]. Since then the Course was held every year, and it is still unique in Italy.

Another key feature of this period is the dissemination of the database to many other Institution throughout Italy, upon subscription of an annual fee. Indeed the addition of product pictures, the new distribution medium (CdRom) and later the migration to Windows (1999) had made the system more appealing outside. This helped several new ATCs to take wing throughout Italy on the initiative of user organisations, school authorities, rehabilitation centres, and in some cases also public Health authorities. In 1996 the GLIC national association of AT centres was created.

In this period, ***11.580*** consultations were provided (***figure 3***). Those addressed at end-users, health care professionals and students were free-of-charge, while a fee was introduced for clients from companies. As opposite to the "pioneer age", most of them were "phone" (about 27%), followed by "mail" (23%), "on-site simple" (23%), and "on-site complex" (20%). Almost like in the pioneer age, the top four subjects were mobility (20%), communication (17%), general or legislation information (13%) and appliances for home adaptations (13%). Again most clients were relatives or friends of persons with disabilities (31%), however persons with disabilities themselves had a significant increase (22%), overtaking therapists or medical-allied professionals (14%), teachers (7%), medical doctors (also 7%) and social workers (5%). The majority of clients came on their own initiative (50%). In comparison to the previous period, there was a significant increase in clients referred by private Institutions, such as user organisations or rehabilitation centres (19%).

Maturity age (1993-2002)		
Phone consultations	3167	27,35%
Mail consultations	2938	25,37%
On-site simple consultations	2927	25,28%
On-site complex consultations	2261	19,53%
Home consultations	65	0,56%
Other consultations	222	1,92%
Totale	***11580***	

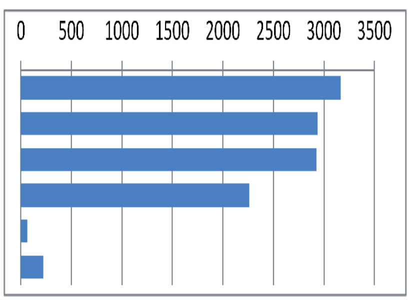

Figure 3: Overview of the consultations provided in the "maturity age".

4. The “Integration” Age (1993-2002)

In 2002 an internal re-organisation led to separating the AT assessment service – which was integrated within the Foundation’s medical rehabilitation services – from the other former SIVA’s activities such as the national AT database, the educational activities and the research projects – which were incorporated in the Research Department (later called “Polo Tecnologico” or “Biomedical Technology Department”).

Thanks to a grant of the Ministry of Social Affairs the AT database was completely re-designed for the Web and the new national AT Portal took wing (Portale Siva, www.portale.siva.it). Later on, thanks to a grant from the European Commission, the EASTIN Web Portal (European Assistive Technology Information Network, www.eastin.eu) was created, by aggregating within a single multilingual engine all major national AT databases existing in Europe. The migration to the web meant making AT information accessible to all citizens; thus the system – that initially had been intended chiefly for professionals and AT specialist – was now addressed at a wider audience, including people with disabilities and their families.

In parallel, the Foundation was working at the new Occupational Therapy Department, called “DAT”, which stands for Domotics (smart home), AT and Occupational Therapy. It was officially opened in 2008; it incorporated the AT assessment service, along with a new AT exhibition and a fully equipped smart home, thus providing the favourable context for a better integration of AT assessment and training activities within comprehensive individualised rehabilitation programmes.

At the same time, the Foundation decided to establish ATCs also in ten other centres throughout Italy, thus giving birth to the SIVA network.

These changes yielded major impact on the clients’ profile of the Milano AT assessment service. The remarkable reduction of number of client per year in this period (***figure 4***) seems paradoxical in relation to the increased resources available: the reason lies in the Foundation’s decision to concentrate on the clients looked after by its own rehabilitation department, whether inpatients or outpatients, rather than on external client applying for just an AT consultation. This decision is related to the priority given to clients with severe disabilities, and to the fact that going through medical intake allowed to include AT assessment within the rehabilitation treatment package, as such paid the National Health Service with no fee by the individual client.

Integration age (2003-2012)		
Phone consultations	1812	*36,87%*
Mail consultations	198	*4,03%*
On-site simple consultations	2028	*41,26%*
On-site complex consultations	694	*14,12%*
Home consultations	8	*0,16%*
Other consultations	175	*3,56%*
Totale	***4915***	

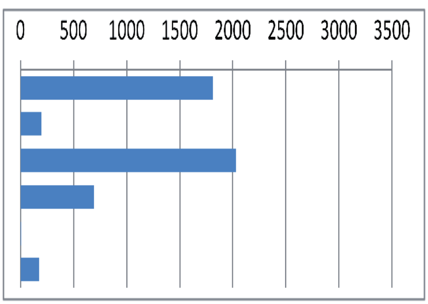

Figure 4: Overview of the consultations provided in the "integration age".

In this period, ***4.915*** consultations were provided (***figure 4***). In comparison with the previous periods, consultations by "mail" (or e-mail) almost disappeared (4%); those by "phone" were still a significant amount (37%) but since 2010 they dropped down; the majority were "on-site simple" (41%) while 14% were "on-site complex". The staff reports that most people who contact the service over the phone look more knowledgeable on AT than in past years: they may have already visited the SIVA Portal, or been at another ATC, or consulted local health professionals who have better AT knowledge than in the past; they ask precise questions on issues they have already thought about, or require intake because of a complex problem that didn't find appropriate answers locally.

Concerning the subjects of the consultations, the great majority refers to mobility (31%) followed by communication (15%), appliances and furniture for home adaptations (15%) and general/legislative information (8%). Most people ask for an AT consultation on their own initiative (49%), however there is a increasing number on the initiative of professionals of the Foundation's clinical department (37%). Children (14%) and teenagers (15%) still prevail, however the majority is distributed across the adult and older age, with a significant increase in the >80 (6%). As opposite to the previous periods, the majority of clients are persons with disability themselves (37%), followed by family members (34%).

5. Conclusions

There is little room in this article for an in-depth analysis of this retrospective look. However, three quick considerations can be inferred on the overall impact of the SIVA activities at both local and national level. First, a significant evolution can be observed in Italy in these thirty years in relation to AT awareness by both the general public and the professionals: the SIVA experience – with its AT database and Portal, its educational programmes, its assessment service and related methodologies – has been a major protagonist of this evolution. Second, the three-tiers approach adopted – empowering end-users by disseminating *information*, providing *consultation* to help solve individual problems, spreading knowledge to professionals by means of *education* – has proved to be an effective strategy to exploit the AT potential in overcoming disability and increase participation. Third, the availability of a common knowledge base at national level (the AT database and the educational programme) has been of great help in supporting the establishment of other ATCs throughout Italy.

Acknowledgements

Thanks are due to all colleagues who worked at the AT assessment service during these thirty years. Special thanks to the colleague Antonio Caracciolo who helped analyse the data.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1071

Using Impact Measurement to Establish Confidence in Emergent Assistive Technology Services - First Phase Translation of the PIADS Outcome Measurement Tool for Implementation in an Arabic Context

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Abstract. For a fledgling Assistive Technology service seeking to establish multi-stakeholder credibility during its early development, the use of a valid, internationally recognized and easy to implement Outcome Measurement tool can be a valuable instrument to gauge the impact of intervention.
This paper reports on the process of identifying an Outcome Measurement tool for the Mada Qatar Assistive Technology service and how the identified tool was translated for use with and by Arabic speakers. Furthermore, the initial results of a wide ranging satisfaction survey of the translated product are also presented alongside the plans for future validation and reliability testing in the context of AT service delivery in Qatar and more broadly in neighbouring Middle Eastern countries.
Finally the value of localizing and translating an outcome measurement tool that captures the impact of assistive technology at an individual level is discussed alongside some of the barriers that may be faced by future such studies.

Introduction

The importance of measuring the impact of Assistive Technology (AT) services has been well documented in the literature [1, 2]. For many services, however the challenges of finding the appropriate measures, of implementing these correctly, gathering data in the required volumes and the multiple requirements of different stakeholders in the AT Process makes it difficult to implement with any sustainability. The process of outcome measurement for AT services is often considered an activity relevant to a service or organization that has been well established, has a mature process model and is seeking either internal or external validation from certain constituents within the service process[3].

For a new organization wishing to factor the establishment of a service level outcome measurement process there is a need for an instrument that can be easily embedded into practice, perhaps forming part of a regular review process post provision. In Qatar, Assistive Technology services have developed as an independent entity operating across all settings, needs and ages. The need therefore was to measure impact for the individual according to personal aspiration and goals.

Context of This Study:

The global population of native Arabic speakers is currently in the region of 300 million, with at least 5 million residing in Europe [4]. In June 2010, the State of Qatar opened the first Assistive Technology Center in the Arabic speaking world (MADA Qatar Assistive Technology Center) to promote the active use of Assistive and Accessible ICT as a mechanism to further the participation of people with a disability within society. The development of the center was an active response to the UN Declaration on the Rights of People with Disabilities [5] and a major goal of the center is to foster the development of Assistive Technologies that can support Arabic speakers both in Qatar and beyond.

Census figures recently published, suggest that there are 8699 registered disabled citizens in Qatar, which has a population of over two million [6]. However, international benchmarks would suggest 13-20% of population experience some form of disability during their lives.

To establish a new, national Assistive Technology Service model that could be comparable with International Standards was considered the primary objective of the Center. Establishing a robust and well validated outcome measurement system within the developing service model was considered a very important element. A number of well known Outcome Measurement tools were explored including PIADS, GAS, COPM, QUEST and MPT [7]. PIADS was chosen for translation into Arabic as it was relatively easier to administer, had been successfully localized into a number of other languages in the past and therefore, provided an international benchmark against which outcomes in Qatar could potentially be compared.

Methodology

PIADS consists of self reporting questionnaire that involves the respondent reading a list of 26 words or phrases that describe how using the technology may affect him/her as an individual [8]. Guided by previous translation work with PIADS [9], the process of translation was based on Guillemin et al's guidelines for adaptation and translation of health questionnaires across different cultures [10].

As such the first phase of translation was conducted by a focus group comprising of seven Assistive Technology practitioners who were fully bilingual in English and Arabic. The second phase of the process involved testing the draft translation with a representative sample of users (n=18). This involved a deviation from the process previously used by Demers et al in their previous translation to French. It was however felt, that this provided the opportunity to gain useful data regarding the language selected at a very early stage and to gain valuable qualitative data from the final target group of this outcome measurement tool. Stage three of the process involved conducting a "backward translation" of the new Arabic version of PIADS by the same translation group (n=6) and a new group of users (n=5) scrutinizing in detail the responses provided in translating from Arabic back to English.

The final step in the first phase translation simply sought to gather a larger volume of data regarding the satisfaction with the translation by a large number of bilingual Arabic and English speakers. To do this – an online version of the Arabic and English versions of the questionnaire were posted online and an accompanying 1 to 5 satisfaction index was added to each item. This was published online using Survey Monkey™, an online tool for creating questionnaires, surveys or polls (http://www.surveymonkey.com/s/piadstranslation).

During this final step in this process, a total of 50 responses from bilingual Arabic and English speakers were collected using the survey published online (as described above). The 50 respondents were not familiar with the field of Assistive Technology and did not have as much background knowledge as the original group of 11 AT professionals used during the original focus groups.

One of the main questions to be answered by extending the process of indicating satisfaction with the PIADS translation was to ascertain if problems emerged with the same areas, or whether the existing knowledge of AT professionals had any influence on their judgments regarding individual translations.

Results

The full results of this phase of the translation have been documented elsewhere [11] however it indicated the following constructs from the original questionnaire proved to be the most difficult:

Item #4. Adequacy
Item #10 Usefulness

This was indicated by the number of respondents seeking clarification or explanation of these words or phrases during the course of all focus groups.

During Phase 3 of this process, it highlighted discrepancies for the following items in particular:

Item 1: Competence
Item 4: Adequacy
Item 17: Quality of Life

It is interesting to note that item 4: Adequacy emerged again, but item 10: Usefulness did not emerge from the online respondents as a translation of contention.

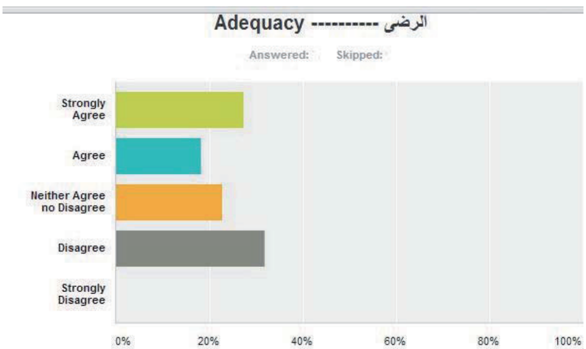
As can be seen from the aggregate of the online survey responses, on the translated Items number 1 and 4: Competence and Adequacy, there was a reasonable amount of disagreement for the translation offered ($> 21\%$ and $> 31\%$). There was also a high number of respondents scoring the translations neutrally (17% and 22%). Of all of the responses, the level of agreement with item 4: Adequacy was the lowest at around 46% - all other items scored above 60% with only three items scoring under 75% for a positive response to the translation.

These two items emerged as the main contentious translations, generally, in line with the feedback from the previous focus groups. As noted above, it is interesting to observe that item 10: Usefulness was not considered contentious during the online survey, and that item 1: Competence did not emerge from the Focus Groups.

Table 1: Responses for PIADS Translation Item 1.

Answer Choices	Responses
Strongly Agree	30.43%
Agree	30.43%
Neither Agree no Disagree	17.39%
Disagree	13.04%
Strongly Disagree	8.70%

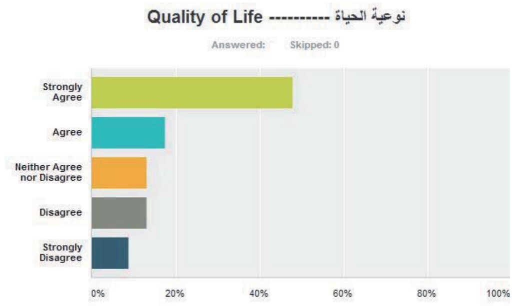
Table 2: Responses for PIADS Translation Item2.



Answer Choices	Responses
Strongly Agree	27.27%
Agree	18.18%
Neither Agree no Disagree	22.73%
Disagree	31.82%
Strongly Disagree	0%

One other area did however emerge as engaging negative feedback regarding the translation; this was PIADS item number 17: Quality of Life:

Table 3: PIADS Item 17: Quality of Life.



Answer Choices	Responses
Strongly Agree	47.83%
Agree	17.39%
Neither Agree nor Disagree	13.04%
Disagree	13.04%
Strongly Disagree	8.70%

As can be seen in Table 3 above the responses for item 17: Quality of Life, were generally favorable (65%), however following the previous items discussed this item was also considered contentious.

During focus group discussions, the Arabic translations for most of the above were agreed as being fairly close to the original English item if not an exact translation. It was agreed that with the help of the glossary provided with the PIADS questionnaire, the original English meaning could still be conveyed. However, there was strong disagreement with the translation of item 4 – Adequacy. In consultation with a professional translator, this was subsequently changed from "الرضا" to "القدرة على التحمل".

Following all phases of translation, the final version established for final testing with services users was as follows:

Table 4: Final Translation of Arabic PIADS.

Item	English	Arabic
1	Competence	الكفاءة
2	Happiness	السعادة
3	Independence	الاستقلالية
4	Adequacy	القدرة على التحمل
5	Confusion	الحيرة
6	Efficiency	الفعالية
7	Self Esteem	تقدير الذات
8	Productivity	الإنتاجية
9	Security	الأمان
10	Frustration	الإحباط
11	Usefulness	القدرة على الإفادة و الانجاز
12	Self Confidence	الثقة بالنفس
13	Expertise	الخبرة
14	Well Being	الشعور بأنك على ما يرام
15	Skillfulness	المهارة
16	Capability	القدرة
17	Quality of Life	نوعية الحياة

Table 4: Final Translation of Arabic PIADS (cont.).

Item	English	Arabic
18	Performance	الأداء
19	Sense of Power	الداخلية الإحساس بالقوة
20	Sense of Control	الإحساس بالتحكم
21	Embarrassment	الإحراج
22	Willingness to take chances	الرغبة في أخذ الفرص و التحديات الجديدة
23	Ability to participate	القدرة على المشاركة
24	Eagerness to try new things	الحماسة لتجربة أشياء جديدة
25	Ability to adapt to the activities of daily living	القدرة على التكيف مع أنشطة الحياة اليومية
26	Ability to take advantage of opportunities	القدرة على الاستفادة من الفرص الايجابية

Discussion:

Providing a transparent, internationally standardized measure for the impact of a new Assistive Technology service is imperative in the process of establishing stakeholder confidence during its development. There is an additional need to promote the use of the tool in other Arabic services to facilitate a wider sample of users through which trends can be identified and local strengths and weakness of services identified and addressed. In developing a tool for use, consideration of a series of issues needed to be taken into account:

- Concepts of successful outcomes may differ from culture to culture according to wider social norms
- Terminology and common usage may be radically different. For instance the translation of assistive technology does not carry the specific nuance and meaning recognized in English
- The debate around “People first” may not have meaning in other languages
- Willingness to complete and respond to surveys may be different from community to community
- The definitions of disability may vary from community to community
- There may be a broader culture of non disclosure of disability and hence an unwillingness to enter into debate regarding accommodations and needs within some communities.

It is clear from the small sample size used in the translation survey (n=50), that a much larger sample group will be required to ensure that the translation is fit for purpose and can be used reliably within service delivery systems in the region. It is hoped to extend this sample size to around 150 or 200 bilingual speakers and to perform more robust analysis of the responses.

The issues around bringing the tool into use for Arabic speakers in Qatar, offers insight into the issues for wider surveys and tools for benchmarking internationally. It also suggest the range of cultural norms that may need to be accounted for in transfer to other community languages as well. It suggests most strongly that transfer of knowledge and experience from one community to another can be an effective model for development, but that full participation of the local community is essential to ensure that both language and culture are suitably accomodated

The experience of the transfer of PIADS to Arabic, along with the wider experience of localizing technology to support Arabic people with a disability has encouraged Mada to begin work on a guide to localization for assistive technologists. It is anticipated that first drafts of this will be available in Autumn 2013.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1078

Measuring the Impact of a Bespoke Engineering Referral Service

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Abstract. This paper describes the bespoke referral service which works with both therapists and users to customise or design one-off equipment for disabled adults and children. The aim is to show how the Bath Institute of Medical Engineering (BIME) has chosen and developed evaluation tools to measure the impact of this referral service; how this impact was achieved, and the outcome for the individuals. To assess the referrals received by BIME, they are screened against criteria to identify if the referral is feasible. User's requirements are identified through an initial assessment to create a novel design that will be manufactured into a prototype and delivered. It was felt the impact of the referral service would be reflected more effectively if more information on the outcome of the novel design was collected; therefore the referral form needed to be revised. Previous referrals success has been collated using a simple outcome measure which reports that these novel designs have been 99% successful in solving the initial problem. This demonstrates the positive impact this area of work has on people with disabilities who experience difficulty with individual tasks.

Keywords. Assistive Technology, Referral, Outcome Measure, Service Delivery.

Introduction

Disabilities vary from person to person and often standard off-the-shelf products do not address the needs of the user. The bespoke referral service at BIME assesses people's individual needs to create novel designs which vary from simple modifications of standard equipment to completely new designs. This helps maintain a high standard of care for both adults and children and provides the institute's designers with an insight into the kinds of problems the user's encounter. This enables and assists the designers when applying sensitive engineering design.

Referrals are received from both local and regional therapists, though the majority of referrals are received from the Royal United Hospital (RUH) and local hospitals. These referrals provide opportunities for many people living with a disability to improve their independence and quality of life by evolving solutions appropriate to the users' needs. The design of these one-off products addresses individual needs and could potentially benefit a larger number of users experiencing the same difficulties. In addition to the novel designs this service makes equipment more accessible to therapists, and provides both advice and expertise on equipment design and selection of available products.

A Study [1] "Rethinking Assistive Technology" highlights some observations of current state of practice of use of assistive technology and describes specific actions to improve the efficiency and utility of assistive technology. The study states that the outcomes of AT interventions are often not known, because of poor documentation. As a result there is little documented evidence of the outcomes. Edyburn asks what proof do we have to document a claim that a specific assistive technology is effective?

Another paper reporting on an assistive technology service [2], highlights how outcome measure tools must be valid, reliable and practical, and be implemented within a reasonable amount of time. Schien used a self-report questionnaire called Functioning Everyday with a Wheelchair (FEW) [3] to review assistive technology interventions with regards to the perceived user function. Schien describes FEW as a "criterion referenced, performance based observational tool used by practitioners and researchers to measure functional outcomes of seating mobility technology interventions". It was felt this outcome measure would not reflect the range of referrals received.

The Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST) user evaluation outcome measure [4] was considered for use in the referral service; however it was felt the criteria were too narrow and would not reflect the range of referrals received by our service; and its application would not be feasible in the time available at referral appointments.

From looking at these studies it was apparent the outcome measure we used to measure the effectiveness of the service should be valid, reliable, practical and be able to be collected within a reasonable time scale.

1 Background – Bespoke Assistive Technology Services

This section examines several other comparable services provided in the UK, and compares them to the BIME service.

MERU (the Medical Engineering Resource Unit) referral service has adopted to working with assistive technology for disabled children and supports its custom design and build service with the sale of a range of affordable products which are manufactured in-house.

DEMAND (DEsign and MANufacture for Disability) designs and manufactures bespoke equipment to help individuals of all ages with their everyday lives. In the same way as BIME they frequently find there are no 'off the shelf' solutions available for people with specific requirements and use standard operating procedures similar to BIME.

Each of these independent charitable services designs and builds one-off solutions to assist people with disabilities. They are similar in that they use a strongly user-centred iterative design process, and are substantially funded by donation. Products are designed and manufactured at the services' own premises.

BIME's service differs in its provision of a paid-for referral service which is available on demand and is not limited to smaller projects that can be funded from donated funds.

2 Methodology

Every week referrals are reviewed and screened against criteria to identify the feasibility of the referral within the capacity of BIME. Referrals are pursued if they meet the following criteria:

2.1 Criteria

1. Is the request available from any commercial source? If yes, then refer client to commercial solution.
2. Is the request technically feasible?
3. Is the request financially feasible?
4. Is funding available for the request?
5. Is there sufficient benefit to quality of life?
6. Does BIME have the ability to complete the request?
7. Does BIME have the capacity to complete the work in a reasonable time?

If the referral is accepted, a meeting is held with the client and their therapists to establish a detailed functional specification. A short series of prototypes are designed, built and evaluated with the user until the device is suitable for use [5]. The referral service has a standard set of forms with a checklist to produce an effective framework for impact assessment. It includes outcome measures which are used to assess the novel designs' impact on the users' everyday life.

Difficulties were experienced when choosing the outcome measures for this service, as they had to assess a wide range of customised devices for a wide range of specific needs, and be quick and simple to complete. Two measures are used: Goal Attainment Scaling [6] and a custom rating scale developed for this service.

2.2 Goal Attainment Scale

A common outcome measure used by physiotherapists and occupational therapists is the Goal Attainment Scale (GAS) [6]. This is a method of scoring the extent to which patient's individual goals are achieved in the course of intervention. Tasks are individually identified to suit the user, and the goals are individually set around their current and expected levels of performance.

2.3 Rating Scale

Another technique used to measure the effect of the intervention is a rating scale. This is a method by which a score is assigned to a set of criteria. For this rating scale three main areas have been identified to assess the intervention: task convenience, task independence and BIME Service. These assessment topics were difficult to choose as they were required to provide broad capacity for assessing a diverse range of referral types.

2.3.1 Task Convenience

This reviews the usefulness of the device, instead of its functionality it does not act as a leading question when assessing the intervention.

2.3.2 Task Independence

Task independence is a common topic used to review a user's progress with a new device. It is hoped that the device will increase independence and enable the completion of tasks to be easier for the user.

2.3.3 BIME Service

To reflect the quality of the work being provided by the referral service, it was felt a score needed to be assigned to assess the referral service before and after each referral. This was so that the assessments would provide evidence of the potential benefits to encourage other therapists to use this type of service.

For each of the rating topics the rating scale would be completed before and after the user had the device for a period of one month. A number is assigned to each of the topic areas using a scoring system where 1 is poor and 5 is excellent.

Table 1. Rating scale to be completed at the initial assessment and after prototype handover.

Scale	1-Poor	2- Less than Satisfactory	3- Satisfactory	4 – More than Satisfactory	5- Excellent
Task Convenience		Task Independence		BIME Service	
Before Referral	After Referral	Before Referral	After Referral	Before Referral	After Referral
1	1	1	1	1	1
2	2	2	2	2	2
3	3	3	3	3	3
4	4	4	4	4	4
5	5	5	5	5	5

3 Research and Development Work and Results: A Design Case Study

3.1 A Whole Body Stand to Support a Guitarist

3.1.1 User Requirements

A young man who had Friedrich's Ataxia, Cardiomyopathy and Diabetes. He was a wheelchair user and lived on his own in the community, and he could transfer in and out of his wheelchair independently. He loved playing the guitar but he was unable to stand and required a 'perching stool' to be able to play his guitar, however there was nothing suitable on the market which provided the required postural support.

3.1.2 Initial Assessment

At the initial assessment, an engineer and occupational therapist met with the user and their local physiotherapist, and the requirements of the guitar stand were discussed. The user's condition had resulted in muscle weakness in his arms and legs and he needed both trunk and ankle support to help him maintain his 'perching' position while playing his guitar. The frame needed to provide arm rests which could move posteriorly to enable him to transfer in and out of the stand. The user voiced that he would like the frame to blend into the background on the concert stage.

3.1.3 Intervention

The intervention designed consisted of a solid aluminium frame and an aluminium base that was fitted with a tread plate. The base plate provided ankle stability and foot support so the user could maintain his position. Attached to the base plate was a base clamp that held the aluminium tubing which was part of the main frame for the guitar stand. Cross clamps were used to attach a perching seat to the frame; a back rest with chest strap to provide trunk support; and arm rests which could be moved to allow for transferring in and out of the stand.

Following the delivery of the guitar stand a clinical decision was made that the user was not stable enough in the stand for him to use it independently. To fulfil the requirements to make the stand more suitable for the user the knee blocks recommended by the local physiotherapist were attached to the main frame using aluminium tubes which extended to the back of the knees where another cross clamp was used to create a ‘T’ junction. Four metal connectors were manufactured which were positioned on the T bar. Webbing was threaded through the metal connectors and the knee block and buckled on the outer side of the leg. Retaining pins were used on the end of the bar to prevent the metal connectors coming off. A metal buckle was used to replace the plastic buckle on the chest strap, and the cross clamps used on the backrest were rearranged to move the backrest backwards.

Once manufactured the guitar stand was returned to the user and upon arrival the user was transferred into it. He was able to comfortably maintain an upright position for forty minutes. It was agreed that the local physiotherapist and a band member would work with the user to help him practice transferring safely in and out of the guitar stand.

3.1.4 Impact on User

Two months following the delivery of the guitar stand, BIME received a letter from the local physiotherapists which only emphasised positive comments about the BIME referral service.

“Thank you for your support in enabling M to achieve his goal of standing to play his guitar. This prototype guitar stand is invaluable to him, not only physically but psychiatrically, and is used on a daily basis. I really thank you for your generosity in giving your time and expertise so freely. Your work is very much appreciated, and has certainly made a great difference to this young man’s quality of life.” Jane Tompsett, Rehabilitation Team Leader.

Although this case study demonstrates benefit to the user it is difficult to quantify the benefits without using the outcome measures which are now implemented. At the one month review the outcome measures will be used and documented to show this assistive technology custom device is effective.

4 Referral Service Statistics

In the past, the referral service has many types of referrals including abduction blocks, tricycle adaptations, oxygen cylinder brackets, seating and medical physics related projects. The effectiveness of these devices was reported using a simple outcome measure which collated limited information on the benefits of these previous referrals.

4.1 Simple Outcome Measure

Question: Has the device solved the problem(s) described above?
Answer (s)

- The problem is solved; The problem is partially solved;The problem remains. The equipment did not help.

This information collated on the past referrals shows these novel designs were 99% successful in solving the initial problems. This demonstrates the positive impact this area of work has on people who experience difficulty with individual tasks.

5 Conclusions: Impact of a Referral Service on the Field

A bespoke referral service can have a significant impact on people with disabilities who experience difficulty with individual tasks. As seen from this case study, it provides hope and positive thinking for people who have unfortunate circumstances as a result of things out of their control. This is one of many individuals who this service has had a positive impact on their quality of life.

It is expected the outcome measures we are using will capture this well as choosing the outcome measures was a difficult task; however, they seem to be effective in the referrals received by BIME to date. The referral form will be audited every 10 referrals to review the form could be designed more efficiently and to check whether there is any other data required to be captured. Clearly more than one case study will be required to validate the effectiveness of this bespoke engineering referral service.

Acknowledgements

I would like to acknowledge Martin Rouse for his active involvement within the referral service and putting the standard operating procedures in place.

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Special Session on Design for All and Mainstreaming in Ambient Assisted Living - The Role of Networking

Special Session on Design for All and Mainstreaming in Ambient Assisted Living

The Role of Networking

In eInclusion, as a first instantiation of the ambient intelligence paradigm, ambient assistive living (AAL) is in the focus of attention at the European level. Even if so far the main interest has been from the perspective of remote people's monitoring (e.g. of parameters connected to healthcare), alarm systems and environmental control by people with severe motor disabilities, recently, particularly for the explosion of the aging problem, there is a shift toward applications of support to any aspect relevant for independent living. This, in turn, has fostered the discussion about the possibility of mainstreaming at least some of the relevant technical innovations, both when they are foreseen as common characteristics of emerging technology and since some of the anticipated necessary developments can lead to improvements for all users, irrespective of their possible lack of abilities.

Due to the potential wide market of AAL, at least in terms of numbers of users, it is arguable that design for all can have an important impact, as a design methodology leading naturally to mainstream the identified solutions. Moreover, it appears that design for all and the following mainstreaming of systems, services and applications may be favoured by the possibility of identifying problems with a common approach and cooperatively finding and testing solutions. Networking interdisciplinary communities of people active in the eInclusion environment and end users can lead to significant improvements, not only from the perspective of identification of user needs and solution, but also toward the diffusion of information and creation of a common level of awareness necessary for building up consensus. Moreover, a more active participation can be envisaged e.g. with some sort of crowdsourcing.

The purpose of this session is first to discuss, with reference to a specific research and development field (Ambient Assisted Living) and, therefore, to specific experiences and results, the possible impact of design for all in producing valuable solutions for inclusion and independent living and the possibilities of mainstreaming these interesting solutions. Then, due to the important developments of networking in the society and particularly the new possibilities, also technological, for cooperation through the networks, it appears particularly important to consider their impact for support design and development in the AAL environment. From this perspective, it is necessary to start from the fact that in the Design for All environment, EDeAN (European Design for eAccessibility Network) has recently attempted to play the role of catalysing interest about these problems at a very general level. Therefore, a discussion of its possible role, starting from a specific application environment, seems also interesting, taking into account e.g. some possible modifications, such as adaptations of the rules for participation, the scope, the sustainability and, possibly, the technical infrastructure on which it is based.

Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1087

Abilities and Limitations of Assistive Technologies in Post-Stroke Therapy based on Virtual/Augmented Reality

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Abstract. The purpose of the research showed in this article, was to introduce an augmented and/or virtual reality technology and that how can it be applied in the healthcare, rehabilitation, in AAL[1]. This article shows, where some limitations using these assistive technologies are, and shows the state-of-the-art in this area.

Keywords. Post-stroke Therapy, Virtual/Augmented Reality, Ambient Assisted Living.

Introduction

Since 1960's multimedia technologies and together with this augmented reality technologies have been sufficiently highly developed. These technologies can be used in many areas in life, from research to healthcare, these can be widely used. A number of these applications can be found in teaching [2, 4, 6], rehabilitation [3, 5, 7, 8], and entertainment. This article focused on healthcare and on rehabilitation applications in post-stroke rehabilitation, especially in the home environment. There are real benefits of using AR[2] technologies in AAL. Users can learn, practise with native methods, but with AR technologies they can do some special tasks, too. There is an opportunity to use wide range of input and output devices in AR technologies in AAL, from the native control devices and indicators up to the brand new ones.

With the analysis of the developed VR[3] applications we wanted to focus on the usability of modern input and output devices in post-stroke therapy. For this we reviewed some articles from the international publications about this topic, and also the international results.

1 The Methodology Used

During the analysis of the VR applications used in home environment, like AAL applications, we wanted to put an emphasis, how the user can use the several devices on their own, as well as the input and output devices' ergonomics.

We focused onto the special user groups: stroke patients with several disabilities.

[1]AAL – Ambient Assisted Living
[2]AR - Augmented Reality
[3]VR – Virtual Reality

We also analysed whether the applied technologies could help the daily activities of the people with disabilities and that how useful is it to gain a greater self-dependence. It was investigated that which way and methodology can be applied by users to solve non-routine tasks with these assistive technologies.

2 The Research and Development Work and Results

During the research of the international publications we found several articles of using VR technologies for rehabilitation. Nearly all of the research results show that virtual, augmented realities, immersive technologies can be a new and efficient way for the therapy of post-stroke patients.

We can get a lot of information about using the applications from different articles, which have been looked up.

Despite these articles there is a relatively small amount of such articles which deal with the limitations of the usability of these technologies.

During our analysis we found several applications from all over the world that use most of the devices according to the opportunities and the development of their technologies. They use input technologies, handled and hands-free devices as input controller, optical sensors; for visualization they use HMD device, visualization with projection technology, meanwhile offering audio and tactile feedback.

We examined the following applications during our research:

- GOET project (Game on Extra Time) [10]
- StrokeBack project (Telemedicine System for Stroke patients) [11]
- Limbs Alive [12]
- GReAT [13]
- ATRAS [14]

We also analysed that in post-stroke therapy how can the different limitations and the loss of skills be treated with the help of sensor and visualisation devices, and we tried to compare their effectiveness.

The differences between using 2D and 3D virtual realities have also been analysed.

3 Results of the Analisys

A GOET – Games on Extra Time project is not typically dealing with the rehabilitation of stroke patients, but is a good example, how can a development system containing interesting interactive games with full experience can be an efficient help for e.g. for children with learning disabilities, i.e. a special age group dealing with several disabilities for the organizing of daily activities.

The LimbsAlive, a project which started in 2010, specialises in the rehabilitation of the hand and arm for people of all ages who have hemiplegia, often through stroke. LimbsAlive project focuses on developing two handed skills – essential for independence.

The GReAT research project is to investigate the use of technology in gesture therapy for people with aphasia (a communication disorder that occurs after stroke).

The ATRAS project was founded to develop an integrated service model incorporating innovative technology for the rehabilitation of the upper limb, following stroke.

The stroke patients are exposed to a bigger psychic load than the 'healthy' user group, because of their obvious restrictions of motion. They can feel frustration or shame, just because they are not capable to do general daily routine activities because of their illness. This is the reason why the introduction of a new telemedicine based method into the treating process of post-stroke therapy is such an important question. As previous studies have already proved, using VR based environment and modern technical devices for the rehabilitation of post-stroke patients, can be an expense effective solution besides the conventional therapies.

After training for two-three hours a day for eight days, all of the patients showed increased control of hand and arm during reaching. They all had better stability of the damaged limb, and greater smoothness and efficiency of movement. Kinematic analysis showed that they also had improved control over their fingers and were quicker at all test tasks. In contrast their uninjured arm and the arms of control game players' group, who had normal hand/arm function, showed no significant improvement at all.

Dr Alma Merians said, "Patients who played these games showed an average improvement in their standard clinical scores of 20-22% over the eight days. These results show that computer games could be an important tool in the recovery of paralysed limbs after stroke." [1]

In the case of using telemedicine systems in the therapy process of patients in home environment, a great part from the sources of psychic problems, arising after the illness, could be avoided. If the patients are practicing the kinesitherapy tasks, which are necessary in the development of upper limb coordination process investigated by us, in their own, well-known environment, which provides them the feeling of security than the efficiency of the therapy can be increased. In some of the previous studies dealing with the application of VR technologies have a promising future.

From the applications mentioned above we investigated the StrokeBack telemedicine system, we tested the application with stroke patients and a 'healthy' control group. With the help of the control group we also examined the previously mentioned spiritual surplus load. Our aim of investigation was to find out how can the patients become acquainted with the therapy application used for home rehabilitation, and how are they able to accept new opportunities gained by the new information technology devices. With the help of the control team we could test the usability of the programs.

Playing with the games found in the rehabilitation applications did not cause any problem for the so-called 'healthy' control group; they found the using of the game learnable, the surface manageable and sensible, appropriate. According to the tests of the 'healthy' control team the difficulty level matches the aims of rehabilitation and therapy.

The tests of stroke patients were made in clinical environment under the supervision of their therapists. All of the tested stroke patients have shown limited movement of upper limb(s) as the consequence of stroke. In their case the usage of traditional input devices, like keypad or mouse, was too difficult for control of the games. With them we used a special touch device looks like a touchpad which was developed for them. Further plans contain the testing of using optic sensors as input devices, which do not have to be held in hand. For this we will use a web-camera with a minimal hardware requirement and Microsoft Kinect sensor for the testing of games.

The results of our tests so far have shown that the patients used the new therapy device gladly, and all of them thought that in the case they do not need further personal monitoring by the therapist, and if they had the chance to choose, they would rather choose home therapy.

During the testing and the personal interviews with the therapists we have also found out, that using 3D technology in the rehabilitation of stroke patients is not appropriate, because for the patients who have co-ordination disorders the usage of different environment, which is a sensible world in its depth can be confusing for them. The usage of 2D applications for these patients did not cause any problems for the patients participating in the tests.

Another important question was the patients' opinion about network communication. The patients did not usually have a special qualification in informatics, but they have already used computer and they were familiar with using Internet. Stroke affects the elderly primarily, but the Design for All, the framework and the games with rehabilitation aims were made taking development and designing viewpoints into consideration, because of this the acquisition of its control does not cause any problem for the participants of the test. Those, who have already used computer and know the technique of using it, are using the new type of therapy safely in the technical environment.

The internet provides the opportunity of remote supervision, which can largely facilitate the work of the specialized hygienic staff, and more patients' therapy may be supervised at the same time. The virtual presence of the therapists does not disturb the home environment of patients, because during playing the games there is not an active, visible contact, but if necessary, the patient may initiate this contact.

4 Conclusions

In our study we have reviewed the some of the applications based on augmented reality and applicable to AAL, within the stroke rehabilitation was in focus. The StrokeBack application introduced is the best examples to demonstrate, what kind of input and output devices can be used for the several sake of the cause. In the 'ambient assisted living' tools we found some, these were developed and applied for user groups with special needs, and we have found many amazing applications, these were produced for all users. As a final result, several other researches should be taken to analyse how frequently and in what scale do the several impairments appear together after stroke; how these appearances of damages can influence the available usage of virtual/augmented reality technologies; and whether it could mean a limitation that can affect the results and efficiency of the rehabilitation. Considering plural damages, it should be tested, whether the generally used therapy application can occupy the function or whether it should be complemented with such input and output device that can solve and unlock the limitations of usability. Between the further development tasks belongs to create a program with such devices, that are applicable for everyone, that can define its role in rehabilitation and besides the game should keep their original aim, the game experience should remain.

It is especially important to create application during the development that can be used by everyone, because after the clinical rehabilitation process, after leaving the clinic the patients' state is deteriorating. This can be because problems in the strain of regular appropriate treatments is not solved, the reason of which can be the patients' inappropriate moving skills on one hand, or the unavailability or low, inadequte quantity of therapies.

A well-planned and properly prepared home care-system is able to overcome these barriers, in which the central role is the patients', the most important aim is the time of the recovery, the repossession of the lost abilities, the corrections to be done under the shortest time, which will be the necessary device and a part of maintaining the adequate quality of life.

Acknowledgements

Special thanks to Ms.Erika László for making and evaluating software tests.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1092

Working Internationally to Meet the Academic Needs of Accessibility Professionals

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Abstract. Middlesex University has recently launched a new qualification, the Post Graduate Certificate, Professional Practice in Design for Diversity in Information and Communication Technology. This programme replaces the MSc Digital Inclusion which was launched four years ago and has been withdrawn due to lack of interest from potential students. The aim of this paper is to address the design and management decisions which went into the creation of this new programme and the way in which the academic community can support students who wish to learn about accessibility whilst holding down difficult jobs and working as figureheads in the accessibility field. Both the MSc Digital Inclusion and the Post Graduate Certificate Professional Practice in Design for Diversity in Information and Communication Technology were based on content created from within the EDeAN: European Design for all eAccessibility Network. This on-going collaboration should enable the material to be of a suitable quality, suitable depth and fit for purpose to enable the graduates to practice as accessibility professionals in both Europe and the USA. It will enable the students to understand both the technical and user benefits of solutions such as ambient assisted living as well as the relevant ethical and business case.

Keywords. Design for Diversity, Work Based Learning.

Introduction

The MSc Digital Inclusion was created with the help of EDeAN at the behest of the EU e-inclusion unit, EDF - European Disability Forum and Digital Europe (the European Information & Communications Technology Industry Association). It was designed to meet the perceived need for experts in accessible technology. Unfortunately in spite of being highly praised (amongst other things it was nominated by the British Standards Institute for the 2011 ISO (International Standard Organisation) Award for Higher Education in Standardization) [1] it did not recruit sufficient students to remain financially viable..

One reason for the lack of students was the difficulty that potential students who were working as accessibility champions had in working on a part time MSc and a full time job whilst acting as experts in their chosen field. Changing the course to a work based learning one appears to therefore make sense to our prospective students.

1. Work based Learning

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In 1996 Middlesex University won a Queen's Anniversary Prize for Higher and Further Education for its development in Work Based Learning Studies, and in 2005 the Higher Education Funding Council for England designated Middlesex University as a Centre for Excellence in Teaching and Learning in Work Based Learning. Work Based Learning (WBL) is defined as “a student learning for credit designed to occur in the work place or in on-campus settings that emulate key aspects of the work place” [2]. The topic of Design for All or Design for Diversity is an obvious one for a WBL approach as both the potential students and the staff (in their consultancy and research) are working on new developments within the field and are committed to the changing the way technology is designed to benefit older and disabled people. WBL is based at Middlesex University in the Institute for Work Based Learning [3]. The new Programme in Design for Diversity is designed to meet the needs of students who wish to gain knowledge to support them in their work. It is assumed that the students will be working in fields such as Web Accessibility, Ambient Assisted Living or Mainstream Design. Professional Practice and Work Based Learning Studies qualifications are especially designed for those that want to develop their expertise within their current profession. The Design for Diversity in ICT course is intended to meet the needs of all ICT professionals and accessibility experts who wish to broaden their experience and gain recognition for their skills and expertise. The WBL Institute will provide the structure and administration of the course whilst the Design for All Research Group in the School of Science and Technology will provide the course content and curriculum. The networking links of the research group will enable access for the students to the wider field of professional researchers and professionals.

The WBL model has benefits for the students and for the employer. All academic work is linked directly to a student’s employment with examples and case studies provided by their work, they should therefore find it easier to complete their studies and to cope with the time pressures of studying and working. The financial cost to the student can also be less. The employer can also benefit from the adoption of an academic thoroughness and new insights into work procedures, although these approaches are not always welcomed by the employer [4], it is thought that the developing field of accessibility and Design for All should be able to benefit from employer and academic partnerships.

2. Post Graduate Certificate Professional Practice in Design for Diversity in Information and Communication Technology

The modules of the new WBL Post Graduate Certificate Professional Practice in Design for Diversity in Information and Communication Technology are based on the requirement for the students to understand the needs of end users of technology and the context of this work (both mainstream and assisted living). The modules will refer to the gap between people with effective access to digital and information technology, and those with very limited or no access at all. They include reference to the imbalance in physical access to technology, the resources to access it and the skills needed to effectively participate as a digital citizen. Students will study three modules:

- Design for All Context - Human Rights
- Design For All Research Principles and Best Practice

- A Negotiated Work Based Project.

All modules are taken using an on-line virtual learning environment. The modules enable the students to identify and practice high quality methods for designing ICT systems and products that meet the needs of all digital citizens.

The programme aims to enable students to have the relevant knowledge, personal and professional skills & competencies to design, understand, evaluate and manage a wide range of ICT systems products and services that adhere to the principles of social inclusion and to understand the ethical and political underpinnings for this work. In the current climate of sustainability there is an increasing need for experts who can insure that system products are accessible and usable. This course will be relevant for all ICT professionals, designers of ICT and policy and strategy leaders in larger company's, corporations and charities.

3. Teaching Approach

The teaching and curriculum design for this course will be supported by the networking, consultancy and research activities of the Design for All Research Group. The links to the wider Design for All environment (and especially to EDeAN (European Design for eAccessibility Network) will enable the students to address the full range of Design for All and Design for Diversity issues in their work. By the use of expert networks the academics teaching on this programme can keep abreast of developments in the ambient assisted living field and provide a more useful and higher quality teaching experience for the students. The students academic work will start from their particular application environment and will cover user issues as well as issues such as sustainability and technical infrastructure.

The learning, teaching and assessment strategies employed in this module constitute'distance learning' including:

- Tutor-led individual and group workshops, presentations, discussions, action learning groups delivered through distance learning.
- One to one academic support and guidance delivered through accessible distance learning technologies.
- Tutor supported peer to peer interactions mediated by accessible distance learning technologies.
- The use of module handbooks and other learning resources available through the University's virtual learning environment and/or Learning Resource Centre online Subject Guides.

4. Design for All and Ambient Assisted Living

The change in teaching method at Middlesex has been accompanied by a change in title from `Digital Inclusion' to `Design for Diversity' this name change is intended to emphasis the complete range of end users and to facilitate greater links to professionals working in supported environments as well as those who address the design needs of mainstream products and services. It is to be assumed that the students graduating with their qualifications will understand the possible impact of design for all in producing valuable solutions for inclusion and independent living and the possibilities of mainstreaming these solutions. The students will also be aware of the impact of the important developments of networking in the society and particularly the new technological possibilities. It is to be hoped that the links within the course to both the Ambient Assisted Living field and to mainstream design will enable the students to understand the benefits and drawbacks of different systems. They will also understand the impact that Design for All could have as a design methodology on mainstream products and services.

5. Conclusion

After taking the course the students will have up to date knowledge and skills to enable them to;

- Critically apply the basic principles of Design for All regarding ICT products and services and reflect on the importance of Design for All as enabler of inclusion (social, socio-political, socio- economic, economic aspects).
- Demonstrate a critical understanding of the ethical context, issues and considerations with respect to access to the information society.
- Select and critically evaluate current theoretical perspectives and other knowledge that supports Design for All regarding ICT products and services.
- Work with and for people with disabilities
- Demonstrate how the development of projects/inquiries and/or other work-based activities are designed to make changes to your work/practice, and persuasively communicate outcomes to work/ practice and academic audiences.
- Analyse and utilise relevant national, European and International legislation, standards and guidelines in the specification, design, implementation and maintenance of ICT goods and services.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1096

Emergency Communication Tool for Deaf, Language Dysfunction and Foreigners: Method to Inform Sensory Level of Ache and Pain, Measuring by MVA on Touch Panel Tablet

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Abstract. This paper discusses the efficiency of the Emergency Communication Tool (ECT) on a tablet with a touch panel. Since the ECT is a simple menu like pictogram panel and the user is simply to point the pain portion and severe level. Those icons and pictograms are created by means of Marble Method which is once proposed by the author. Prototype ECT is evaluated by hearing impaired people in the manner of the usability test. Four hearing impaired people participated the evaluation based on Research Questionnaire Analysis in the statistics. The evaluation results by them with ECT found about three times quicker than the PC mail.

Keywords. Design for All, Human Centred Design, Accessibility, CSCW, Touch Panel Tablet.

Introduction

This paper discusses the efficiency of the Emergency Communication Tool (ECT) on a tablet with a touch panel that is originally proposed by a hearing impaired person. Their appearances are the same in the daily life. However at the unexpected situation, they will be suddenly in trouble at such the occasion of disasters or accidents. In such a case, people tend to be low cognitive as M. Endsley pointed out in Situation Awareness (SA) [1]. For instance at the time of Great East Japan Earthquake on 11 March 2011, hearing impaired people, language dysfunction people as well as foreigners must face serious problems particularly on communication issues. In such an extreme situation, the surrounding people cannot afford to help or support hearing impaired people since they were limited to take care of themselves and their family.

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Because the ECT is a simple menu like pictogram panel and the user is simply to point the pain portion and severe level by the finger to communicate with remote supporters [2]. They are drawn by the collections of the pictograms on a tablet with a touch panel of the iPad or Android tablets. This contributes the effectiveness and efficiency of the communication and collaboration between them since the selections of the pictogram are representing disabled people requirements and lifesavers.

This research is particularly focusing on how to express the sensory level of “Ache and Pain” by them. Physical entities for instance, “a House” or “a Cat” would be relatively easier to communicate just simply pointing at them. However such abstract and subtle expressions of “Ache” or “Pain” are difficult to inform since there is no entity at all. Similar thing may happen in spoken language, for instance there are various expressions with difference of the degree; Pain, Sore, Ache, Smart, Itching, Distress and Grief. It may be also necessary to consider the cultural background as well.

1 Pre-survey and Determining the Context

At first survey, hearing impaired people are asked their difficulties of the sudden situation. Emergency patient complaint data are collected from Tokyo Fire Department, Keio University Medical Department and Kasuga Onojo Nakagawa Fire Department in Kyushu prefecture and then analyzed by clustering. In conclusion by brain storming, selected ten patient complaint items of the data are; pain/ache/grief, unconsciousness, hard of breathing, fever, faint, convulsion, vomiting, hard of standing up and walking, cardiopulmonary problem, and external injury.

2 Concept and Prototype Design

The ECT will not be necessary to cover all situations from the point of context of use [3]. However it must be best useful, effective and efficient at the hearing impaired and language dysfunction people complaint of pain/ache/grief among the selected ten patient complaint items. Then the ECT is to particularly focus on the communication method of complaint of pain/ache/grief by hearing impaired users.

Figure 1 Snap shot collection of the multi-national sign languages regarding “Pain”.

The ache portions are to be eight positioned; head, face, chest, back, belly, waist, hands and leg/foot. Hence three ache depths come from surface skin, visceral and bone. It is necessary to express the degree of pain; such as severe pain, painful, smart, itching, slight pain. Those parameters of pain/ache/grief by the people complaint are to be drawn by pictograms and icons that are easy to understand even such emergency situation for them.

Those icons and pictograms are created by means of Marble Method which is once proposed by the author [4]. The first step is to collect several multiple sign languages to express pain/ache/grief (Figure 1), and then to create summarized an icon or pictogram by the designated designer. The similarity among seven sign languages is to be found by means of Multivariate Analysis (MVA) [5], and then to create summarized an icon or pictogram by the designated designer.

The ECT is implemented on Android touch panel by the outcome icons and pictograms with help of minimum selected key words. Ache portions are drawn in the two dimensions. Ache depth and pain severity are drawn in the third dimension. The hearing impaired and people will simply touch the designated icon or pictogram to communicate the remote support people in such emergency situation by ubiquitously carrying a tablet with a touch panel.

The ECT is referring to the user experience [6] of usability by elderly people on Automated Teller Machine (ATM) considering the similarity in low cognitive at emergency situation and elderly people behavior [7, 8]. There are three points in the guidance to design a tablet with a touch panel;

1. Make limit choice selection referring to "Magic Number" by G.A. Miller [9]
2. Change the screen explicitly
3. Make confirm the input data at the very end.

Furthermore G. Kouroupetroglou discussed the accessibility issues of ATMs for the deaf [10].

The process of the screen transition on ECT is referring to several dialogues of the call centre in the fire brigade. Then ECT user is to simply touch the icons and pictograms on the touch panel following the transition process and then an urgent sentence by e-mail is spontaneously created (Figure 2).

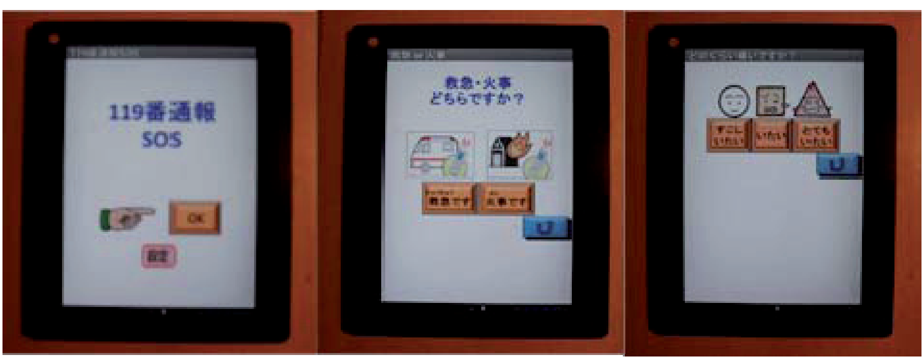

Figure 2. ETC on a Tablet with Touch Panel.

3 Evaluation

Prototype ECT is evaluated by hearing impaired people in the manner of the usability test. The four tasks are prepared to compare with ETC and Personal Computer (PC) mail. They are requested to inform the forest or building fire to the nearest fire brigade, then to call ambulance by means of car accident and preterm birth of the daughter. The efficiency is measured by the elapsed time using a stop watch with and without ECT. The accuracy of the dialogue is measured by the preciseness of mail sentences.

Table 1. The Results on Efficiency Applying UCS.

Subjects	Task-1	Task-2	Task-3	Task-4
MKS	12"82	3'40"07	2'45"28	53"26
YNY	24"20	1'34"08	2'23"72	59"85
SZKM	19"52	1'54"84	2'02"72	49"72
SZKK	20"87	1'06"68	2'01"68	N/A
Average	19"35	2'03"92	2'18"35	54"28

4 Conclusions and Discussions

Four hearing impaired people, who are daily using e-mail, participated the evaluation based on Research Questionnaire Analysis in the statistics. The results with ECT showed about three times quicker than the PC mail (Table 1). The created sentences by the ETC are much more precise than the PC mail.

At the interview after the evaluation, almost all hearing impaired pointed out that the ETC use will make ease their predicted mental worries at the emergencies [10]. The ECT will be translated into multiple languages such as English, Spanish, Korean and Chinese for the foreign people. This service is also being proposed to Japanese government to have the available in the ambulance, hospitals and public spaces. In practice the printed placard of the service is currently carried by several ambulances in the local fire departments to aid to communicate between the hearing impaired user and lifesavers.

Looking at the modern mobile devices, they are equipped the following functions; Tap to select, Double tap to do scaling, Drag to jump, Flick to move next page, Pinch in/out with double fingers, accelerate sensor to position upright, Photo browsing to display icons or pictograms, Backlight for dark place usage, Wi-Fi function to download the new contents as well as connection to the cloud. Currently an experimental ECT is prototyping on a tablet with a touch panel. Now on above functions are implemented by the circulation of trial production and the evaluation by means of the concept of Human Centred Design (HCD) [11].

The focus groups in this primary study with the trial production are deaf, language dysfunction and foreigners, however ECT will be able to elaborate the aspect furthermore, such as potential deaf, elderly people with less cognitive, language impairments as well as users of augmentative and alternative communication (AAC).

In the former study of this research, the icons or pictograms with several languages such as English, Spanish, Korean and Chinese, and Scandinavian languages are printed on a booklet and distributed to the fire stations to install in the ambulances, hospitals or the public places. It is also possible to freely download from following URL of Architectural Association of Japanese DEAF (AAJD); http://www.aajd.org/sos/index.html

As for the outcome of this research, ECT must be included in the system of Fire and Disaster Management Agency by means of the cloud computer technology to realize bi-directional dialogue with several languages between the user and the remote lifesaver with free of charge.

Acknowledgements

This research is supported by the Project organized by Fire and Disaster Management Agency under Ministry of Internal Affairs and Communications (MIC) of Japan. A collection of local sign language database is supplied and permitted for research use by Mr. M. Akatsuka of Architectural Association of Japanese DEAF (AAJD). Dr. H. Akatsu of Oki Electric Ind. Co., Ltd. introduced the cognitive design method on ATM for elderly people.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1101

Design for All and Ambient Assisted Living: The Role of Networking

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Abstract. The paper aims to show the possible impact of design for all (DfA) in the development of future ambient intelligent (AMI) environments and the possible role of networked stakeholders. It takes notice of the general technological development and the needs of users in the future. Ambient assisted living is used as an example of current AMI focus and connects the ideas with design for all. It identifies collective intelligence as one of the future key concepts leading to the need for intensified networking. Finally, it starts the discussion on the development of networking based on the European Design for All eAccessibility Network (EDeAN).

Keywords. Design for All, Ambient Assisted Living, Networking.

Introduction

The present paper aims to show the possible impact of design for all in the development of future ambient intelligent environments and the possible role of networked stakeholders.

Society is undergoing important developments toward an information society. New opportunities and additional difficulties for all citizens and for people with activity limitations in particular, are foreseeable and action for taking advantage of opportunities and minimizing possible difficulties has to be taken at the conceptual level, at the level of design methodologies and in the production of real equipment, services and applications.

One of the main characteristics of the new environment will be networking, of intelligent objects, complex systems and people. The network of people can be instrumental in discussing about problems, contribute toward possible solutions, and support people, including people with activity limitations.

The purpose of the paper is first to outline, with reference to a specific research and development field (Ambient Assisted Living - AAL): (i) the impact of design for all in producing valuable solutions for inclusion and independent living and the possibilities of mainstreaming these interesting solutions; (ii) the contribution of the important developments of networking in the society and particularly of the new options (also technological) for cooperation through the networks, in order to support design and development in the AAL environment, as an example of potential significant impact in the near future; (iii) the possible role of EDeAN (European

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Design for All eAccessibility Network), taking also into account some possible modifications, such as adaptations of the rules for participation, the scope, its sustainability and, possibly, the technical infrastructure on which it is based.

1. The Emerging Environment

Society is undergoing a transition toward an information society [1]. This is caused by many different factors, two of which are considered here with some examples for their direct impact on our discussion: (i) the very fast development of information and telecommunication technology itself and (ii) the new approaches to its use for producing equipment, services and applications. From a basic technology perspective, the available computational power is ever increasing while the size, power consumption and cost of the corresponding components are decreasing. Nanotechnology is also developing very fast, with foreseen impact e.g. in the sector of sensors. Finally, computing power is being made available in the network. From an interaction perspective, wherever persons are, they are supposed to be able to use whatever display or input-output peripheral is convenient for them, normally made available by the environment. Gesture recognition and voice technology are developing hands-free operation. From the network perspective, the World Wide Web, originally used as a document repository, is rapidly transforming (Web 2.0) into a fully-fledged virtual collaborative environment, facilitating media services, interaction and communication. The future network is seen as a space where services can be implemented and/or modified by end users. Moreover, Internet it is developing toward a semantic Web, where meta-information is available to allow intelligent agents to reason about its contents, and toward an Internet of Things, where everyday objects, buildings, and machines are connected to one another and to the wider digital world.

The integrated use of the above technology is creating a general evolution, with the reorganisation of the Information Society as an interconnected intelligent environment (Ambient Intelligence – AMI) [2]. From a conceptual perspective, there is a migration from a model based on products (computers, terminals) and activities (tasks) to be carried out through them to a model in which functionalities are made available to people, irrespective of their real technical implementation, by intelligent objects available in the environment [3]. AAL (Ambient assisted living) is a first instantiation of the AMI environment in smart houses, at the beginning mainly seen from the perspective of assisting people and granting them independent living at home, but now considered as a development of interest for all people. From this perspective, AAL is not limited to grant some sort of advanced house automation, but also includes a specific system layer where the use of technologies is supposed to facilitate social interaction with relatives, neighbours, caregivers, Internet users in general and access to network services at home and on the move.

2. Accessibility as a Component of Inclusion

From the perspective of people with activity limitations, these developments are shifting the focus from accessibility to a more general level where accessibility is only a prerequisite to deal for the more general problem of the complexity of the emerging environment. Some examples are offered in the following.

From the user perspective, it must be considered that access to information technology and telecommunications is no more a business for specialists but a need for all citizens. Difficulties can be expected not only due to lack of physical, sensory, or cognitive abilities, but also from the fact of being part of a specific social class, ethnicity, and educational background. Citizens are no more supposed just to use a dumb telephone for communications and a TV set for accessing information, but to use now equipment and services, which so far were only used by expert professionals. Functionalities and interfaces should therefore be scaled down to accommodate knowledge and interaction capabilities of all people. Otherwise, the environment could become too complex to be used by many persons.

Moreover, an age divide is produced by the new technology, leading to a clash of interests among different groups in the population. Young people, the so-called digital natives, consider the interaction with digital devices as natural and are eager to get and test new equipment and interactions. Older people often realize that some new technology can give them important services in terms of safety, health and leisure (such as mobile devices), but address their interest to a limited set of functions and for each of them to a limited and well defined number of usage steps. Instead, devices are continuously enriched with new functionalities and interaction methodologies. It is true that the developed interaction technology could be very useful for non-conventional interactions needed by people with activity limitations. However, very often this is only used for fancy applications addressing games and technologically expert people.

From an equipment perspective, so far reference could be made to a Personal Computer with a keyboard, a monitor, a pointer, a microphone and loudspeaker as a standard configuration. Now different devices are available: Personal Computers in the offices or at home, but also laptops, tablets, smart phones, smart TV sets etc. Then, environmental control systems are also becoming available. All these devices have different characteristics (e.g. dimensions of screen) and software configurations (e.g. the operating system). Finally, the variety of available equipment and functionalities provided has also an important impact from the interaction perspective. Interaction with ICT applications is no more limited to the manipulation of objects in windows on a screen with a pointer and the input of text. New forms of interaction are emerging, as voice and tactile interactions, gesture recognition, and interaction based on behaviour patterns, user preferences and situations. Even if this can be considered positive for universal access, because different modalities of interaction can be accommodated, however it is also introducing additional complexity in the ICT environment.

Traditionally, in the context of inclusion most emphasis has been on accessibility to elements in the environment. Accessibility indeed is very important and producers of equipment (e.g. smart telephones and tablets) are starting to consider it in the design. However, the concept of accessibility must be generalised from the traditional concept of accessibility of equipment or services to the accessibility of an entire environment as e.g. the house in the AAL.

Moreover, the environment and the applications must be not only accessible, but also usable. People with activity limitations share this problem with all citizens. The environment must not be too complex to create problems of usability. Its complexity should be (automatically) matched with the capabilities of the users.

Finally, services and applications should also be useful in addition to be accessible and usable. However, usefulness is a concept too subtle and personal to be considered in this paper.

3. Design for all to Cope with Complexity

In the emerging situation the normal procedure of designing equipment and services for the "average" users and then adapting them for people who have limitations of activities is showing evident limitations. The equipment and services to be adapted are too many and the speed of innovation is so high that many people risk lagging behind. On the other hand, special solutions for small groups of people can be costly and quickly outdated. Features and functionalities of applications tend to vary in order to meet the diverse activities of people and the ways to carry them out. Design for all is a methodology, which starts from the integration of the needs of all potential users in the design specifications. It is based, as technical approach, on the introduction of adaptability and adaptivity in the products according to individual requests and different contexts of use. Therefore, it can be considered a suitable approach to manage the different aspects of the above outlined complexity [4], [5], [6].

This is particularly true for AAL, which does not address a population niche but, being supposed to affect the life of the majority of the population, may create an incentive for mainstreaming solutions developed for people with activity limitations that could be useful for all citizens to cope with the potential complexity of the emerging home environment. Apart from applications in the health care environment, where examples of deployment of home-based technology are available, producers of mainstream electrical appliances are now starting to design interconnected equipment with different levels of intelligence. It is therefore the right time to spread the knowledge about design for all, aiming to new generations of equipment that are user friendly and ready to support people with activity limitations and older people.

4. Design for All, AAL and Networking

From the above short discussion it seems that design for all and AAL fit together. Both important strands of development have been supported over years in the European context and provide approaches to better support people in need due to age and/or disability through technology. Design for all follows the idea of mainstreaming solutions and tries to address a wide range of different users as beneficiaries. Although AAL was derived from a similar concept in the context of ambient intelligence, it has somewhat focused on living solutions for people with the need of care – namely older people and people with disabilities – mainly in home environments. Due to different origin, separate funding opportunities, national and European organization etc. the two strands have to some extent created two different R&D communities, not completely disjoint but still widely separated. How can networking come in the scene?

There are many perspectives from which the contribution of networking can be considered. First, while it has been discussed and shown in many projects the design for all does not necessarily involve additional effort and therefore cost, the methodology itself and its implementation approaches are not widely known, meaning that they are not normally part of the knowledge offered by university courses for designers in the ICT industry. Therefore, a first role of networking could be in the dissemination of knowledge about the design for all approach, offering both remote education and the space for discussion about problems connected to this approach.

A second way of coming to the scene is again through intelligence. Recently, there have been many discussions about intelligence. This term has often been used in ICT, specified by two different adjectives. One is ambient intelligence, as considered above (AMI, AAL). A different meaning is assumed by the term, when it is connected with the adjective collective. In this case, it characterizes a phenomenon that involves a group of people who communicate through a network sharing their knowledge in order to solve common problems. The concept of collective intelligence can be considered as a new emerging feature of communities of connected human beings and a new contribution to the acquisition and production of knowledge.

Considering an example from AAL, in the kitchen inhabitants can rely on different levels of intelligence. At the lower level intelligent objects and their interconnection take care e.g. of the correct behaviour of all alarm sensors (as fire or flood), the correct opening and closing of the doors, the basic maintenance and control of the equipment, the control of the equipment from the perspective of energy consumption. Then, all networked and centrally controlled equipment of the kitchen are supposed to support the person in tasks connected to the preparation of food, from reminding them that they have to prepare it to controlling that all activities are compatible with security standards and coherent with the task people are carrying out. At a higher level, intelligent agents have the responsibility of supporting people in activities relevant for acquisition of food that can be automatized, at least partially. Examples are: inventory and control of the goods that people have at home, automatic acquisition, if authorized, or support to the acquisition of food for shops in the neighbourhood, suggestion of diets compatible with the health situation. On top of it, the collective intelligence of the people in the network of caregivers, relatives, neighbours and Internet users in general is supposed to be active as an external support.

The collective intelligence of the professionals who are interconnected can be used to support people at home, but also to contribute to the solution of specific problems and to the increase of the interdisciplinary knowledge in different environments. This is in accord with the emerging paradigm whereby network users themselves become actors in producing, even cooperatively, solutions to problems of common interest. The crowdsourcing concept, defined by Wikipedia as "the practice of obtaining needed services, ideas, or content by soliciting contributions from a large group of people, and especially from an online community, rather than from traditional employees or suppliers", can become very important. People are no more considered active only in accessing information and communicating, but in the production of information and in the implementation of solutions of interest for the society.

5. A Possible role for EDeAN

From the above considerations, it appears that it is necessary to guarantee people the possibility of taking part in a knowledge process, in which information is produced in cooperative activities and communication is inside groups of cooperating participants. Different R&D communities, not completely disjoint but still widely separated have evolved in design for all, assistive technology, AAL etc. It is time to review the options to combine the strands for the benefit of research, company and state economics but also the users of these products and services.

From this perspective, the role of EDeAN could be considered, starting from the fact that in the Design for All environment, EDeAN has attempted to play the role of catalysing interest about these problems at a very general level. A discussion of a possibly more active role in looking at solutions of eInclusion problems of common interest, starting from a specific application environment, seems convenient. AAL is a very interesting example, due the important resources presently devoted to work in this environment. An in depth discussion of real possibility of evolution of EDeAN from a very structured network set up to collect and organize information into a more informal discussion and cooperation environment is necessary, aiming to identify if and how: (i) it can become a channel for diffusion of information about Design for All to industry and for training of designers; and/or (ii) it can be the basis of a crowdsourcing community, contributing to the solution of common problems, through the cooperation of its members; and/or (iii) it can be used as a repository of human intelligence to be used for supporting people.

This involves considering the different aspects of the possible evolution, as e.g. adaptations of the rules for participation, the scope, the sustainability and, possibly, the technical infrastructure on which it is based, starting from available modelling work [7], [8].

6. Conclusions

Over the years, different strands of R&D in the context of supporting people with ICT have evolved. ICT Assistive Technology, AAL, Design for all etc. have common technology and application fields, but have stayed sometimes more separated rather than cooperative. A discussion is recommended to better integrate R&D and technology services for the benefit of society. The R&D community needs investigate modern forms of exchange and networking options. Programme developers are requested to overcome boundaries and support cooperation in programme definitions, and on project level. Organisations like AAATE, EDeAN and others should consider strengthening cooperation efforts. Jointly organised events like workshops and conferences, sharing publications and common public relations are only few examples of the networking options. Concrete application strands like AAL offer a good basis for intensified joint action and dealing with R&D issues from varying perspectives.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1107

Creating Design Scenarios for Elderly Communities: Opportunity Areas and Positive Behaviours

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Abstract. The design of practicable systems for elderly support that develops through Design for All agendas in ICT development are enabled by particular front-end user-centered and experience-centered design methods. From the outset, what are sought are not "problems" in an elderly home or lifestyle, but "opportunities," where either positive behaviors and technology appropriations by elderly individuals or the emergence of speculative scenarios can highlight and inspire the design of systems and services with broad applicability and interest. Shifting from a need-based approach to an opportunity based one when designing ICT solutions for elderly people further creates market and technical solutions not normally revealed when ICT and engineering are used as a means of "solving problems," presumed or otherwise. Using user-centered design techniques in elderly peoples' local communities and support networks, design drives beyond usability and the often too-narrow focus of these solutions. Herein, this argument is supported through the description of a design process undertaken within "FOOD," a European Union Ambient Assisted Living project focusing on the development of services for new kitchen technologies and environments, aiming at supporting the autonomy and independence of elderly people in their own homes. The FOOD project design process and initial service concepts derived from the opportunities areas mapped out through fieldwork with the elderly are presented.

Keywords. ICT; elderly; active ageing; independence; kitchen; people-centered.

Introduction

ICT projects for the European elderly population have the general aim of improving independence, participation and, more generally, quality of life for an ageing population. Under different frameworks, such as the EU's Ambient Assisted Living (AAL) and E-Inclusion, the vision is one of ICT solutions for elderly helping people cope with disabilities; acknowledgement of the need for caregivers to perform daily activities; renewed potential for elderly people taking care of their own health; and combating social exclusion [1]. The way ICT projects have been framed reflects this age-related problem-based approach, and consequently technologies have been designed to tackle and solve direct needs or clusters of these. We describe here a different approach, linked to Universal Design philosophies [2], that allows for other kinds of emergent opportunities from the context in which elderly people live and age.

Universal Design is a tendency toward the generalizing of design spaces, primarily in technologies and ICT, creating design solutions that do no specialize in their

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treatment of particular disabilities of needs, but allow for the broadest applicability for use and user: “The design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design” [3]. These techniques have been criticized for being overly general, totalizing and utopian [4], and for having vague methods for application of goals. Aligned with Universal Design, WHO’s Policy Framework for Active Ageing [5] opens up the research phase of ICT projects to the context of ageing, such as the spatial and socio conditions in which people age, in order to create cohesive social innovation. This means that researchers are not only focusing on elderly needs to be fulfilled by ICT solutions, but they are also discovering new situations in which to ground original research questions towards the unfolding of innovative uses and appropriate technology. This approach in ICT projects for the elderly is important because it saves researchers from jumping ahead with too-early assumptions, and from thinking about elderly people as *in need of assistance*, and avoids easy and repetitive assistive technology solutions that target older people as passive subjects.

One potential, specific, methodological orientation for developing more-universal solutions comes through understanding innovation and inventiveness as arising from many directions and sectors in parallel: Not just from (ICT) expert to user, but from particular circumstance and in-context innovation to *generalizable* (not generalized) solution. Allowing for the channeling of solutions in “both direction” (both more specialized and more generalized) directions in this way creates new potentials for Universal Design solutions, as well as “use-based fundamental research” outputs where design and ICT theory and practice coincide [6].

1. From “Problem Solving” to Opportunity based Design

ICT projects for the elderly are often spurred through a search for problems: Definition of user needs, their conversion into user-requirements, and their solution through a presumed technology. Due to market, industry or technological interests and constraints, technologies are often a primary vector, serving a presupposed useful or novel capability (e.g.: “SMART home” technologies). Often technological solutions can appear to serve as complete design solutions, as the process (needs → requirements → technology) can prove a self-satisfying, if a rather narrow, closed loop process. Projects for the prevention of falling like the “Smiling project”[7] or the fear of being alone when falling like the “Fearless project”[8] give technological solutions to these problems. These and others like them are successful development processes for specific problems, but do not always enable Design for All and Universal design directives: firstly because there is difficulty in accounting for ecosystemic and complex interactions that take place around and through each action and interaction a user undertakes; secondly as such design orientations can contribute to stigmatizing the “elderly condition” even further, targeting only those specific ageing physical impairments and social limitations. Frequently, projects for the aged population that focus on topics like disabilities, independence and inclusion, derive from a narrow characterisation of the problem space. They concentrate on technologies and need fulfillment, without including the context and the social structure in which people age and the solutions that arise for, from and by individuals in their context.

The broadening of the design space, and looking for user-derived solutions leads to the emergence of “opportunities areas.” The opportunity-based design approach saves the design process from any narrowness of ICT need-based design by directly engaging with the context and networks of the existing individuals as design inspiration. We think that ICT projects for elderly communities need to develop these more holistic approaches at early research phases, when the aims and final outcomes of projects are first conceptualized. This because the generation of more systemic design concepts within elderly communities avoids the mere imposition of technologies toward more engaging, meaningful and sense-making socio-technical scenarios. Moreover, opportunities arising by considering a whole network of elderly people promotes design concepts in line with the Universal Design philosophies, and that we could refer to as "Design for All User Experience" since it better integrates social participation across age-groups and is inclusive of "normal," non-target groups (e.g.: family members and caregivers). Inter-generational, and cross-sector collaboration and generativity are both requisite and resultant goals [9].

2. Opportunity-based design in the FOOD Project

In the FOOD project user-research phase, we allow the emergence of opportunities areas to inspire the generation of enabling services for elderly people more generally around food. It is crucial to empower elderly people to stay engaged in food related activities as these are central to independent household management, personal dignity, and rich social lives. Experiences of food play a fundamental role in the life of people as they age, as they are a set of activities at once functional (health-related), emotive and affective. From continuing to cook independently, to hosting family and friends, to maintaining healthy cooking and eating habits, to changing eating habits after the loss of a partner: Food and eating processes signal, example and effect fundamental aspects of health and wellbeing.

By conducting fieldwork in three different EU countries and meeting and discussing with elderly people, we focus on the experience of ageing related to food, gaining insights from which opportunities areas for design were mapped out. What emerged from observation of the elderly, and direct engagement in their context were insights (Fig.1) either framing positive behaviors self-generated by elderly people, as for example: *"Planning meals is a brain exercise that keeps their mind active and sharp"* and *"Spreading the smell of food while cooking is a social aspect to indirectly channeling social engagement and attention";* or speculative scenarios emerging in the intertwining of elderly independency, their social participation and their experience of food while ageing, as for example: *"Sitting around food, reduce generational discussions among elderly people and their families"* and *"Asking a person to buy food for themselves[the elderly people] is about trusting the choices he/she will make on their behalf".*

From the collection of insights, five opportunity areas emerged (Fig.2). The opportunity areas framed situations and constraints of design challenges to seed brainstorming processes and help envision meaningful socio-technical scenarios for the elderly for the following concept generation phase, as expressed in the following list:

- Enabling proactive behavior against ageing watersheds (i.e.: Life events causing or triggering behavioral or physiological change.).
- Keeping elderly people involved in context as active solution creators.
- Freedom for the elderly to find and improvise their own custom solutions.

- Food as a touch point for elderly people and their social lives.
- Support networks, mostly proximal (i.e.: neighbors), as social scaffolding.

3. Design Concepts of the FOOD Project

The opportunity areas constitute the base of design-brainstorming processes for new services ideas for elderly people. Among the generated concepts, the following, entitled "Senior Chef" and "Cooking Academy", were the most promising, and were developed further into a video scenario [10] and an experience prototype [11].

3.1. "Senior Chef" Service Concept

"Senior Chef" is a social network for neighborhoods, aimed to create occasions to collaborate with local seniors in planning and shopping for their meals and to eat together. "Senior Chef" is built on the social connections that people living in the same neighborhood establish over time, due to the physical proximity. Most elderly respondents interviewed highlighted that they were able to identify their neighborhood groups by sight, but had knowledge of individuals to different levels of depth. The fieldwork carried out also indicated that as long as local communities are not providing systems or occasions for the socialization of elderly people in their neighbourhood group, such encounters and social bonds are not likely to occur. "Senior Chef" provides the platform for the emergence of a support community for the elderly around food activities.

3.2. "Cooking Academy" Service Concept

"Cooking Academy" is a peer to peer cooking tutoring network run by elderly people to share their recipes and instruct others how to prepare favored foods. The audience that "Cooking Academy" attempts to address is various: from non-national and foreign care-givers to elderly widow/er and nursing home staff. "Cooking Academy" is enabled by embedded technologies in the kitchen which take pictures of the cooking process while performed. Lately the elderly person can add and record spoken description of the recipe upon each single meaningful picture.

4. Conclusion

Beginning with opportunity areas and positive behaviors, the potential for opening design spaces which all for the inclusion of non-target users becomes apparent. It is in deriving solutions alongside and from users' perspectives, that more complex and universal solutions arise. As pilots proceed through the project the potential of these strategies for evoking Design for All systems and designs will be tested and reported.

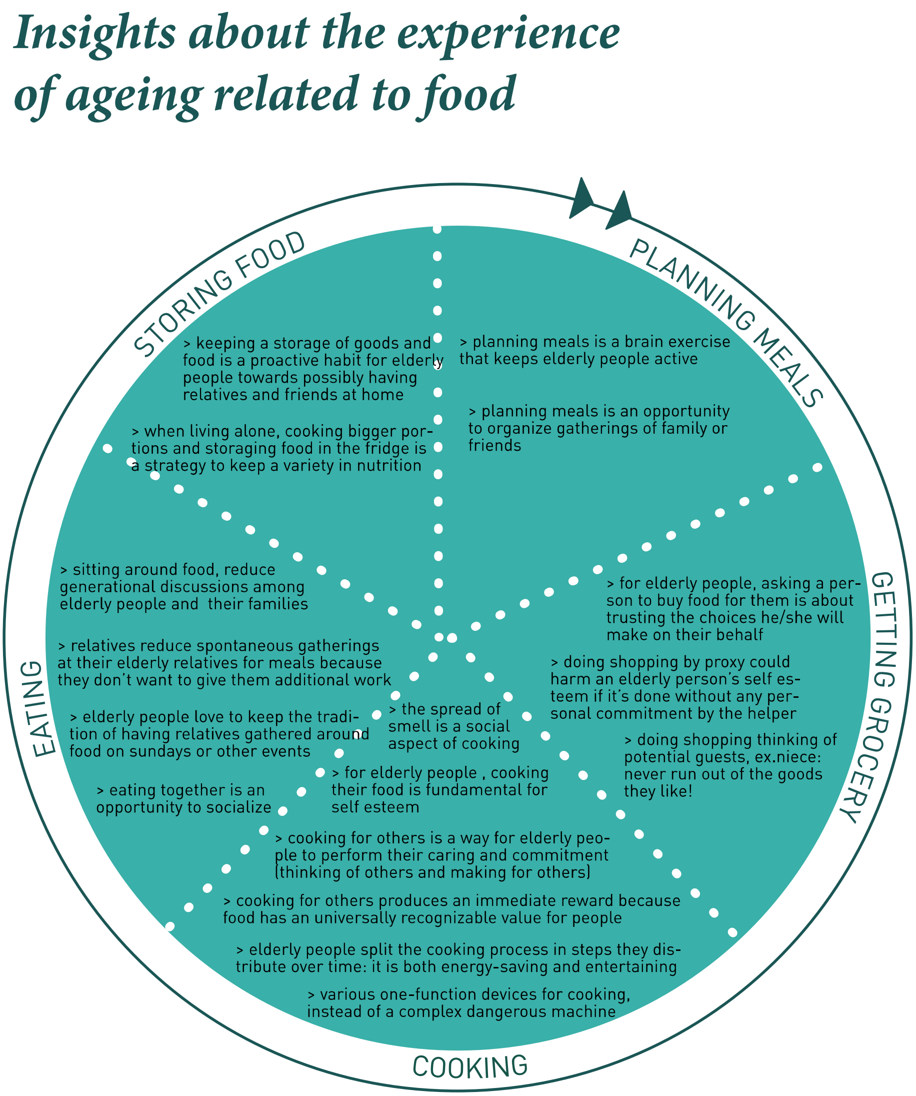

Figure 1: Detail of the Insight Map describing the insights about the experience of ageing related to food collected during the "FOOD" fieldwork. A full printable version of the Insight Map is downloadable from the following link: https://www.dropbox.com/s/svxui8y7x7kqerl/Map%20Of%20Insights.pdf .

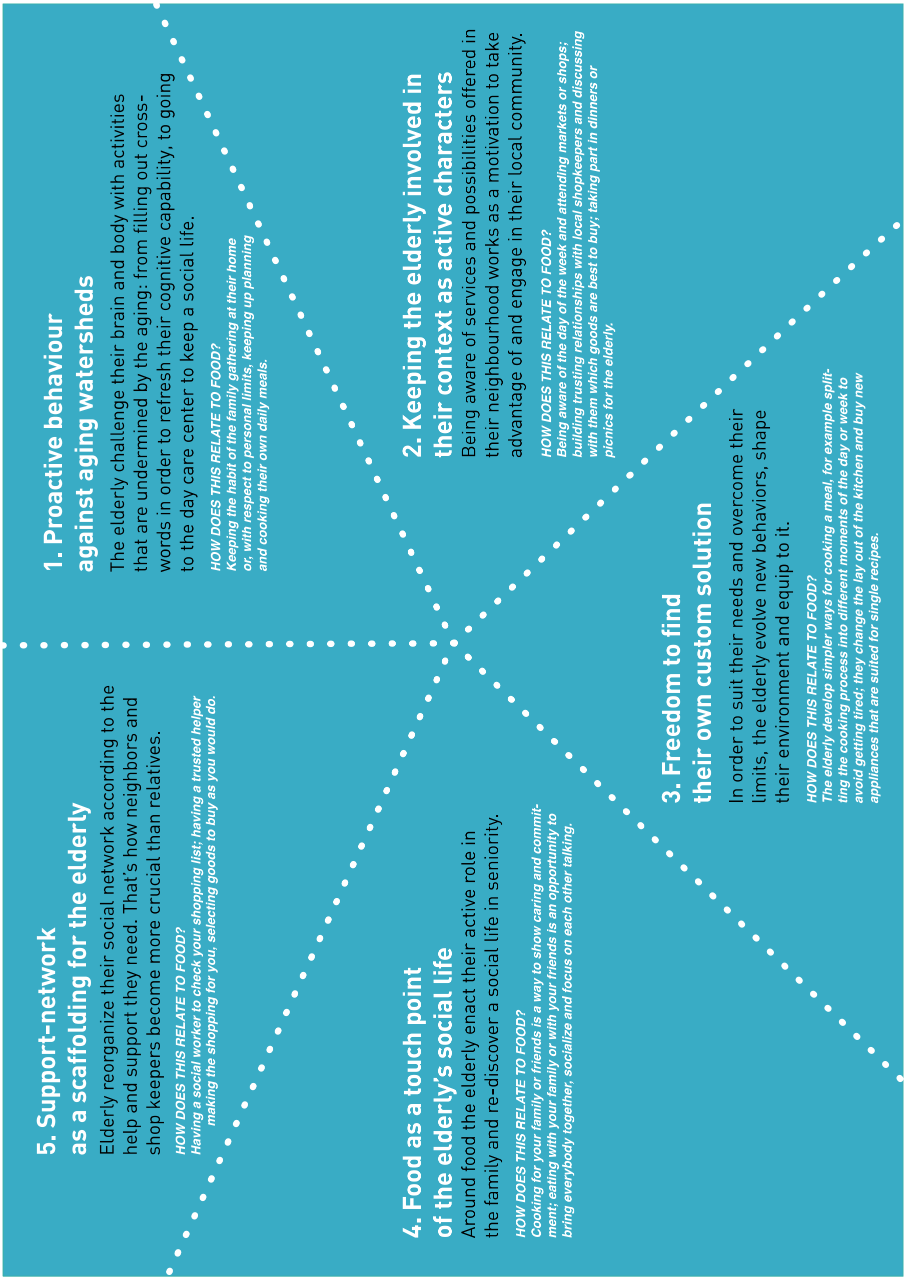

Figure 2: Opportunity Areas Map indicating the 5 opportunities areas for design as emerged from the insights collected in the "FOOD" fieldwork. A printable version of the Opportunity Areas Map is downloadable from the following link: https://www.dropbox.com/s/7xoqv1bpk9wlzl5/Opportunity%20Areas%20Map.pdf

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1114

Mainstreaming Design for All in Ami Environments in a Dedicated Experimentation and Demonstration Facility

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Abstract. This paper discusses the contribution of an Ambient Intelligence (AmI) facility towards adopting, promoting and mainstreaming Design for All principles and approaches. Design for All is fostered through the multidisciplinary approach that is adopted, the scientific exchange and experimentation actively engaging researchers, the capabilities offered by AmI environments towards supporting multimodal interaction and multimedia output, the actual involvement of representative users, as well as the networking activities that are ensued.

Keywords. Design for All, Ambient Intelligence.

Introduction

This paper aims to illustrate how a novel demonstration and experimentation laboratory facility (the Ambient Intelligence Facility of the Institute of Computer Science of FORTH) can contribute to the promotion and mainstreaming of Design for All through enabling real life demonstrations of ambient technologies and applications, while actively engaging researchers in scientific exchange and experimentation. An approach to networking for Design for All in the context of Ambient Intelligence (AmI) is presented, that combines the conventional approach of information, knowledge, and good practices exchange, and brings forward new opportunities for more effective communication, dissemination and mainstreaming, by exploring the possibilities of hands-on experimentation and real time experiences in an in vitro environment, designed and developed to test and showcase AmI technologies and applications.

1. Ambient Intelligence and Universal Access

AmI is perceived as a technological development which should integrate universal access characteristics in a mainstream fashion, to address accessibility and usability of interactive technologies by users with different characteristics and requirements [1]. AmI is also considered as offering a range of new opportunities towards Universal Access, and in particular towards the integration of disabled and older people in the Information Society. One of the main intrinsic benefits of AmI in this respect is identified in the emergence of new forms of interactive applications supporting every day activities by integrating (or, in some cases, substituting) limited human abilities with the intelligence spread in the environment, resulting in the support of independent living, higher quality of healthcare, easier interpersonal communication, etc. [2]. The potential of AmI environments to address older and disabled people's everyday life needs in a not so distant future is expected to have a radical impact on independent living and e-Inclusion. Many applications and services are already becoming available, for example in the domain of Ambient Assisted Living (AAL), which relies on the exploitation of AmI technologies and addresses a wide variety of issues critical for older and disabled people, targeted to make possible and enjoyable a more independent, active and healthy life [3]. The European strategy in ICT for Ageing Well of 2010[1] identified a number of ICT solutions addressing daily and independent living in areas such as social communication, daily shopping, travel, social life, public services, safety, reminders, telecare and telemedicine, personal health systems, and support for people with cognitive problems and their carers. The same report also pointed out the importance of user interaction for ICT solutions, and mentions user-friendly interfaces for all sorts of equipment at home and outside, taking into account that many older people have impairments in vision, hearing, mobility or dexterity [4].

In the context of AmI, Universal Access faces new challenges posed by the pursue of proactive accessibility and usability of embedded interactivity "hidden" in a variety of interconnected, multifunctional artefacts. Universal Access will need to broaden its scope, as accessibility and usability of each device in isolation will become a necessary, but not sufficient condition for the accessibility and usability of the overall distributed environment. New factors are increasingly and dynamically being involved in the cooperation of all elements in the technological environment, which need to be addressed and studied [5].

2. Demonstrating AmI environments

With the advent of AmI and the increasing importance of AmI technologies in various domains, including AAL, the availability of facilities and laboratories for the development, testing and experimentation of AmI environments becomes increasingly important. The benefits of AmI environments can only be fully achieved and accepted by their target end-users if such technologies can demonstrably be developed in such a way as to guarantee inclusive accessibility for a wide variety of functional limitations brought about by age or disabilities [4]. Some efforts worldwide towards addressing this need have been recorded. In the US, examples include Georgia Tech's Aware Home[2], MIT's House_n[3], and the MIT Living Labs[4] interdisciplinary effort comprising

[1] Overview of the European strategy in ICT for Ageing Well: http://ec.europa.eu/information_society/activities/einclusion/docs/ageing/overview.pdf
[2] http://www.awarehome.gatech.edu/
[3] http://architecture.mit.edu/house_n/
[4] http://livinglabs.mit.edu/

of international research partners. In Europe, examples such as Philips' HomeLab[5] and ExperienceLab[6], Stichting Smart Homes[7], Fraunhofer-Gesellschaft's inHaus[8], and the Assisted Living demonstrator of the Welsh Centre of Excellence for Assisted Living Technology[9], are all targeted mainly at the Smart Home environment.

3. The AmI Facility at FORTH-ICS

The newly built AmI Facility at FORTH-ICS, in Heraklion, Crete, Greece, is a large-scale multidisciplinary facility where different AmI technologies are developed, integrated and tested in a real-life context. It occupies a two-floor building comprising simulated AmI-augmented environments and their support spaces (e.g., computer and observation rooms), laboratory spaces for developing and testing related technologies, staff offices and public spaces. It is intended to primarily address various application domains including housing, education, work, health, entertainment, commerce, and culture, through dedicated spaces simulating typical everyday environments.

The AmI Facility provides a showcase for demonstrating the potential added-value and benefits of AmI technologies in different aspects of everyday life and activities with the involvement and active participation of target users. It provides an ideal environment not only for developing, testing and validating the proposed solutions in a realistic simulation environment, but also for studying the users' behavior over extended periods of time, demonstrating the technological feasibility and ultimately mainstreaming the AmI approach. At present, a few months after the completion of its construction, some of the developed in-house systems that are showcased include:

- A smart patient room featuring embedded intelligent devices and systems which allow patients to control the environment and help nurses and doctors in their clinical routine
- Smart home systems which improve the living experience by automating common actions (e.g., lights control), supporting multi-modal and natural interaction with the environment.
- Intelligent interactive educational systems, to be used in the classroom and beyond, which support natural interaction with digital and traditional learning content
- A smart office augmented with AmI technologies, demonstrating how these are seamlessly integrated into the working environment in order to support everyday activities robustly and consistently.
- Interactive museum systems, supporting a variety of interaction techniques ranging from touch-based interaction to body interaction.
- Entertainment systems and games, engaging people of various ages, ranging from very young children to elderly.

Operating since May 2012, the Facility has already hosted a number of demonstrations of prototype applications and international stakeholders' visits during the second half of 2012. Stakeholders groups included, among others, representatives of the European

[5] http://www.research.philips.com/
[6] http://www.research.philips.com/focused/experiencelab.html
[7] http://www.smart-homes.nl/default.aspx?lang=en-US
[8] http://www.inhaus.fraunhofer.de/en.html
[9] http://cefalt.org.uk/

Network of Social Authorities (ENSA)[10], the European Local Inclusion and Social Action Network (ELISAN)[11], and the Functional Home initiative of the Municipality of Helsinki[12]. Moreover, the facility has been used to conduct user trials of a robot prototype developed in the context of the EC-funded FP7 project Hobbit[13], which - through the mutual care concept that it promotes - aims at enhancing wellness and quality of life for seniors and prolong independent living. This was the first case of international collaboration and hands-on user testing and experimentation conducted in the AmI Facility.

4. Design for All Activities at the FORTH-ICS Ami Facility

Design for All is adopted during the design of applications developed and deployed in the AmI facility by employing appropriate methods and tools, and by designing systems and applications supporting a variety of end-users. A characteristic of AmI environments, which constitutes an important advantage and promotes Design for All, is the multimodal input they support and the multimedia output they provide. This section presents three case studies, focusing on accessible home control. The available interaction modalities and output for each system are described in Table 1. Furthermore alternative interaction techniques (gestures, body and head movement, card-based interaction) are also discussed under a Design for All perspective.

Table 1. Overview of input modalities and output provided by each system discussed.

System	**Input**	**Output**
Head scanner for domotic control	• Head movement / pose • Binary input AT • Scanning	• Audio describing selected item / action • Visually highlighting the selected UI element through scanning • Feedback by the controlled device (e.g. TV turned on)
Universal control wand	• Wand • Remote control (mounted on the wand)	• Audio describing room artifacts that are pointed at • Audio describing the user's interaction with an artifact
CAMILE	• Touch • Remote control and speech • Switches and scanning	• Visual feedback (room lights graphically displayed) • Visually highlighting the selected UI element through scanning • Sound effects and auditory feedback

4.1. Head Scanner for Domotic Control in AmI Environments

Through the head scanner system users can gain full control of the surrounding environment's devices and interactive components (e.g. doors, window blinds) using only their head for selecting the desired device. The device is then controlled through a binary input assistive technology, such as sip and puff or binary switches [6]. In more details, users can select a device by directing their head towards the specific device and "looking" at it for a specified time. Once the device is selected, a control panel for the device is deployed in the nearby tablet, allowing scanning-based access to the

[10] http://www.ensa-network.eu/
[11] http://www.elisan.eu/
[12] http://www.toimivakoti.fi/
[13] http://www.hobbit-project.eu/

interactive panel elements (see **Figure 1**a). As a result, users with severe motor impairments are provided with intuitive interaction with their environment.

4.2. Universal Control Wand

A four-buttons remote control mounted on a plastic stick enables blind users to control a room's devices and applications in a seamless way [6]. More specifically, users can receive auditory feedback regarding their environment by pointing the wand to diverse directions. Every time a room artifact is pointed at (see **Figure 1**b), auditory information regarding the artifact and its state is provided. Furthermore, users can interact with the room artifacts (e.g., television, audio system, lights, doors) through the remote control, while the system constantly provides audio feedback for the available options and the interaction carried out.

4.3. CAMILE: Controlling AmI Lights easily

A more targeted application aiming at controlling multiple sources of light in AmI environments, accessible by a wide audience (the young, the elderly, people with visual disabilities, and people with hand-motor disabilities) is CAMILE [7]. The system provides three modes of interaction: touch-screen based, remote control in combination with speech, and binary switches in combination with scanning (see **Figure 1**c).

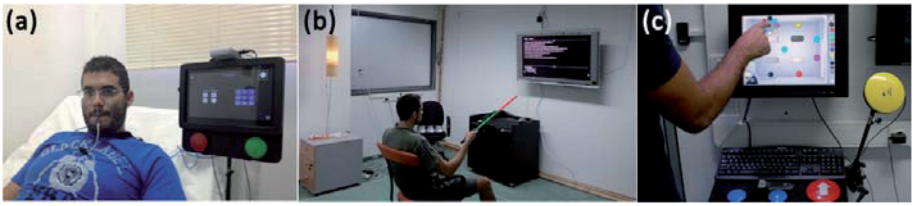

Figure 1. (a) Head scanner for domotic control (b) Universal control wand (c) CAMILE.

Additional interaction techniques that have proved to be interesting under a Design for All perspective include gestures and body movement, as well as card-based interaction. For instance the game described in [8] employs gestures and body movements in order to control the player's shadow displayed on a brick wall and gather in a basket as many falling rusks as possible. The game was played by more than 500 people aged from 2 to 76 with remarkably positive results both for children and aged users. Furthermore, an alternative interaction technique that is promising in the context of children's interaction is through cards [9], [10]. Initial tests with children have indicated that the method is intuitive and unobtrusive, while the combination of physical media (cards) with electronic media (computer screen) enhances the overall user experience, as well as young players' enthusiasm and engagement. The card-based interaction method has also been tested with two children with cognitive disabilities indicating that it is very easy to learn; nevertheless additional tests with more children need to be carried out in order to validate the initial evaluation results.

5. Conclusions

The AmI Facility of FORTH-ICS aims at fostering the vision of AmI, facilitating multidisciplinary international collaborations, and providing a focal point for technology transfer and dissemination of know-how to European industry. In this respect, the AmI facility can also play a vital role in enhancing the traditional approach to networking and mainstreaming Design for All and AmI, as a real technology showcase and a demonstration space, while also offering the infrastructure necessary for international collaboration, knowledge exchange and research in the area of AmI. Although still at early stages, recent examples of international collaboration using the AmI facility showcase the potential of the facility as an interactive laboratory space for interdisciplinary research and experimentation in AmI technologies. In the context of international networking and dissemination efforts to promote AmI technologies, the AmI facility can be seen as instrumental for European and international networks and stakeholders who wish to use the infrastructure offered to experiment, test, evaluate AmI applications or collaborate with other international initiatives / programmes / projects operating as a European-wide space for the testing and evaluation of AmI technological solutions.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1121

Exploiting AAL Environment for Behavioral Analysis

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Abstract. Recent environmental control systems, designed and developed according to Ambient Assisted Living paradigm, can increase the chances of active and independent living for elderly people and people with disabilities, by improving their safety and autonomy. Such systems can play an assistive role, interacting with users through non-invasive smart-sensors, monitoring their wellbeing and implementing behavioural analysis. This paper aims to present some tools developed into the CARDEA AAL system to foster a more effective transfer of AAL outcome to caregiving practices. By processing raw data generated from low-cost environmental sensors, CARDEA allows for the identification of behavioural "trends", which can be meaningful to caregivers. Presentation tools are proposed, suitable for highlighting relevant issues, the actual interpretation of which is left to the caregiver.

Keywords. Ambient Assisted Living, Behavioural Analysis, long-term monitoring.

Introduction

Great expectations are placed on Ambient Assisted Living (AAL) techniques to support independent life of ageing people and to foster sustainability of caregiving systems. Health and safety monitoring, as well as environmental control systems are being designed and tested in many living-lab environments and in real contexts too [1]. Nevertheless, AAL solutions are still to enter the mass market, due to issues related to both costs and users' perception (expected benefits, acceptance, invasiveness, reliability, etc.).

A wide range of mature technologies are available indeed, which now needs to be brought to the user in an effective (and appealing) way, in order to become an ordinary part of the mainstream care network. With this respect, we need to extend the "user" definition, to include formal and informal caregivers: introducing AAL techniques may have great impact on their activity too and suitable inclusive approaches need to be devised. In this abstract, a "low-technology" approach is presented, aimed at extracting behavioral information (connected to healthiness and wellness) from raw data - commonly available in AAL environments- and to provide meaningful interpretation of such data to (not technically skilled) caregivers [2]. Through the proposed approach, "intelligence" of AAL system is pushed beyond the mere "automation" level, entering a more perceptive and interpretative level which may support system adaptivity and prevention policies.

1. Methodology

CARDEA is an AAL system, featuring comprehensive environmental control, wearable smart sensors, full Internet operation [3]. CARDEA has been deployed at a number of trial sites, scattered in the region close to Parma, Italy. Most sites are active from several years now, so a great amount of usage data has been collected so far. At each site, a variety of sensors and devices has been deployed and networked to provide AAL functionalities. For the sake of interoperability, all data coming from the supervised ambient are suitably virtualized and stored in a MySQL local database; to this purpose, a specific ontology has been developed and a multi-level hardware abstraction strategy has been implemented. The database then feeds a number of different applications, including user interfaces, supervision and alarm functions, remote control, etc. I.e., the database records the history log of every single sensor in the structure, which can be then also used for purposes different from their primary aim. For instance, we may found a number of behavioral clues even in fairly simple, unstructured information: taking it to the limit, a simple light switch log record may be exploited to infer user's habits and to look for possibly meaningful alterations [4,5]. For instance, sleep/wake cycles can be tracked with fair accuracy without using intrusive devices, or other daily living activities can be profiled looking at specific home appliances (e.g., in the kitchen).
In the following, we discuss a simple example based on the tracking of a simple presence sensor (a passive infrared, PIR, device) located in the bathroom within flats in one of the CARDEA-supervised sites [6]. A number of tools are introduced in the following section, in order to extract meaningful information from such a raw and inexpressive data, and to present it to caregivers in an eloquent fashion.

2. Application Example

A timeframe of about two years is taken into account: first, in order to make circadian rhythms more evident, data are arranged on a 2D density map, shown in Fig. 1. The color scale maps the activity intensity and makes immediately perceivable main features: lunch and dinner occurs at regular hours, while wake-up time follows a seasonal behavior. A second example (actually related to a different subject) is shown in Fig. 2: in this case, some declining behavior can be appreciated at a glance, by looking at the fading color in the map. Less evident behavior can be appreciated by

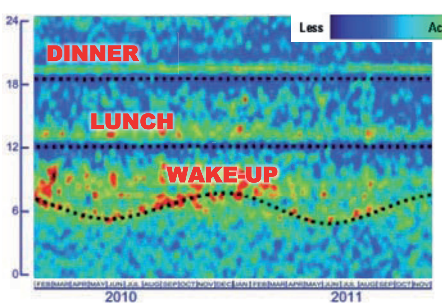

Figure 1: Activity density map.

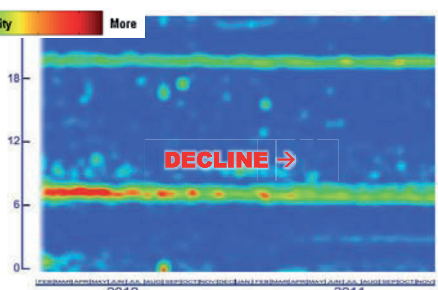

Figure 2: Density map, showing decline.

carrying on some data processing: in Fig. 3, the sensor activity is integrated over each day, and resulting figures are compared along time. From these plots, one can easily infer long-term increase or decrease of overall daily activity, which of course may have relevance to the health status [7, 8]. Also, partial sums (related to day- and night-time behaviors) can be worked out, allowing to appreciate more specific behavior components. Intensity (i.e., sensor activation count) in such graphs is somehow related to sensor configuration data, so only its change has immediate meaning. However, absolute indicators can be worked out from the same data, through simple mathematical reasoning: in Fig. 4, the daily count of bathroom access is reported, confirming a similar trend. Frequency distribution of such data is shown in the figure inset, allowing for estimating a "normal" behavior. Since data are quite noisy, suitable (low-pass) filtering is applied: besides large variances, meaningfulness of averaged data is still fair, as shown by error bars in Fig. 4.

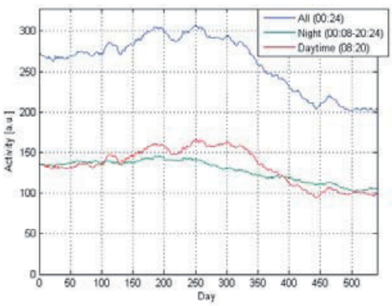

Figure 3: Sensor activity profiles.

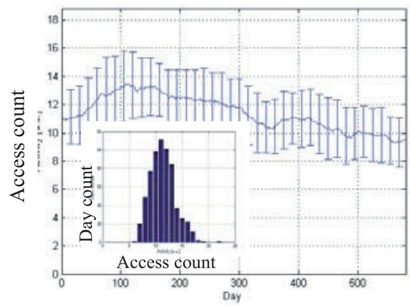

Figure 4: Bathroom access count.

More synthetic, "automatic" indicators can be worked out: in Fig. 5, the "long-term trends" extracted from the plot in Fig. 4 are shown. To obtain such trends, a regression line is computed along a relatively wide, moving window; the slope of such line is assumed as the trend indicator. Positive values stand for increasing activities, whereas negative figures indicate decreasing activities. Based on the above tools, a set of simple "flags" can be worked out to detect "abnormal" behaviors:

1) "Out of range" - Whenever the current activity figure deviates significantly (i.e., exceeds by a given threshold) from the normal range, a caregiver warning can be issued.
2) "Too fast increase/decrease" – if the trend figures introduced above exceed a given threshold (even if the activity magnitude is within the proper range). See Fig. 6.
3) "Too long increase/decrease" – if a prolonged activity increase/decrease is observed (even if the slope is within the proper range). See Fig. 6.

Of course, thresholds (both intensity and duration) in the above flags need to be sensibly settled and may need to be adapted to the specific subject at hand; for this reason, a test campaign is being carried on, involving several sites under the control of a shared supervision facility.

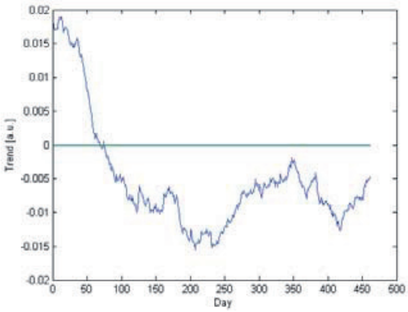

Figure 5: Trend evaluation.

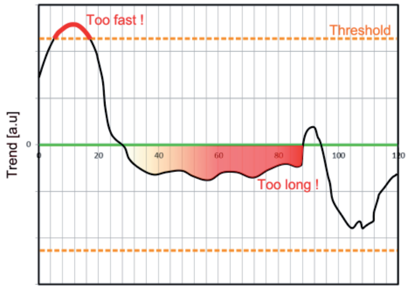

Figure 6: Flags example.

3. Results and Discussion

Besides the simple application shown so far, the approach and the developed tools can be applied to any (set of) sensors within an AAL environment. Meaning (and meaningfulness) of analysis outcome depends, of course, on the specific kind of observed device(s) [9,10,11]. The perspective application spectrum is therefore much wider than presented here. Basic advantages lie in the inherent low added cost (just exploiting already available data) and in low intrusiveness and burden to the user.

It is worth highlighting that analyses shown here are carried out in a retrospective mode, i.e., looking at data collected in the past, whereas the usefulness of such a tool should come from real-time use; i.e., caregivers should be given early prompts of changing behaviors, possibly well before they become evident to human observation.

The approach does not claim to provide clinical interpretation of such changes, but just aims at providing caregivers with simple, easy-to-compute, warning flags, capable of drawing their attention to phenomena which may remain unnoticed otherwise (for instance, due to their inherent slowness or due to the lack of constant caregiver presence).

To this regard, it is of the utmost importance to involve caregivers and physicians in the tuning process, exploiting their knowledge of the subjects and their professional sensitivity. Also, adoption of such analysis methodology on a larger number of sites (as being currently done in Parma) will allow for building a larger knowledge base, useful for better calibration of the methodology and to identify more robust and reliable indicators.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1126

Remembering the Old Days – Designing Tangible Tabletop Games for the Elderly

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Abstract. The literature has shown that normal ageing is associated with a decline in sensory, perceptual, motor and cognitive abilities. This decline contributes to isolation and depression. We argue that tangible tabletop games have potential for enhancing the life quality of the elderly. This potential has not been fully explored. This paper aims to explore this potential by designing tangible tabletop games to help the elderly to remember and talk about the past.

Keywords. Tangible, Multimodal, Tabletop, Ageing, Memory, Cognitive Rehabilitation.

Introduction

The elderly population in many industrialised countries is increasing significantly and will continue to grow in the future. According to the literature, normal ageing is associated with a decline in sensory, perceptual, motor and cognitive abilities. The effects of ageing on motor abilities generally include slower response times, coordination reduction and a loss of flexibility [11]. The decline in motor ability is a problem for many older people when using computer mice. A double-click is found to be very difficult, if not impossible. Reduced motor skills also cause more errors during fine movements. Both hearing and visual perception worsen with ageing. Ageing also causes the short-term memory to retain fewer items, the working memory to be less efficient and the perspective memory, that is, the ability to remember, to be reduced when complex tasks are involved [4]. In addition, certain ageing-related diseases, such as arthritis and Alzheimer's are becoming more and more common. According to the World Health Organisation, it is estimated that 0.441% of the world's population will have dementia in 2015 and the prevalence will increase to 0.556% in 2030. The various declines contribute to a loss of confidence, which may cause isolation and depression and lead to difficulty in learning, and sometimes hinder the use of new technologies. In fact, studies such as that by Cornwell and Waite [3] have shown that social disconnectedness (e.g. a small social network, infrequent participation in social activities) and perceived isolation (e.g. loneliness, perceived lack of social support) have distinct associations with physical and mental health among older adults. Hence, social activities and engagement are found to be important for the well-being of elderly people.

With information technologies becoming commonplace in society, the opportunities and necessity for elderly people to access these technologies in their everyday activities

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have been increasing. Human-computer interaction must be designed and implemented so that age-related challenges in functional abilities are taken into account. More natural and intuitive interfaces such as digital tabletops/surface computers and Tangible User Interfaces (TUI), therefore, are gaining popularity among the elderly. Compared with traditional user interfaces using a mouse and keyboard, these interfaces have the advantage of simplicity; they require less learning time. For older users, who may operate a mouse or keyboard with limited speed and accuracy, these interfaces can make applications more accessible.

In this research, we aim to explore the potential of tangible user interfaces for enhancing the life quality of the elderly. This paper presents the design of a suite of tangible tabletop games to help the elderly to remember the past.

1 Tangible and Multitouch Tabletop User Interfaces for the Elderly

1.1 Multitouch Tabletop Interfaces

The multitouch tabletop interface is one of the post-WIMP (Window, Icon, Menu and Pointer) technologies and provides a shared interface to support interaction among co-located users. Post-WIMP interfaces are considered to be more natural and intuitive than traditional WIMP interfaces. Such technologies provide more opportunities for flexible collaboration compared with traditional WIMP interfaces through allowing face-to-face interactions and multiple simultaneous inputs from several users. The characteristics of the multitouch tabletop have advantages over traditional computers with a mouse and keyboard. These characteristics provide special affordance for interactions. For example, the touch screen allows for direct manipulation of digital objects on the surface. It also provides the possibility of non-verbal and gestural communication; large physical space allows for face-to-face interactions among multiple users. It is also more inviting and allows users to interact with larger shapes and more objects compared with smaller screens (e.g. iPad); multitouch allows for the simultaneous manipulation of objects. It is suitable to support social activities; the tabletop supports intuitive and natural interactions and allows for rough motor skills and imprecise manipulation. It is advantageous compared with a mouse pointer [2]. Studies have shown that older adults found that the tabletop interface is less intimidating, less frustrating, and less overwhelming than a traditional computer [10].

Several studies have focused on developing games on multitouch tabletops for the elderly. For example, Annett and colleagues [1] developed a multitouch tabletop system, the AIR Touch, which combined existing multitouch technologies with a suite of new rehabilitation-centric applications taking advantage of the affordance offered by the multitouch tabletop technology. Mahmud et al. [8] designed a tabletop game for older adults. The tabletop game was tested against a traditional board game and found more engaging by the older users. Gabrielli et al. [5] also created a single-user tabletop card game for older adults.

1.2 Tangible User Interfaces

In contrast to traditional graphical user interfaces, where user input is basically through a mouse and keyboard, tangible user interfaces (TUI) merge physical objects with digital information. The digital information associated with an object of the TUI can be accessed or modified directly by interacting with it. Tangible user interfaces interlink the digital and physical worlds. Drawing upon users' knowledge and skills of interaction with the real non-digital world, tangible interfaces show a potential to enhance the ways in which people interact with and leverage digital information [12]. The form of the tangible objects can be chosen freely, so it is possible to use objects with which the users are familiar. This familiarity of tangible user interfaces has the potential to make applications more accessible to the elderly users, even those without prior computer knowledge [13].

Applications with tangible user interfaces have also been developed for the elderly. For example, Guía, Lozano and Penichet [6] developed two collaborative tangible games for the cognitive rehabilitation of people suffering from Alzheimer’s.

One of the most relevant studies is on Nostalgia [9]. It is a tangible application for the elderly to listen to old news and music from the twentieth century. Nostalgia consists of an interactive textile runner and an old fashioned radio placed on a table. The runner is divided into sections representing decades (from the twenties to the seventies). Users interact with the interface by pressing somewhere on the runner, and the chosen music or news will be played on the radio. The evaluation showed that the elderly learned very quickly how to use it, and they enjoyed the application. They talked about subjects related to the news and sang along to the music they heard.

2 The Design and Development of the Game Suite

This project adopts a user-centred design approach. Two dedicated elderly users are involved in the whole process of design, development and testing. Additional elderly users participate in the testing after major iterations. Various methods such as observations, interviews and focus group discussions are used to collect feedback on the design of the games.

Based on the discussions and feedback, a suite of tangible tabletop games have been designed. They can be played individually and/or in a group. These games are for entertainment, enhancing memory and encouraging social and communicative activities.

Observation and informal conversations with the elderly show that cards were a popular and frequently used game element [8]. Many elderly people play some kind of card game. We therefore decided to include this familiar element in the games. Cards are made tangible for the users to interact with in the system. Each card has a picture or the name of a person or information about an event on one side and a tag on the other side.

Taking into consideration the constraints caused by ageing, the user interface is designed to support multimodal interactions [7]. The combination of different modalities such as physical objects, touch, text, video and audio provide users with different means to interact with the system. The games are implemented on a multitouch tabletop, Samsung SUR40 with Microsoft PixelSense. This allows for direct interaction by the fingers without the need for a mouse or keyboard, and multiple users can interact with it simultaneously. It can also recognise the presence and orientation of tagged real world physical objects placed on top of it. Hence, it allows non-digital objects to be used as input devices. The games are programmed to recognise the unique values of the Byte Tags (Figure 1) and respond to them with actions.

In the remaining part of this section, we will present three examples of games from the game suite we have developed. These examples demonstrate the main idea and design in this project. All the games can be played alone or with others. When playing in groups, players can collaborate with each other.

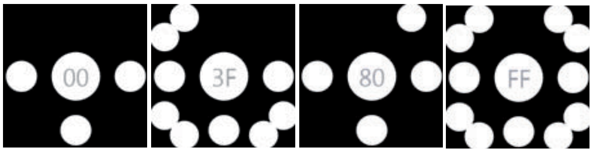


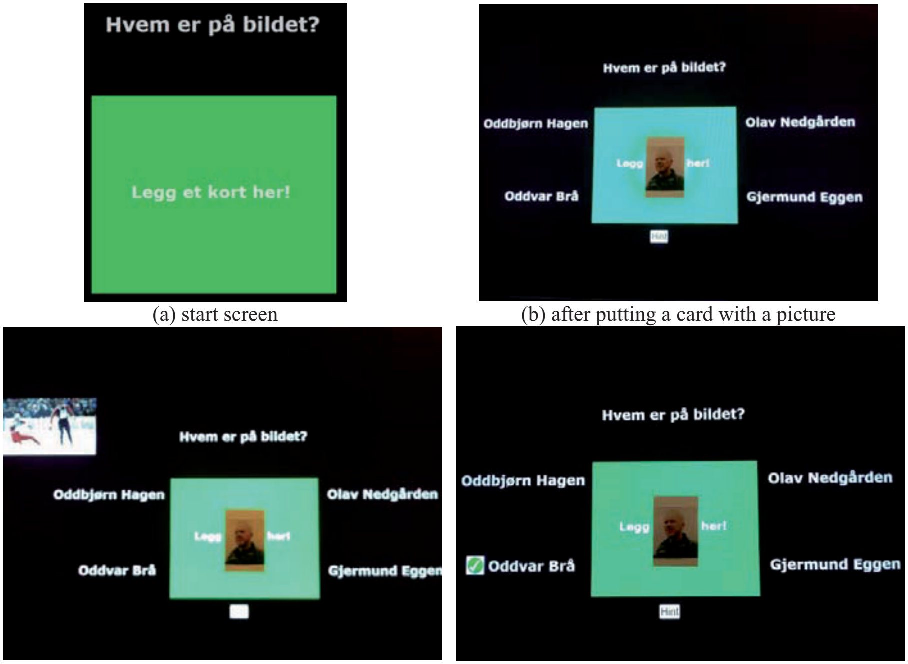
Fig. 1. Example of tags used in the games.

2.1 Who Is in the Picture?

In this game, the user is provided with a set of cards, on each of which is a picture of a popular figure from the past. When the user puts a card on the table, four names will appear beside the card. The player chooses one by touching it. If the answer is correct, an icon for the correct answer is shown beside the choice and extra information (e.g. about what the person is famous for) will be displayed on the table or an audio/video clip is played.

Figure 2 shows a sequence of screenshots in the game. The story behind it is that at the 1982 FIS World Ski Championships in Oslo, Oddvar Brå took the last leg in the 4x10km relay in cross-country where he was in close competition with Alexander Zavjalov from the Soviet Union. Right before the finishing line, his ski pole broke. This created a big commotion among the audience. The TV commentator shouted, “Give the man a pole!” Han managed to finish it with one pole and crossed the line at the same time as Alexander Zavjalov. So Norway got to share the gold medal with the Soviet Union. The dramatic finish became a memory for most Norwegians, leading to the popular all-Norwegian expression "Hvor var du da Brå brakk staven?" ("Where were you when Brå broke his pole?").

The game starts with (a) where the user is asked to choose a card from the card deck and put it on the green area on the table. When the user has done so, the table shows four different names for the user to choose, one of which is the correct name. There is also a Hint button. If the user touches the Hint button, depending on the person on the card, a picture or a video will be shown, or an audio clip will be played (c). The picture or the video can be moved and rotated; so all users have the possibility to see it with the appropriate orientation. When the user touches the correct name, an icon will appear beside the correct name (d) and a relevant audio clip will be played. In this example, the audio played is “Gi mannen an stav” (“Give the man a pole!”) by the TV commentator.



(a) start screen
(b) after putting a card with a picture
(c) after touching the Hint button
(d) when touching the correct name

Fig. 2. Screenshots from "Who is in the picture?".

2.2 *Who Sings the Song?*

In this game, the user is given a set of cards and on each card is the name of a popular singer from their younger days. The table shows a speaker icon first. When the user touches the icon, the table will play a song. While the song is playing, the player chooses one name card from the card stack and places it on the tabletop. The user can ask for a hint, ask for the correct answer, pause the song, sing along or choose the next song. Figure 3 shows the picture of the singer after the user touched the Hint button.

Fig. 3. Screenshot from "Who sings the song?" (featuring Leif Juster).

Fig. 4. Screenshot from "Talking about the past' (featuring 1952 Winter Olympics in Oslo).

2.3 Talking about the past

In this game, the users are given a set of cards and on each card is a picture of a famous image from a certain period or a special event in history (e.g. the 1930's, the second world war, after the war, EU membership, Vietnam war, etc). When a card is put on the table, a list of prompts is shown beside the picture in order to help to trigger memories. Users follow the prompts and talk about what happened, their feelings, and associated memories. They can also ask for hints or the correct answers to the questions. Figure 4 shows the screen when a card is put on the table and the Hint button is touched.

3 Conclusions and Future Work

The limited research with tangible and tabletop technologies for the elderly has shown that these technologies have potential in offsetting the negative effects of physical, cognitive and social ageing. The research goal of the project is to develop tangible tabletop games for the elderly and demonstrate the value and further explore the potential of tangible tabletop games in enhancing the quality of life for the elderly. In this research we have adopted a user-centred approach and designed a suite of tangible tabletop games helping elderly people to remember and talk about the past.

Currently we are finalizing and fine-tuning these games based on the feedback from users. Orientation and size of the table is one of the known problems with tabletop interfaces. In the games, only some of the elements can be moved and rotated. We found that when the users do not sit in the right direction, they normally ask the people sitting on the other side to read for them. In the future, we can also consider that all textual information can be read out by the system if the user chooses to do so. We plan to conduct a formative evaluation of the games in the near future.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1133

The Role of IT Technology in Ambient Assisted Living and the Assiduous Involvement of EDeAN Network in AAL

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Abstract. In this paper, we focus on putting into evidence the role of the computers, computer networks, mobile devices and sensor networks in order to interfacing the ambient with the humans in a very efficient way, even enlarging the ambient feeling towards the perception of cultural values connected with a certain geographic area, layered in the historical time. The role and the importance of EDeAN network in AAL will also be pointed out.

Keywords. IT technology, Ambient Assisted Living, Design For All, crowd-sourcing, geocriticism

Introduction

Concerning the Ambient Assisted Living (AAL), the role of computers, and moreover the role of IT technology is huge. Just speaking about the networking, which is crucial to assure crowd-sourcing, based on collaborative, inter-disciplinary participation with ideas and solutions for AAL - as in every human knowledge domain, the computer networks, and especially the Internet, represents by default the universal solution of our days.

When speaking about the most spectacular approaches targeted to assure independent living for any kind of human categories, and consequently improving human life at a general level, a wide range of dedicated microprocessors and/or microcontrollers based devices represents, in many cases, already usual solutions. Smart sensor networks, various mobile devices, wireless connectivity and all this kind of infrastructure, is already aimed to offer the basis for more and more spectacular innovative solutions in the domain of AAL.

More exactly, in our days, the computers, connected in computer networks, together with all kind of mobile devices and sensor networks, has the spectacular and even surprising role (from certain point of view), to manage the interface between the ambient and the human beings. The quality of this new kind of interfacing the ambient with the humans, depends on the quality of the implementation, in terms of IT&C technology, both of the interactions between the humans and the ambient through computers and/or mobile devices, and on the capability of such IT systems to connect and capture, as directly as possible, the real world, in order to offer a more much wider contact of the humans with the ambient, than it is possible just by existing in a certain place in a certain moment.

1. Ambient Assisted Living through IT Solutions, Related to Major Cultural Events

Taking into account also the major role of the intellectual and cultural needs of today's humans, a very important role in this direction is played by the fusion between the living solutions enhanced by IT technologies, and IT technology based knowledge acquirement and sharing targeted computerized environments and tools. Here, the role of the web is obvious, his importance in the domain of teaching and knowledge sharing e-learning tools being presented in details in our former materials [2], [3], [4].

A newest approach about cultural values sharing, by means of Design For All (DFA) principle based web platforms, may be directly linked with such major socio-cultural events, which are currently organized in the context of European Union in our days. The fact is that, in each year, one of the European cities is host for the Cultural Capital, other European city is host for Youth Capital, such events bringing the European people together, around the socio-cultural values of such an European city which has remarkable socio-cultural values with European dimensions. In order to enlarge the accessibility to these events and similar ones, their extension by virtualization is the best solution, and here the principles of Design for All are crucial.

A concrete occasion to implement this approach is given by the fact that our vision about the organization of European Youth Capital in 2015 has, as major focus, the total virtualization of the event. This being obviously a quite challenging approach, the work is started in the context of a consortium which is part of a new born IT Cluster (the Cluster ClujIT of the IT companies and IT oriented academic entities).

The principal concepts and functional entities of this platform, will be centered on the general structure detailed as follows:

1.1. Main Functional Modules of the "Youth-Capital" and "Cultural Capital" Type Events Virtualization Platform:

- ***Module 1***: CMS (Content Management System) based - to manage the pages with standard contents
- ***Module 2***: Photo&Video Gallery Module
- ***Module 3***: News management system
- ***Module 4***: Events
- ***Module 5***: Testimonials

All these functional modules will embed IT solutions aimed to assure full accessibility from mobile devices, for which will be developed special interfaces aimed to facilitate the universal access of all the people categories, including people with various kinds of disabilities.

1.2. Integration with Facebook and Twitter

The web platform will integrate direct links to the functionalities of the most important social networks (Facebook and Twitter), as follows:

At the level of the main page (home-page): follow on Twitter, like on Facebook, last tweets, Facebook Social Plugin;

At the level of News/Photo&VideoGallery: Share on Twitter and Facebook, Like on Facebook.

1.3. Other Features

The web-platform will have friendly (human readable) URLs and SEO.

The Sitemap will be generated dynamically, based on the current structure of the site, considering the incremental development of the site/sub-sites). Each sub-site will have the own sitemap.

Here, BreadCrumbs Level1/Level2/Level3 can prove useful for persons with an intellectual impairment. [5] [6]

1.4. Internationalization

The site will be accessible in at least six languages: Romanian, English, French, Italian, German, and Hungarian, for other languages, volunteers will be welcome to translate, but as automatic solutions, the Babelfish or Google translate API /plug-ins are potential mechanisms which may be involved here. [5][7][8]

All pages according the structure of CMS will be translated from the back-end.

All content elements, despite their type (Photo Gallery, News, etc) will be translatable.

1.5. Map-based Event Localization

In order to produce the total virtualization required by the „live-visiting" effect by mean of the functionalities of the web platform, a map-based event localization and remotely visualization component will be integrated in the context.

2. The Role of EDeAN

As the EDeAN network is already known for his active involvement in DFA, e-accessibility for all and AAL [1], the contribution of his members with good ideas, may consolidate the necessary DFA, e-accessibility for all and AAL related know-how, as a solid base aimed to assure an exhaustive approach concerning the implementation of all possible universal accessibility mechanisms in the context of the web platform. This is the reason why we were already started a "brain-storming" with all the EDeAN network members on this subject, aimed to produce firstly a set of useful ideas, as large as possible.

The next step will be done by collaboratively working on the concrete design and IT implementation aspects, which are related to the needed "e-accessibility for all" features, identified by means of the initial brainstorming mechanism.

The most important in this approach is to be able to prove the value of the so-called "crowd-sourcing", applied in obtaining the best results in conceiving, designing and implementing DFA, e-accessibility for all and AAL principles based socio-cultural value sharing web platforms, as efficient mechanisms to enhance the socio-cultural perception, knowledge level and positive, human cohesive behavior of all.

3. Accessibility for All Assured by Putting Together All Good Ideas Captured by "Crowd-Sourcing" between the Edean Members

In all our approaches (including the major cultural events virtualization platforms) we implement the Web Content Accessibility Guidelines (WCAG) 2.0 standard/Level AA of conformance [9].

The design is following, in particular, the sections 1.4 of this standard, with particular accent on criteria 1.4.1. Use of Colors, 1.4.3. Contrast, 1.4.4. Resize text.

These criteria address especially the following types of users, by enabling them to access the features of such web platforms :

- Users with partial sight, who often experience limited color vision.
- Some older users, who may not be able to see color well.
- Users who have color-blindness, who benefit when information conveyed by color is available in other visual ways.
- People using text-only, limited color, or monochrome displays, who may be unable to access color-dependent information.
- Users who have problems distinguishing between colors, who can look or listen for text cues.
- People using Braille displays or other tactile interfaces, who can detect text cues by touch.
- People with low vision often have difficulty reading text that does not contrast with its background. This can be exacerbated if the person has a color vision deficiency that lowers the contrast even further. Providing a minimum luminance contrast ratio between the text and its background can make the text more readable even if the person does not see the full range of colors. It also works for the rare individuals who see no color.
- People with low vision, who will be able to increase text size in content so that they can read it.

Another important section of the WCAG standard is related to the navigation (section 2.4) [11]

The implementation of this set of criteria, grouped in section 2.4.-Navigation, brings the following benefits

- Screen reader users who visit several pages on the same site can avoid having to hear all heading graphics and all navigation links on every page before the main content is spoke
- People who use only the keyboard or a keyboard interface can reach content with fewer keystrokes.
- People who use screen magnifiers do not have to search through the same headings or other blocks of information to find where the content begins each time they enter a new page.
- People with cognitive limitations as well as people who use screen readers may benefit when links are grouped into lists
- Users can quickly and easily identify whether the information contained in the Web page is relevant to their needs.

- Users who rely on the keyboard to operate the page, by letting them visually determine the component on which keyboard operations will interact at any point in time.

Being obvious that, without this kind of computerized assistance, the contact of some people with the ambient is limited, we focus on involve and also enhance all methods oriented on e-inclusion, e-accessibility for all and DFA.

4. Geocriticism as an Innovative Way to Connect the Ambient to the Cultural Values Perception

Another direction of our approaches targeted on enhances and enlarge the relation between the humans and the ambient, is oriented on promoting the ambient elements at the level of so-called “cultural value rich ambient”. This concept is integrated in the field of geocriticism, which holds as a main goal the study of space in literature and art from an interdisciplinary perspective. For a better understanding of the concept, geocriticism is an innovative theory which benefits from the very beginning an interdisciplinary vocation and uses a multifocal perspective. At the same time, geocriticism is an analysis method that does not only focus on time data, like the relations between the life and time of the author, the history of the text, but also takes into consideration the space data. This research method assumes a literary referentiality between the word and the text; in other words, between the referent and the representation. Another innovative aspect of our approaches is given by the fact that we apply the study of Geocriticism in the field of Humanities.

As for the practical approach, the software component, which will ensure the upload of the fundamental concepts database (ontology), corresponds to an explanatory system, whose functionalities will be accessible at the level of the User Interface of the platform, placed on the web in view of ensuring the necessary ubiquity and maximum connectivity of the primordial resources at hand. The inferential logic component of the expert-system core, accessible and configurable at the level of operating interfaces of the platform, will contribute, together with the generate/edit knowledge base component, to the configuration and upload of specific knowledge, organized in literary genres, authors, temporal hierarchies and GIS compatible geographic location. Organizing the information in the database recordings will allow the generation of complete cultural data specific to the selected geographic locations, the generation of such cultural itineraries, which are guided by the creations of a certain author, as well as the tracking of a certain theme through mapping that, resulted from the fusion of thematically correlated recordings.

As main final results there will be: the generation of a mapping component of concrete field areas; a functional model of the cloud platform on the software system dedicated to geocriticism research; a functional model of the kernel-system of knowledgebase generation, knowledge accumulated by means of research, a place where a geocriticism database collecting information about the literature and art in the targeted field area will be uploaded. In such a way, the users will enjoy the results of collecting the cultural values of a certain region and also benefit from the geo-location facility offered by the mobile devices, which in fact resides at the basis of easing complex experiences that allow tracking a geographic route loaded with time stratified values of the cultural thesaurus, specific to the successive geo-positioning of the tracked geocritic route.

5. Conclusions and Further Approaches

Connecting the concepts of DFA and Geocriticism, as well as some features of the so called NFC (Near Field Communication) techniques [12], it is possible to assure ambient assisted living platforms targeted to offer intuitive, geo-contextual, multidimensional feeling of the environment, including the cultural dimension, layered also in time, so localized both in time and space.

Face to such an approach, it is very important to involve all good experience regarding e-accessibility for all and Ambient Assisted Living for all. Taking into account the points of interest and good experience of the EDeAN network members in these fields, it is obvious that the contributions issued from their part will consolidate an exhaustive achievement in these directions.

On the other hand, the necessary interdisciplinary context is assured only by collaboration between IT specialists - who are to outline area's cultural representations by creating a series of web applications using the GIS technology as a source, and human science specialists (like specialists in literature, history, arts, and sociologists).

In this way, also the role of the computers, mobile device networks, sensor networks will turn from the "cold" calculus prior target to the role of interfacing the ambient with the humans, enlarging the direct human perception of the ambient with his cultural/scientific dimension, identified based on the specific methods of geocriticism.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1139

Design for All and Mainstreaming in Ambient Assisted Living e-Service to Support Management of the Personal Economy

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Abstract. Managing the own economy via Internet is becoming increasingly necessary. People with cognitive disability and older persons do not often have access to e-ID. Efforts have been made to manage the own economy via mainstream services. The network of EDeAN with its knowledge about standardization and DfA could be a resource to develop a strategy or road map for aiming for accessible e-Bank Services for All.

Keywords. Design for All, e-Services, Personal Economy.

Introduction

For 17 years, Internet access in Sweden among the population has increased on an annual basis, from 2 percent in 1995 to 89 percent in 2012. [1]Now the spread has begun to taper off and is no longer increasing among those over 18. However, use among those who already have access to the Internet continues to rise. Daily Internet use has increased among all age groups except older persons. The greatest increases occurred among school children aged 9-11.

According to the report mentioned above more than 1,2 million people remain outside the Information society or the Internet. There are also persons who do not or seldom use the Internet. First of all this this concerns people over the age of 45. The main motive is that they have no interest in using the Internet. The real reason behind the expressed lack of interest is not investigated.

1 Special Solutions or Mainstream Services

An important instrument to have access to e-Services provided by agencies and banks are e-ID. Still half of the Swedish population lack e-ID. Not much has happened the last years in this area. Only 19 percent of persons 65 years old and older persons with low education or low income have an e-ID, compared to 90 percent of people with high education in the ages 26 – 45 years old. Many old persons do not use e-Commerce. Neither they pay their bills on line.

[1] Internetstatistik (2012)

Since many years there have been assistive products available for people with disability with the aim to compensate for disabilities. The products have stretched from low-tech to very advanced applications or products. With the emerging ICT domain there has been an increasing grey zone in between assistive products and consumer technology products or services. At the same time more and more it has become important to be part of the mainstream systems and services. Otherwise you risk to be excluded from some services or opportunities. The positive development has meant that more and more people with disability can make use of mainstream technologies. This means also that the service can be produced at a lower cost and with less risk for stigmatization.

2 Handling or Management of Own Economy

The Swedish Institute of Assistive Technology (SIAT) has been involved in development projects together with different organizations with the aim to provide end users with more accessible e-Services to handle the daily household economy.

Managing money and being able to pay the bills is expected by people to be done by themselves, but for many groups in society, this is a great challenge. A person with a cognitive impairment has difficulties with planning and structure. Abilities that are essential when making a budget and allocating income according to expenditures.

In a report 2011 "Internettjänster för äldre och personer med funktionsnedsättning – möjligheter och begränsningar" (In english: "Internet services for older persons and persons with disability - possibilities and limitations")[2] it was stated that the service among older persons and people with disabilities that was most important was bank e-Services.

As the number of bank offices are being reduced and the banks administrative charges are being raised dramatically it has become even more important to manage the Internet for daily life handling of ordinary expenses, like paying the bills for the apartment, telephone services, electricity, heating, garbage collection etc.

e-Commerce has increased over the years. One contributing factor to this is that concerns over credit-card fraud have declined, particularly among older persons. In the year 2000, 72 percent of the population was concerned about credit-card fraud, nowadays the percentage that is concerned has fallen to 21 percent, according to the report Swedes and the Internet[3]

3 e-Services

Well-designed e-Services and accessible products could contribute to greater independence and increase participation or inclusion in the community. The aim with the activities from SIAT has been to support the development of solutions to handle the problems around the personal economy in such a manner that people with cognitive difficulties also can understand. It concerns how to demonstrate the status of different types of accounts, how much to spend per day in average, the concept of plus and

[2] Hjälpmedelsinstitutet (2010)
[3] Internetstatistik (2012)

minus and supporting a sound handling of the budget limitations in the household economy.

One service SIAT supported financially with a loan was a concept “Web service overview”. The idea behind had a company developed. It included a gathering place for consumers everyday economy where the economy was presented clearly in the form of graphs. The company had some success initially, attracting numerous people subscribing for this service. Hinders or problems related to limited recources to develop a nice interface and fulfilling new stricter requirements from the bank sector with reference to the concept of firewalls ended this idea. Up to that moment the banks involved had been quite positive and interested.

Another track SIAT has been involved in concerns supportive measures to develop apps for Smart Phones for managing household economy. The idea behind the app was to provide a simplified accounting software, where you could not in principal create a deficit on your bank account.

The project was driven by a consulting firm in collaboration with one of the bigger banks in Sweden and user organizations. The financing of the project was retrieved from a Government Mission aimed to develop better services for people with psychiatric disability. The idea was to build on a collaboration where the Consulting firm developed an e-Bank Service concept shoulder to shoulder with the bank, where each partner knew the other partners needs and requirements. It was a challenge to create an attractive app-service, with the aim to build a general e-Bank Service to everyone. The result was a design of the functionalities, the interface and the different deliverables from the app. The idea included i.e. a card purchase registered by the bank, the bank sends the information to the buyers mobile application, the app visualizes the purchase in a clear manner. In this way the user can understand the consequences of a purchase.

By “translating” abstract concepts to images it makes it easier for people with cognitive disability to understand money and its value. This is to support people at risk of falling into destructive behavior and support people before they become indepted.

People with cognitive disability considered this type of general e-Service as something of a base. But depending of the prevailing disability it could be need for more specific services or interfaces complementing the more general services, like support for people with visual impairment, cognitive disability or people with dyslexia.

Also this project faced some hinders related to limited economic resources and different priorities within the bank sector.

In general hinders for wider dissemination of mainstream e-Services are lacking e-Accessibility, the need for training of end users, problems with interoperability, economic restrictions and lack of support.

The hinders could or should probably be dealt with by different stakeholders. To find the common ground or interest is crucial. It is crucial to overcome the fears that might exist within mainstream companies when it comes to DfA and fears among producers of assistive products or services when it comes to co-operation with mainstream companies.

Recently SIAT has been involved in a development – standardization-project, funded by the Swedish Government, concerning social alarms. In that Government Assignment the starting point was a fragmented market with no co-ordination between producers of social alarm equipment, broadband or telecom operators, providers of social alarm receptions, end users, municipalities etc. After a joint work a common ground could be settled where all actors could see a win-win situation with a new social alarm scheme based on a completely coherent digital social alarm service.

4 EDeAN-network

Trying to make use of that experience and other experiences when it comes to e-Bank Services one driving force could be the involvement of organizations and people dealing with standardization. The aim would be to create a common ground where all stakeholders from user representatives, assistive products/services and mainstream providers of different kind of services including the bank sector could see the potential and together build a BIGGER market together by providing an arena where a dialogue about requirements and benefits could be addressed.

With EDeANs experience and network it could be useful to look into the possibilities for EDeAN to have a role when designing a road map.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1143

FOOD: Discovering Techno-Social Scenarios for Networked Kitchen Systems

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Abstract. The FOOD AAL-JP project is introduced, which brings AAL concepts within the kitchen environment and deals with technical devices as well as social applications design. The large and competitive market view makes mainstreaming and DFA concerns mostly relevant. Participatory design tools have been exploited to get users involved since the early design phases and to spread awareness of the users' perspective among the project partnership.

Keywords. Ambient Assisted Living, User Centered Design, Design Research, Wireless Sensor Networks.

Introduction

The way food enters our life is changing. Having food, besides being a vital need, has always had profound implication in social life: in the recent decades, however, food issues impetuously came to the forefront of many social and leisure activities, pervasively entering our lives in many and complex ways; this holds especially true for people getting older, for several reasons:

- keeping healthy implies more attention to nutritional issues: people need to mind more about eating;
- after retirement or after the own partner passes, more time is spent at home, looking after house (and kitchen) chores;
- dealing with food preparation may become more demanding, difficult and tiring, due to motion, sensorial or cognitive age-related impairments;
- also due to the above, food (and food talk) is an effective way of keeping socially engaged and to share time with relatives and friends.

Food can be a key component in fostering independent life of elderly people. So the kitchen (which is already among the most technology-intensive spaces in the home) is quite a promising, yet challenging, field for introducing Ambient Assisted Living technologies. In this abstract, the AAL-JP project FOOD (a **F**ramew**o**rk for **o**ptimizing the process of fee**d**ing) is presented, which aims at enabling elderly people to deal with feeding and food-related tasks in a safe, effective and rewarding way.

In particular, besides a short overview of the technologies involved, we shall focus at a couple of aspects, mostly relevant to the project effectiveness and impact: *i)* the manufacturer perspective, discussing how AAL and assistive concepts may enter the mainstream industry production, and, *ii)*, the user's perspective, reporting how fieldwork with real people inspired the overall FOOD concept generation.

1. FOOD Project Overview

The FOOD project [1] involves 9 partners from 5 European countries. The consortium is led by Indesit Company, among leaders in the Europe "white goods" market.

The FOOD system relies on a technical infrastructure, made of **sensors** (watching over kitchen safety, for instance), smart kitchen **appliances** and user's interaction tools (**interfaces**), building a kitchen **networked environment** which, in turn, is connected to wider, external physical and digital networks (i.e., neighborhood community and shops and more in general the web). Based on such infrastructure, **services** will be provided to the user's.

FRAMEWORK FOR OPTIMIZING THE PROCESS OF FEEDING

Indesit Company SpA, IT
Ass. Naz. Mutilati ed Invalidi del Lavoro, ANMIL, IT
Brainport Development N.V., NL
Copenhagen Inst. of Interaction Design, CIID, DK
Dept. of Social Services, Local Council Brasov, RO
Internat. Business School, Jönköping University, SE
Consiglio Nazionale delle Ricerche, CNR, IT
Università degli Studi di Parma, IT
SC Vision Systems SRL, RO

Figure 1: FOOD project logo and partnership.

The basic FOOD system architecture is illustrated in the figure 2 below: the peripheral layer of the system includes kitchen appliances as well as environmental and personal sensors. Field devices communicate

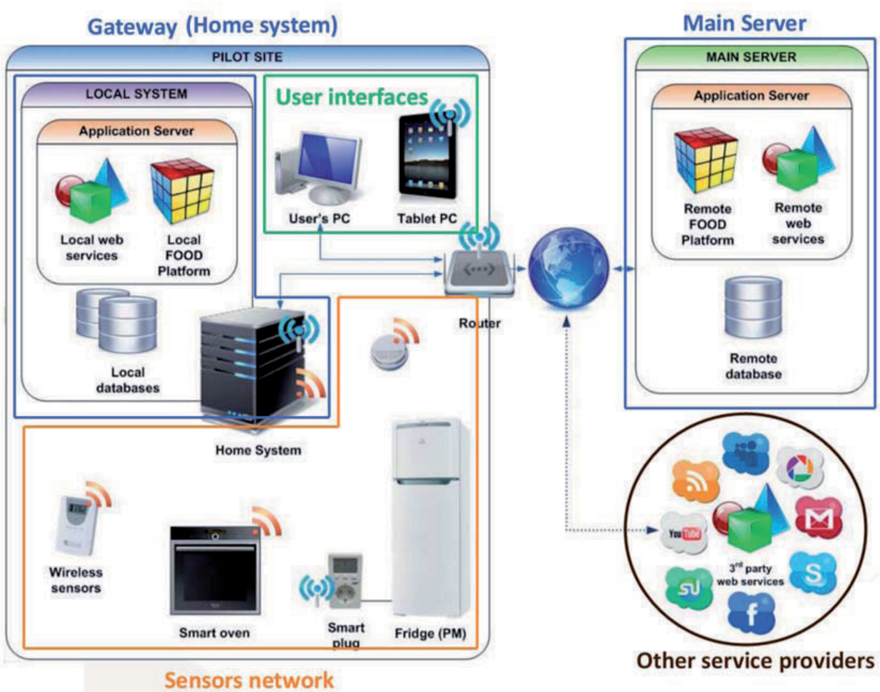

Figure 2: FOOD system architecture.

with the FOOD system through a "gateway" box, which exchange information with the field and with User's Interfaces. All devices (appliance and sensors) wirelessly communicate by exploiting the IEEE 815.4/ZigBee protocol. Supervision layer will exploit the CARDEA [2] architecture, and will take care of acquiring data from the field (irrespective of their actual origin), implementing local operating rules and managing high-level communication between devices. On the opposite end, the supervision layer will made field data available to higher-level layers and to applications, by storing them on a suitable database. Data are made accessible to UI and external services through a webserver process, which allows for implement a Service Oriented Architecture, aiming at flexibility and interoperability. The web server acts as a front-end toward the database, making available to external users a set of web services for interacting with FOOD environment. Cloud-based services will access the FOOD database in the very same fashion of LAN-connected interfaces and services, except, of course, for the provision of suitable authentication and security features.

It is worth remarking that the "white goods" market is quite competitive, and there is currently no space for expensive solutions strictly dedicated to the "silver market": internal surveys have shown that people renovate kitchen apparatuses once or twice in their whole life, and is less prone to consider such changes when getting older. This implies the need of embedding AAL-oriented features into standard products, which, as a positive side effect, helps reducing the stigma of ageing and force designers to think in the frame of Universal Design [3]. Of course, this also implies to keep their costs as low as possible. Network connectivity, onto which FOOD application are built, however, is relatively expensive: to overcome such obstacle, we looked for synergies with other emerging technologies. More specifically, appliance connectivity [4] is also a basic building block for smart energy management, as well as for implementing remote maintenance (M2M and cloud-based) services; by considering the whole picture, the same technical element (the on-board network node) contributes to the solution of multiple problems, thus splitting its cost over different domains and making the solution more sustainable. Appliances involved in the FOOD project and pilots, indeed, will not be just prototypes functional to the project needs, but fully-standard devices, coming from the main production line, ready and certified for home use. I.e., instead of looking for *"a posteriori"* mainstreaming of project outcomes, we based the project itself on mainstream devices since the very beginning. This, of course, placed more stringent constraints on the design of further system components and stressed the need for inclusive design: specific appliance features devised by the FOOD project had to be validated against the industrial design needs and the widest possible user's target.

Introducing "design for all", according to the fundamentals given by Ron Mace [5], meant to the project accounting for accessibility and usability of aimed devices and services: to the purpose, reference were made to the International Classification of Functioning, Disability and Health (ICF), as well as the AAL Association declarations. Compliance with related guidelines, although quite demanding in some aspect, has been considered since the early beginning of the project.

2. Core of FOOD Services

In order to identify basic blocks for the services, a first list has been produced by the consortium, based on state-of-the-art analyses in both scientific and commercial environment: an overview of the market provided awareness of existing products and systems, whereas the scientific literature review gave hints about new ideas in this field and some preliminary evaluation criteria, with respect in particular to accessibility, usability and acceptability.
The resulting list includes three basic service clusters, called “Environmental Control”, “Food Management” and “Shopping”. The first cluster includes services related to energy consumption, environment control and safety. The “Food Management” cluster includes services related to food inventory, personalized recipes and so on. The “Shopping” cluster deals with services connected to grocery shopping, ranging from the compilation of a shopping list up to payments services.
At a higher level, a group of more complex services relevant to wellness monitoring, cooking learning, food-related social involvement have been devised, to be included in the final phase of the project and exploiting the above base-service clusters.

3. Users Participation in Service Design

The project exploits networking concepts not just at the technical level, and aims at further investigating the role that networks of people, when mediated and even enhanced by technology, can assume. Different networks can be recognized, pertaining to the project: users, caregivers, support network (like the neighborhood community), institutional stakeholders, researchers and technology suppliers. Basically, the project aims at having such networks eventually connected together: the intention of early design phases undertaken by project partner CIID were to investigate and elucidate for the rest of the research team, the contexts of use and potential design opportunities and related non-problem driven solutions that could help to improve the lives of elderly people as regards the food-habits in a constructive and holistic manner. Although the FOOD project starts with certain assumptions of technological infrastructure, we derive user context and multimedia expressions of this, in order to situated the project and development partners better in the culture of elderly people, and keeping these ‘users’ seen as ‘real people’ in the context of the project and its solutions. To this purpose, a thorough fieldwork was carried out, meeting perspective users from each pilot country and exploiting design ethnography tools, such as interviews, observation techniques and cultural probes [6] (e.g., diaries, postcards, and photos), designed to support different phases of the interaction with researchers. From each respondent, slideshows and short videos were prepared by CIID researchers and shared with the whole partnership. This raised awareness in all partners, providing them with user’s insights, and fostered a shift from the basic approach of “searching for user’s requirement”, to the discover of the “opportunity areas” listed in Table 1. Such areas (and their specific relationship with feeding activities) were subsequently exploited as discussion

Table 1.

FOOD Opportunity Areas
1) Proactive behavior against ageing watersheds
2) Keep Elderly involved in their context as active characters
3) Freedom to find theri own custom solutions
4) Food as a touch point of elderly social life
5) Support network as a scaffolding for elderly

guidelines while devising services. Actual services were identified, by cross-checking technical feasibility and emerging opportunities and ranging from basic, simple ones (related to the kitchen power or safety management) to more articulated examples, fully exploiting potentials of networking among devices (remote operation features) and among people (social-oriented applications).

In this phase too, tools were introduced to facilitate the development of service concepts within the consortium and to include users in such process: for each service, a "blueprint" [7] is conceived, mapping out every element and interaction of the aimed service as a logical sequence in time and context. In the blueprints, roles of the elderly and of her/his supporting network is highlighted. Also, commented storyboards were prepared to introduce services in a more intuitive and captivating fashion, allowing the user to get the service feeling without too technical hassle, and leading researchers to early identify critical interaction issues, or even to enact interactions they hadn't think of yet. The design cycle hence is iterated, building resulting services as a "social" construction upon participation of the whole spectrum of partners and users competencies.

It is also worth underlining how the FOOD approach, besides its primary technical goals, may provide fertile ground to the development of a much wider set of services, leaving ample space to the development of third-party applications. The FOOD communication and interaction facilities, in fact, can be made available to service providers, different from the white-goods manufacturer, enabling an open environment similar, with some respects, to "app markets" in the telecom market (on an inherently different scale, though). Simple examples may be thought of: a food producer could make available a set of personalized recipes and provide specific kitchen settings for its cooking; a patient's organization may provide food counseling for a given disease treatment; elderly grocery shopping can be simplified through monitoring of food consumption and e-commerce access...

A "multiple win" scenario can thus be envisaged: the appliance producer benefits from the increased appeal of its products, brought in by add-on services; the user may get more personalized and aimed services; new business opportunities are offered to third parties.

Such openness feature does not benefit the sustainability of the business view only: it may also enable cooperation with parallel initiatives, for instance projects addressing other aspects of daily life managements in the AAL community, or participating in networks aiming at overcoming disability and aging-related barriers [9, 10]. In a more general sense, the concept of open platforms can be considered as a way for facilitating mainstreaming of AAL solutions, as well as for networking initiatives, involving wider communities in the quest for useful solutions.

4. Results and Discussion

The project is about at halfway, and pilot starting (in Italy, Romania and the Netherlands) is planned at August, 2013. On the infrastructure side, a full prototype of the pilot kit has been demonstrated and is being tested. Main technical features include a complete set of safety sensors (flood, gas, fire), additional sensors needed for inferring kitchen activities (presence, opening drawers, doors, etc.), a tablet-based user interface and a set of smart appliances: a hob, a refrigerator and an oven. All the appliances can be monitored through the internet, and the oven can be remotely controlled and user-configured, enabling a set of innovative functionalities. As stated above, appliances are undergoing standard certification procedures, and will be ready-to-market well before the project's end.

On the service side, first service concepts have been validated (i.e., first iterations of participatory design sessions have been carried out). For instance, a couple of perspective services were discussed in a specific "co-creation" session: "Senior Chef" and "Cooking Academy" services were introduced, aimed at exploiting most of technical features of the FOOD system, at the same time stimulating users' experience in socially inclusive tasks[7]. Being the whole infrastructure not yet available at that time, storyboards, paper mock-ups and simulation were exploited, as shown in Fig. 3. One of the key concerns of the service and design-led teams on the project revolve around ensuring that the insights generated from these types of communications are understood by the community of researchers and technologist on the project. Agreement on these kinds of interdisciplinary boundary-objects for the communication of research across different fields and orientations (e.g.: technology versus user focused) is important to emphasize in projects of this kinds. Overall, returns from prototype and user-led process have been deemed encouraging, and similar processes will be replicated over the range of services. Pilot design is being carried out, accounting for evaluation tools and training of support teams: a relatively long-lasting pilot phase is planned, in order to effectively include pilot outcomes into the iterative, user-participated

design process introduced so far.

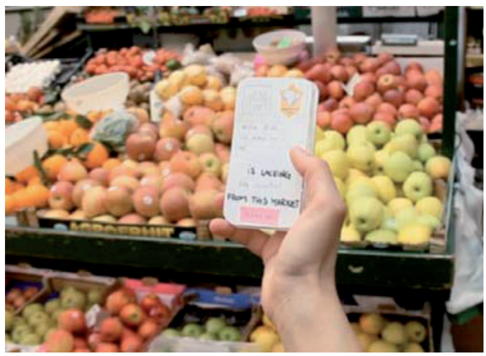

Figure 3: Paper mock-up for user co-creation session.

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Special Session on ICT-Based Learning Technologies for Disabled People

Special Session on ICT-based Learning Technologies for Disabled People

Education should be considered a basic right, but many disabled people experience barriers in accessing it. The focus of these sessions will be ICT-based learning technologies for disabled students and the associated pedagogical issues. In addition to computer based and multi-media learning technologies, mobile learning using smart phones and PDAs is now feasible. Disabled people may require access to both purely learning technologies and assistive technologies to to obtain the full benefit from education.

The two sessions have brought together a wide range of different types of papers (listed below). They cover technologies which are assistive in terms of giving access to either other technologies or education in general and technologies which directly support learning. The technologies address a wide range of educational contexts, including classrooms, mobile learning and the workplace. They comprise both technologies for disabled people in general and ICT solutions for specific groups of disabled people, including those with learning difficulties, hearing impairments and visual impairments. Learning topics and applications include sign language dictionaries, literacy support, independent living skills, on the job mentoring and training for assistive technology trainers for blind people. There are two papers which overview ICT learning technologies for disabled people, arising from the Enable Network for ICT Learning for Disabled People, one of which considers a new approach to classification of learning technologies, and the other a number of case studies of the use of ICT learning technologies. The papers also have a wide geographical spread, covering five European countries (Austria, Germany, Italy, Scotland (UK), Spain and three outside Europe (Algeria, Egypt and Tunisia).

The oral presentation session comprises the following six papers:

- Declarative transcription system for sign language dictionaries creation
- Classification of ICT-Based Learning Technologies for Disabled People: Outcomes of Enable Network Project
- A Web-based Interactive Multimedia Application to Support Independent Living at Home for Youth and Adults with Intellectual Disabilities.
- Innovative ICT solutions supporting students with Learning Disability and Hearing Impairments during classes
- A Virtual Hearing-impaired Listener (VHI)
- Mobile technology for illiterate education

The poster session comprises the following four papers:

- A new approach for animating 3D signing avatars
- IT4Blind
- Supporting mentoring on the job through social media
- ENABLE – collection and user evaluation of ict assisted learning for disabled persons in europe

Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1151

Declarative Transcription System for Sign Language Dictionaries Creation

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Abstract. Up to day, the majority of Sign language animation systems rely on 3D content dictionary. However, to create Sign language dictionary, two main techniques are employed: pre-synthesized animation and generated animation. The first one relies on an expensive material based on motion capture pre-recorded animation using avatar technology. The second technique relies on proprietary solutions that consist on automatic and real-time generation of animations using specific transcription systems. Unfortunately, the majority of proprietary transcription systems require user specific skills. Therefore, the sign language creation process still remains a hard task. In this paper, we propose a new approach inspired from the declarative language to make sign language dictionary creation easier. Our aim is to provide a high-level layer using a transcription language that resembles to the spoken language .We illustrate the sign creation logic without describing how our complex animation functions are executed or evaluated. Therefore, our solution can be used by any user without any specific skills requirement. The proposed approach also can be used to create signs independently to sign language nature. In this paper we describe also, how our tool generates a natural sign animation based on human motion trajectory analysis.

Keywords. Transcription language, declarative language, virtual animation, 3D motion analysis.

1. Introduction and Motivation

In the world, there are around 70 million people with hearing deficiencies (information from World Federation of the Deaf http://www.wfdeaf.org/). There are varying degrees of deafness: hard of hearing, "profoundly" deaf, and completely deaf. Deaf or profoundly deaf people may wear no hearing aid. Some will be able to lip read and understand you nearly perfectly. But some have problems with verb tenses, concordances of gender and number, etc., and they have difficulties when creating a mental image of abstract concepts. Consequently, many communicate with sign language rather than with written and spoken language [14][11]. For example, the American Sign Language (ASL) is the primary means of communication for about one-half million deaf people in the US [3]. Sign Language is a distinct language from spoken languages. In fact, the majority of hard of hearing people have many difficulties in reading written text [3]; consequently, they find it difficult to use technology such as computers. However, there are some solutions to make accessible textual information by providing a generated animation of sign language based on virtual agent [1][10][13]. These systems use two main techniques in the Sign language creation process: pre-synthesized animation and generated animation. The first one relies on expensive material to build signs based motion capture pre-recorded animation using avatar technology. The second technique consists on automatic and real-time generation of animations using proprietary transcription systems. There are many transcription language used by existing generation animation software. Unfortunately, the majority of these transcription languages require user training and some specific skills. In other word, the sign creation task still remains difficult. In this paper, we propose a new approach based on a declarative language to provide an easy to use tool for sign language creation. Our aim is to make the sign language creation process easier using a transcription language that resembles to the spoken language. We rely on the declarative programming that expresses the logic of a sign creation without describing how our complex animation functions are executed. Consequently, our tool can be used by any user without specific skill requirement. The proposed approach also can be used to create signs independently to sign language nature. In this paper we describe also, how our tool generates a natural sign animation using virtual agent. We rely on human 3D motion analysis of elementary sign movements to reach a natural sign animation. The remainder of this paper is organized as follows. In section 2, we present some related works. Section 3 is devoted to present our approach. In section 4 we describe the evaluation of our system. Finally, we conclude by a conclusion and some perspectives.

2. Related Works

Up today, the majorities of animation generation software [5] are based mainly on pre-synthesized animation or generated animation. There are some works that rely on pre-synthesized animation such as Mathsigner, DIVA framework [1] using motion capture pre-recorded animation. This approach depends on expensive material to build signs. Therefore, the generated animations are proprietary and depend on specific sign language. In generated animation field, there are SignSmith studio, Tessa ViSiCAST, eSIGN, [12], [10], [9] works. However, SignSmith studio provides a gesture builder to create signs with elementary movement and allows users to script an ASL performance (using a dictionary of signs), eSIGN is based on synthetic signing works by sending motion commands in the form of written codes for the Avatar to be animated. In other words, there are many different transcription systems used by animation generation software to codify gestures.

2.1 Transcription Systems

The sign language transcription concept is related to how signs are codified or annotated. In this respect, the transcribing of sign language [6] data is not different from transcribing data from any other language, although systematic linguistic research on sign language is less than half a century old. Up today, there is hardly agreement about which transcription system to be used as a standard.

2.1.1 Hamburg Notation System for signs HamNoSys

HamNoSys is a notation system that was developed by a German group of hearing and deaf people as a scientific/research tool in 1989. This system uses 200 symbols from left to right covering the parameters of hand shape, hand configuration, location and movement. The order of the symbols within a string is fixed, but still it is possible to write down one and the same sign in lots of different ways. HamNoSys is not adapted to everyday use to communicate (e.g. in letters) in sign language. This system requires symbols memorization, specific user training and is not adapted to automatic generation.

2.1.2 SiGML

SiGML (Signing Gesture Mark-up Language) is a sign language XML-based notation system that was created to support ViSiCAST and eSIGN projects. These projects are both based on virtual agent to communicate with deaf people. There are also many other work that rely on SigML such as [8], [10]. SigML uses mainly HamNoSys to describe signs. In fact, SigML is an XML codification of Hamburg notation system. It allows sign language sequences to be defined in a form suitable for performance by a virtual human. The inconvenient of this annotation system is the difficulty to make sign, due to the linearity of this transcription and the nonlinearity of sign language. Moreover the sign creator should memorize and understand symbols and their equivalent in sign language. Therefore, the sign creation process becomes more difficult and closely related to existing symbols.

2.1.3 Sign Description using Geometry Concept

This work was presented by [4] titled Sign description: how geometry and graphing serve linguistic issues. However, in this study they present a description for signs using the geometric model. The inconvenient of this codification, is that still a prototype and there is no complete study to produce a transcription system based on this aspect. Also, the description process proposed is difficult to be decoded (uses incomprehensible symbols) and requires a specific user skills.

3. Our Approach

The sign language creation process still remains a difficult task. This is due to that the creation of sign language dictionary, consumes too much time and a lot of resources. Our objective is to make sign language creation process easier. We rely on a declarative transcription system which based on simple syntax to facilitate the memorization process. Our approach includes also a tool that allows a lexical and syntactical interpretation of the transcription language. Our work enables a real time animation overview of the input sign codification using virtual agent. The sign language creation process is based mainly on human gestures. However, there are some signs characterized by their complex movements. Unfortunately, there is no direct geometrical equation for these complex movements to animate our virtual signer. For this reason, we built an algorithm that analyzes automatically the human basic movements in SL and provides the equivalent sub-movements. We are based on inverse kinematic solver to animate our virtual agent and to produce natural gestures.

3.1 The proposed Transcription Language

We propose a new transcription language inspired from the declarative language that aims to provide a high-level layer using a codification system that resembles to the spoken language. We illustrate the sign creation logic without describing how our complex animation functions are executed or evaluated. This transcription language includes sign language specificities such as manual signal (hands), non manual signal (body, facial expression and emotion), spatial reference (reference pointing) and movement (synchronization, velocity, acceleration).

MOVE object **FROM** initial location **TO** final location **AS** alias **WITH**

MOVEMENT_TYPE = movement type **AND ORIENTATION** = movement type **AND**

HAND_SHAPE = hand shape type **AND MOVEMENT_DIRECTION** = direction value **AND**

MOVEMENT_PLAN = plan value **AND MOVEMENT_VELOCITY** = velocity value **AND**

MOVEMENT_ACCELERATION = acceleration value **ANDAMPLITUDE** = amplitude value **AND**

NON_MANUAL_SIGNAL = non manual signal **AND** **REPEAT** **(repeat value)**

WITH: Sign Language parameters **AND**: parallel +: parallel **THEN**: sequential

Figure 1: General form of our declarative language.

As shown in figure 1, our transcription language relies on movement. The "MOVE" keyword indicates the movement "FROM" initial location "TO" final location of a specified object according to H-ANIM articulation nomenclature. However, in sign language there are two types of locations used in the sign creation process. The first one is related to virtual agent body location in which we use the ordinary nomenclature such as head, forehead, right eye, left eye, chin, chest, etc…, and virtual agent operators (contact, near, between, corner, forward, back, up, down). The second one relies on space location divided into 8 areas (two frontal FA and FB, two sagittal SGA and SGB left and two sagittal right SDA and SDB) each area contains 15 sub-areas in order to use the spatial reference [7]. The "WITH" keyword indicates that the movement has other parameters such as movement type, palm orientation, hand shape type, movement direction, movement plan, movement velocity, movement acceleration, movement amplitude, non manual signal and movement repetition. The movement type can be linear (segment), circular, wave, zig zag, triangle, ellipse, arc or the combination of several movements type such as circular and linear to obtain spiral motion. Our transcription language allows the manipulation of palm orientation in the sign creation process. In sign language, there are principally 6 palm orientations (IN, OUT, LEFT, RIGHT, UP, DOWN) that can be combined to obtain new orientations (IN-DOWN, IN-UP, OUT-DOWN, OUT-UP, etc...). This codification system enables also hand configuration manipulation. User can choose one of 40 ASL predefined hand shape. Moreover, the proposed codification language enables movement creation with the specification of movement direction (clockwise direction or inverse clockwise direction), movement plan(X or/ and Y or/and Z), movement velocity (slow, normal, fast), movement acceleration (slow, normal, fast), movement amplitude (small, normal, big). The movement synchronization is manipulated through the "AND" operator to indicate that primitives are interpreted at the same time, the "+" operator for a same time interpretation of sub-primitives and "THEN" operator for a sequential interpretation. Our transcription language enables also non manual signal specification. However, in sign language, non manual signal is divided into facial expression that includes emotions and body expression. We rely on MPEG to specify emotion (joy, anger, disgust, fear, sadness, surprise, neutrality, etc…) and we implement some functions to manipulate the facial expression such as OPEN (mouth), CZ (mouth), WRINKLED (nose), PURSE (lips), KNIT (eyebrow), TAUT (lips), etc. Furthermore, to manipulate body expression, we specified also some primitives such as SHAKES(head, no/yes), TILT(object[“head, shoulder”], direction[”back, “forward”, “left”, “right”, “up”, “down”]), FOLLOW(thing[hands, …]), ROUND(object[“shoulder”, value), etc. In sign language, movement repetition is a part of sign creation. This criterion is used mainly to indicate how many times movement is repeated. In our context, we specify the REPEAT (repeat value) primitive which can placed before any movement primitive. The repeat value can be (+), (++) or (+++) to indicate that movement is repeated respectively one, two or three times.

3.2 Our Interpretation Tool

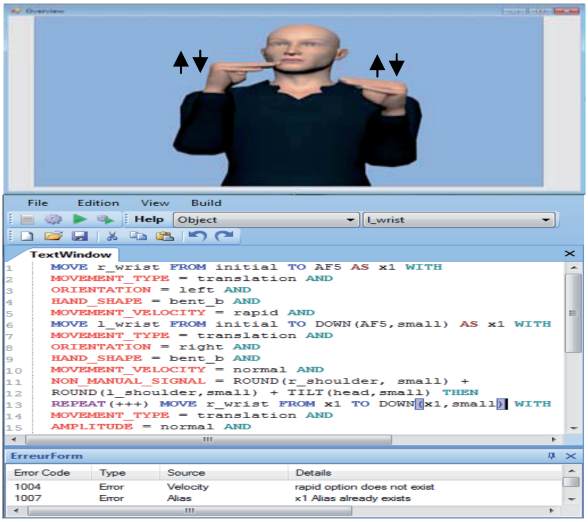

Figure2. Our interpretation tool.

Our aim is to assist user in the sign creation process, for this reason we built a tool that allows an automatic syntactic and lexical interpretation of our transcription language. In other word, this tool gives a syntactic coloration of recognized tokens (Keywords) and interprets automatically the sign codification and generates errors related to syntactic and lexical faults. As shown in figure 2 there are some errors such as rapid does not exist in movement velocity, X1 alias is defined more than one (already exists). Our tool allows parameterization of errors list, keywords, and operators; in this manner we can ameliorate the interpretation process easily through XML configuration files.

3.3 Natural Motion Analysis

The sign language creation process is based mainly on human gestures. However, to reach natural virtual agent movements, it is necessary to analyze human gestures. In sign language, there are some signs characterized by their complex movements. We chose to analyze the motion trajectory of both hands instead of the storing of 3D hand positions or rotations. This is due to in sign language phrases, the hand position changes according to sign location in the sentence. In other meaning, we depend always on these stored positions although the hand position changes during the interpretation. Also, if we choose to store motions based on articulation rotations, the generated rotations cannot be used by other systems to animate their avatars. This is due to there is no standard used by animation generation software's to animate their virtual signers. In other word, our aim is to provide a mathematical solution of elementary sign movements that can be used by different systems to animate their avatar using the proposed codification language. Our motion analyzing approach is based on conic approximation of initial motion data of both hands. We try to find the best approximation which composed of several conic curves that can be as Hyperbola, Parabola or ellipse. We tried to find the conic nature and the conic parametric equation that describes motion.

The parametric equation of the conic in the initial axes system and the conic nature and characteristics [2]:

$$\begin{cases} k_{0.2}\beta^2 + k_{0.2}\alpha^2 + k_{1.1}\alpha\beta + k_{0.1}\beta + k_{1.0}\alpha + 1 = 0 \\ X = X_m + V_{1.1}\alpha + V_{2.1}\beta \\ Y = Y_m + V_{1.2}\alpha + V_{2.2}\beta \\ Z = Z_m + V_{1.3}\alpha + V_{2.3}\beta \end{cases} \qquad k_{0.2}k_{2.0} - 4(k_{1.1})^2 \begin{cases} > 0 \rightarrow Ellipse \\ = 0 \rightarrow Parabola \\ < 0 \rightarrow Hyperbola \end{cases} \qquad (1)$$

4. Evaluation of Our System

In order to prove that the proposed codification system can be used as a transcription system, we reached to implement 800 signs from ASL dictionary. Table 1 shows ASL sign codification using our declarative transcription language. if we take the ASL sign "Africa" as example, we can show that the sign codification is composed of a translation movement of right wrist from the initial position to near forehead followed by a circular movement of the same articulation from the last position (alias x of (near(forehead)) to the same location.

Table 1. Declarative codification example.

Our declarative codification		
MOVE r_wrist FROM initial TO NEAR(forehead) AS X WITH MOVEMENT_TYPE = translation AND ORIENTATION = left AND HAND_SHAPE = a AND MOVEMENT_VELOCITY = normal AND AMPLITUDE = normal AND REPEAT(++) MOVE r_wrist FROM X TO X WITH MOVEMENT_TYPE = circular AND MOVEMENT_PLAN = z AND MOVEMENT_SENS = clockwise AND MOVEMENT_VELOCITY = slow AND	 	**Africa**

We use the conic parametric equation of our motion approximation (1) to draw the natural circular movement automatically using the inverse kinematic solver with plan indication (Z) and movement direction (clockwise).

5. Conclusion and Perspectives

The research described in this paper is the first attempt to create signs using a declarative language. In other word, this paper has laid a methodological foundation for future research and amelioration in the sign language creation process. We proposed a transcription language inspired from the declarative language to illustrate the sign creation logic without describing how complex animation functions are executed or evaluated. Our aim is to provide a high-level layer using a transcription language that resembles to the spoken language and can be used by any generation animation software to create signs. Therefore, this approach can be used without any specific user skills. This methodology can be adapted by researchers to be applied to French Sign Language, Arabic Sign Language, etc. We have also presented a tool that allows automatic interpretation of the proposed codification language using avatar animation preview. In the animation module, we described a solution that enables a natural virtual agent movement based on human motion analysis using our conic approximation. This approach can be considered as a theoretical foundation of natural motion analysis that can be used by existing animation software to reach a natural virtual agent movement. The ultimate goal of our future research is to provide facial expressions codification and to ameliorate body expressions codification. Also, we plan to create a collaborative approach through web service that allows different users to implement their sign language (French Sign Language, British Sign Language, Canadian Sign Language, Arabic Sign Language, etc...).

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1158

Classification of ICT-based Learning Technologies for Disabled People: Outcomes of Enable Network Project

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Abstract. This paper presents what seems to be the first methodology for classifying ICT-based learning technologies for disabled people. It was developed through the work of the Enable Network for ICT Learning for Disabled People. Its potential is illustrated through application to one of the learning technologies used in the partner countries.

Keywords. ICT, learning technolo1gy, classification, framework, disabled learners.

1. Introduction and Overview of the State of the Art

Developments in ICT have led to a number of exciting possibilities for its use in education, including mobile learning e.g. [1, 2], microlearning [3] and games based learning e.g. [4]. The use of ICT also has a number of potential advantages for disabled learners if accessibility and usability [4] requirements are met and it is matched to the particular needs and learning styles of specific groups of disabled people. Thus some (groups of) disabled people may require existing learning technologies to be modified in order to use them either at all or to best effect. Others may require the use of one or more assistive technologies to access learning technologies, raising issues of the compatibility of learning and assistive technologies. Several European projects have developed educational ICT but lack of knowledge and classification of the available technologies are preventing best use being made of them.

The development of methodologies for the classification or categorisation of ICT-based learning technologies for disabled people would provide a framework in which to evaluate existing technologies and develop new ones. This could include identification of areas where new technologies or modifications of existing technologies are required; the prerequisites for accessibility and usability and compatibility with assistive access technologies and the characteristics of the disabled learners particular technologies are suitable for.

There does not seem to be any literature which deals specifically with the classification of ICT-based learning technologies for disabled people. The closest is the literature on the classification of assistive technology, a summary of which is given in [5]. This includes the hierarchical four component Comprehensive Assistive Technology (CAT) [5, 6] and Human Activities Assistive Technology (HAAT) [7] models, the World Health Organisation International Classification of Functioning, Disability and Health (ICF) [8], and the International Standards Organisation standard ISO 9999: 2011 Technical Aids for Persons with Disabilities, Classification and Terminology. A number of modelling frameworks are used in assistive technology outcomes modelling, including the Matching Persons and Technology (MPT) Model [9, 10]. Other relevant classifications include the classifications of learning objects e.g. [11,12], learning outcomes e.g. [13] and learning environments e.g. [14].

2. Methodology

Developing and applying a methodology for classifying ICT-based learning technologies for disabled people is one of the main aims of the Enable Network for ICT Learning for Disabled People. The research and associated activities of this Network are divided into three main workpackages, WPs 2, 3 and 4. The first stage in WP2 involved data collection on the current state of the art with regards to the development and use of ICT-based learning technologies for disabled people and the factors that affect their use in the 17 partner countries.

A methodology for the categorisation and evaluation of ICT-based learning technologies for disabled people is being developed in the second stage in WP3. It will be applied together with other outcomes in the third stage in WP4 to develop on-line in-service training materials on ICT to support disabled learners, as well as recommendations for the future research agenda. The approach to developing the classification methodology is based on a worksheet completed by all partners and the Comprehensive Assistive Technology (CAT) model [5, 6]. The worksheet involves the partners evaluating the four factors of the disabled learner, the context, the learning technology and the learning activity derived from the CAT model and then being led through a process of developing additional factors and formulating a structure for them. The resulting partner classifications were then validated by application to the technologies identified in WP2 and modification if required to give a better fit or description of these technologies.

The paper author, who is the workpackage leader, is using a process of synthesis and validation of the partners' methodologies to produce the final methodology. Validation will be carried out through application to the learning technologies in the partner countries identified in WP2. Several cycles of synthesis, model validation and modification may be required to obtain the final methodology.

3. Results: Classification Methodology

A preliminary version of the methodology in presented as a structured list based on the four factors of disabled learner, learning technology, context and learning activities. Graphical tree diagram and other representations could also be used, but are not presented here due to space limitations.

3.1 A Disabled Learner

1. Accessibility requirements

1.1 Compatibility with assistive technology e.g. screen readers, keyboard with shortcuts, switch or other keyboard emulation and pointing device(s)
1.2 Text representations of all visual and audio features, magnification and/or particular colour of text and background
1.3 Low cognitive and other demands and low memory requirements, including division into short tasks, use of clear, precise language, particularly for instructions and avoidance of time pressures
1.4 Sign language or communication support
1.5 Avoidance of stimulation e.g. visual and sound effects, colour, scrolling text, animation

2. Skills/education level/knowledge

2.1 Literacy and numeracy
2.2 Computer/IT
2.3 Background/general knowledge
2.4 Languages
2.5 Subject specific and which subjects
2.6 Physical skills

3. Personal characteristics

3.1 Age
3.2 Gender
3.3 Cultural factors
3.4 Interests and hobbies

4. Learning related factors

4.1 Learning style
4.2 Preferences for group, teacher support and/or individual learning
4.3 Learning level and perquisite level of knowledge of topic

3.2 B Learning Technology

1. Type of technology

1.1 Type of platform(s) – mobile, stationary or dedicated device
1.2 Single technology/tool or package of technologies/tools
1.3 Learning, assistive or multi-functional technology
1.4 Facilities provided by the technology
1.5 Underlying pedagogy if relevant

2. Interface

2.1 Types of input and output
2.2 Intuitive and attractive interface
2.3 Design for a particular user group or a range of different user groups (design for all)
2.4 Availability of customisation options

3. Use factors

3.1 Free/open source or commercial, costs and licence requirements
3.2 Compatibility with and the ability to import and export data from other software e.g. Microsoft office/libre office
3.3 Compatibility with different operating systems
3.4 Memory and other technical requirements
3.5 Availability of accessible documentation, training, on-line help and helpline
3.6 Maintenance/updating and costs

3.3 C Context

1. Requirements
1.1 Time
1.2 Calm environment without noise or disturbances
1.3 Learning delivery – online, blended, face-to-face, part of learning community
1.4 Modern technology
1.5 Stationary, mobile or both
1.6 Individual or group and/or with teacher support

3.4 D Learning Activity/Ies

1. Type of activity
1.1 Subject specific or non-subject specific and subject
1.2 Type of learning – skills, knowledge, understanding, attitudes and values
1.3 Level of difficulty or complexity
1.4 Learning, retraining, rehabilitation, revision or assessment,
1.5 Nature of activity - exercises, tutorials, games, video. quiz etc
1.6 Individual or group activity
2. Learning context
2.1 Educational organisation
2.2 Student or teacher directed and centred
2.3 Educational level
2.4 Vocational, re/training, rehabilitation, qualification-related, non-qualification related formal or informal education
2.5 Learner control of confidentiality

3.5 Simple Classification

The following simple classification based on six factors allows some comparison of technologies, but not the range of applications discussed above.
1. The accessibility features provided
2. Assistive technology, learning technology or both
3. Learning activities supported
4. General/skill based or subject specific
5. Open source or commercial
6. Level of skills and knowledge required.

4. Validation through Application to Specific Technologies

In this section an illustration of the validation of the classification methodology through application to Global AutoCorrect is given. This is a technology which automatically corrects the user's spelling as they type in any program. It is designed for people with dyslexia and literacy issues, but can also used by non-disabled people. Some of the categories are not listed, as they are not relevant to this tool.

A Disabled Learner

1. Accessibility requirements
1.1 Can be used with screenreaders, on-screen keyboards and touchscreens and other devices that allow text input and output.
1.3 Does not make additional cognitive demands
1.4 Only suitable for sign language users who are able to use text
2.Skills and knowledge: 2.1, 2.2 and 2.4 Knowledge of English & ability to input text
4.Learning related factors: 4.2 Can be used in individual or group learning

B Learning Technology

1 Type of technology
1.1 Any platform that supports windows XP and above or apple (in a few months time)
1.2 Single technology
1.3 Main function: assistive technology for correcting words; secondary function: learning technology for improving spelling
1.4 Spelling correction

2. Interface

2.1 Any input and output that supports text other than speech text conversion software
2.2 Easy and intuitive to learn
2.3 Can be used by anyone able to input and output text other than by speaking

3. Use factors

3.1 Commercialised, costs about £130/€152
3.3 Windows XP onwards and apple in a few months
3.4 150 GB hard disc and 1 GB RAM
3.5 Documentation on video and screenreader compatible text. Help by emailing or phoning manufacturer, assessor or vendor (so not 24 hour)
3.6 Upgrades itself if connected, currently no charge for upgrading

C Context

1. Requirements: 1.3, 1.5 and 1.6 Can be used in a variety of contexts

D Learning Activities

1. Type of activity
1.1 Non-subject specific
1.2 Skill – spelling
1.4 Learning or retraining
1.6 Can be used in individual and group activities

2. Learning context

2.2 Student directed and centred
2.5 No confidentiality issues

The simple classification gives the following results:

1. Usable with most input and output devices, but not speech text conversion software.
2. Primarily assistive technology, but can also be used as a learning technology.
3. Spelling correction and improving spelling.
4. Skill based – spelling
5. Commercial
6. Basic knowledge of English and ability to input text to a computer or other text processing device.

5. Conclusions and Further Work

This paper will make a very important contribution to the field as the first (systematic) methodology for classifying ICT-based learning technologies for disabled learners. This will have a number of very useful applications. In particular it will for the first time establish a clear framework which can be used to discuss and evaluate existing ICT-based learning technologies for disabled people, identify gaps or the need for modifications of existing technologies and support the design and development process for new technologies. It will also have applications in identifying the characteristics of the (groups of) students particular learning technologies are most suited to, as well as enabling better use to be made of existing technologies. Although the methodology is aimed specifically at learning technologies for disabled students, it will almost certainly also have applications to learning technologies for non-disabled students. The methodology can also be used to support the determination of good practice and identification of the various national, legal, regional and other factors required to support it. It further has the potential to play an important role in informing policy, including in determining the future research agenda.

Further work to be carried out during the project includes the application of the methodology to analysing data collected during the project in order to identify good practice in the use of ICT to support learning by disabled adults. This will include consideration of methodological, pedagogical and end-user issues, as well as the factors to be taken into account when developing new ICT-based learning systems. In addition, the methodology will be used to support a comparative analysis across the Network partner countries of the legislative context and the different pedagogical and methodological approaches. Application of the methodology will also be used to develop recommendations for the future research agenda.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1165

Automatic Gestures Generation Approach for Sign Language

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Abstract. The animation of virtual characters can improve the dialogue between human and machine. We note that the new technologies of information and communication invest more and more our daily space. We observe the emergence of new services that tend to facilitate the generation, the propagation and the consultation of information. However, such technical progress is not accessible to everyone. In this paper, we present an automatic gestures generation approach for sign language that allows automatic animation of the different body parts of an avatar in order to improve the fluidity of the avatar movement and to generate realistics mouvements.

Keywords. Assistive technologies, Avatar, Inverse Kinematics, Sign language.

Introduction

Sign Languages are natural visual-spatial languages [11], developed and used by deaf and hard of hearing signers all over the world [16]. They combine simultaneously orientation and movement of the hands, arms or body, emotions and facial expressions. For generating natural communication by making more realistic movement for signs, it is crucial to consider both, natural facial animation and realistic body gestures [10]. The notion of gesture is not precisely defined. It varies depending on the area of study, on whether one takes a sociological point of view, cognitive or biological. Furthermore, due to the richness of gesture modality and the variety of forms that covers, it is not easy to establish a taxonomy, and there is no consensus on the matter. Facilitate access to information for everyone requires new methods to improve dialogue between human and machine. In response to this context, the development of virtual persons can improve this interaction [3] [8].

1. The need of Signing Avatars

The development of virtual characters (avatar) able to generate postures in sign language, is a response to this request. These applications are based on an gestures generation. Generally, within the set of admissible postures, the user is free to manipulate the avatar rather than specifying the value of each individual degree of freedom. Generally, to create their own descriptions of signs and participate in the development of their dictionary communities, these applications use graphical tools. These interface are based the technique of key frames to select the important moments assumed (the key moment) for training movement. But this technique raises difficulties especially in terms of time spent in the creation of postures and had lack of precision in the generation of gestures. The main problem induced by the use of direct kinematics is to achieve the desired position by the avatar. Therefore, the first step is to rotate the shoulder of the virtual character then the elbow and the wrist. This causes a multitude of solutions to generate this posture. So the user must intervene to choose the right solution (the best meets their needs). This operation is costly in terms of time and presents several challenges to create a fluid motion understandable by the deaf. The Inverse Kinematics (IK) method automatically computes these values in order to satisfy a given task usually expressed in Cartesian coordinates [17] [5]. This technique requires the resolution of complex nonlinear equations and usually expressed as a constraint-satisfaction problem [14] [4].

2. Our Contributions

In this context, our system permits [1] to animate automatically different body parts of an avatar in order to improve realistic animation of virtual character [12] [9]. We can from a web interface create the sign by selecting the desired joint and move along different axis (x,y,z) to the target position. The system, based on a new IK method.This method calculate automatically in a real-time the angles of rotation of each joint that are required to generate the posture. We can from a SML description [7], containing the position of the desired joint as shown (Figure 1), generate the animation of the avatar.

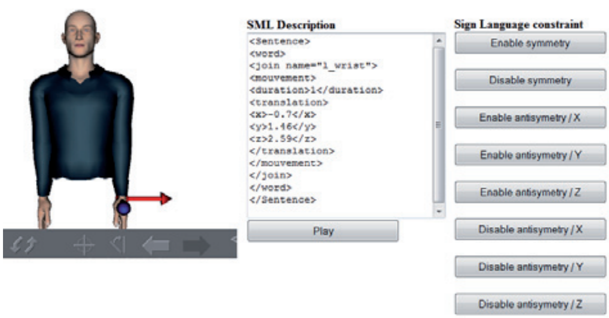

Figure 1. Gesture builder interface.

Our approach is based also on a thorough study of sign language and gestures classification [18]. We have identified the constraints that need to be used for automatic generation postures sign language i.e. symmetry relations (Figure 1), that facilitate the specification of movement of the non-dominant hand knowledge of those dominant articulator and various types of repetition in sign. Therefore, it is essential for an IK method to be able to solve problems with multiple end effectors and targets. The animation engine can be extended to process models with multiple end effectors and achieve the different targets positions.

3. Animation Engine for SL

Our system relies on several inputs. We can from a web interface create the sign by selecting the desired joint and move along different axis (x, y, z) to the target position. The system, based on IK, calculate automatically in a real-time the angles of rotation of each joint that are required to generate the posture. From a biomechanical study, we identify the degrees of freedom of each joint. This study has allowed us to generate real time and natural postures of the virtual character. We can from a SML description [7] [2], containing the position of the desired joint as shown (Figure 2), generate the animation of the avatar.

```
<Sentence>
 <word>
  <join name="l wrist">
   <mouvement>
    <duration>1</duration>
    <translation>
     <x>-0.7</x>
     <y>1.46</y>
     <z>2.59</z>
    </translation>
   </mouvement>
  </join>
 </word>
</Sentence>
```

Figure 2. SML description.

Thus, we can animate the virtual characters in real-time. Complex movements are infrequent in sign language. They can take the form of zigzags or sinusoids, but in most cases, cannot be simply described by a predefined type of trajectory [13] [15]. In this context we decompose the movement in several parts (Figure 3): the description of the initial hand posture, the dynamic step and the final posture, manual specifications including the parameters that are related to the hand configuration, position and orientation, and contact point. These parameters can vary or remain constant during the movement. In

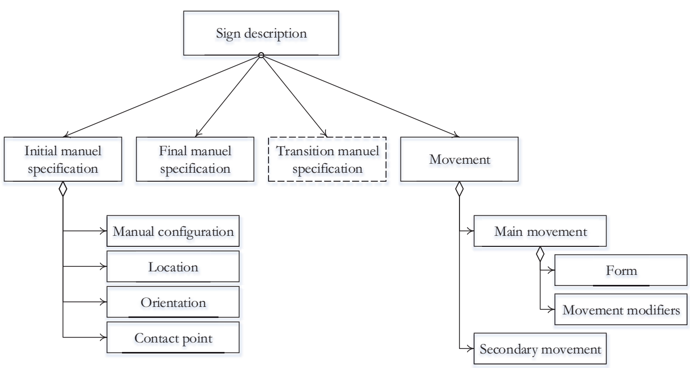

Figure 3. Sign language decomposition.

case where the hand comes into contact with a body part, the wrist position is no longer relevant, which is the manual contact point that must be included in the manual specification. The arm movement is already specified by the shape of the wrist path. Many grammatical processes affect its amplitude, so the movement modifier must inform it the latter in order to be amplified, shortened, or stopped. This problem appears in some local hand signs, as the vibration of the fingers. More generally, we denote by secondary movement such repeated movement that occur in the fingers, wrist, or even the forearm (but never affects the position of the wrist). It can be superimposed on the main movement or just be the only dynamic character of the sign.

4. The New IK Method for Animating Signing Avatars

The IK is a method for calculating the postures, in order to satisfy a given task by the user, based on degree of freedom of each joint. This method plays an important role in the animation and simulation of virtual characters to improve and facilitate the use of interfaces.

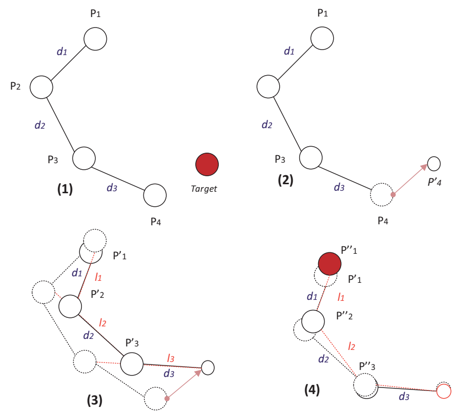

Figure 4. Inverse kinematics method. (1) The initial position of the manipulator with 4 joints and the target. (2) move the end effector p_4 to the target. (3) find the joint p'_3 which lies on the line l_3 that passes through the points p'_4 and p_3, and has distance d_3 from the joint p'_4 .(4) repeat the same procedure but this time start from the base and move outwards to the end effector.

The new used IK method here, involve the previously calculated positions of the joints to find the solution to achieve the target. This method minimize the error of the system by adjusting each joint angle. The proposed method starts from the last joint of the IK chain, iterate and adjusting each joint along the chain. Thereafter, it iterate in the reverse way, in order to complete the adjustment. This method, instead of calculating directly the angle rotations, try to find the joint locations. Hence, the time dedicated to compute and resolve the constraints can be saved. So, we can generate realistic and human animation in real time. If we consider (Figure 4) $p_1, ..., p_n$ the joints of the avatar. Note that p_1 is the root joint and p_n is the end effector. The target is symbolized by a red point. The method used is illustrated with a single target and 4 joints 4. First we calculate the distances between each joint. Assuming that the new position of the end effector be the target position, $p'_n = t$, we find the line, l_{n-1}, which passes through the joint p_{n-1} and p'_n. The new position of the p'_{n-1} joint, lies on that line with distance d_{n-1} from p'_n. Similarly, the new position of the p'_{n-2} joint, can be calculated using the line l_{n-2}, which passes through the p_{n-2} and p'_{n-1}, and has distance d_{n-2} from p'_{n-1}. The algorithm continues until all new joint positions are calculated. The new position of the root joint, p'_1, should not be different from its initial position. This procedure is repeated for all the joints, including the end effector. After one complete iteration, the solution is often not just, means that the end effector doesn't coincide with the target. The procedure is then repeated, as many time as needed, until the end effector is the same or achieve to the desired target.

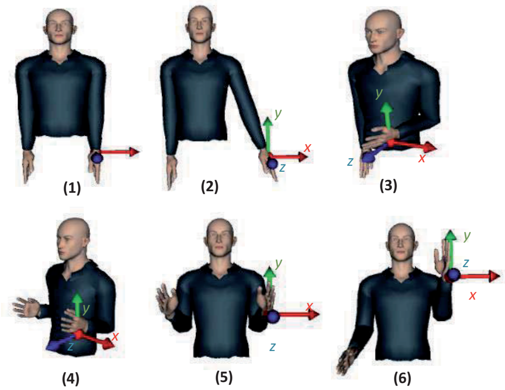

Figure 5. Signing avatar using Inverse kinematics method. (1) initial posture of the avatar. (2) movement of left wrist along the *x* axis. (3) movement of left wrist along the *x*,*y* and *z* axis. (4) activate symmetry for different axis. (5)(6) activate antisymmetry for *x* and *y* axis.

The IK method converges to any given goal positions, seeing that the target is reachable. However, if the target is not within the reachable area, there is a termination condition that compares the previous and the current position of the end effector, if this distance is less than an indicated tolerance. The method gives very good results and converges quickly to the desired position. This method is based only on the position computing and avoids the tedious rotations computing. Therefore, it is essential for an IK solver to be able to solve problems with multiple end effectors and targets. The animation engine can be extended to process models with multiple end effectors and achieve the different targets positions. The signing avatar model is comprised of several kinematic chains, and each chain generally has different end effector. The figure 5 shows the use of this notion by considering several kinematic chains and several end effector (left wrist and right wrist) by applying the notion of symmetry that uses two kinematic chains, the first correspond to the avatar left side and the second to the right side. We tested the animation engine by adding constraints of sign language as the notion of symmetry either total or anti-symmetry and of course along different axis *x*, *y* and *z*. The animation engine is integrated into the project Websign [6] to facilitate the task of creating signs. The figure 5 shows the use of this notion by considering several kinematic chains and several end effector (left wrist and right wrist) by applying the notion of symmetry that uses two kinematic chains, the first correspond to the avatar left side and the second to the right side.

5. Conclusion

This automatic gestures generation approach for Sign Language permits to animate automatically different body parts of an avatar in order to improve realistic animation of virtual character gesture and allow deaf person to visualize realistic gestures. Our approach is based on a thorough study of sign language and gestures classification. We have identified the constraints that need to be used for automatic generation postures sign language i.e. symmetry relations, that facilitate the specification of movement of the non-dominant hand knowledge of those dominant articulator. The challenge of this approach is to find the tradeoff between computation time and realistic representation. Indeed it must be closer to the maximum generation of real-time signs.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1171

Innovative ICT Solutions Supporting Students with Learning Disability and Hearing Impairments during Classes

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Abstract. University students with Learning Disability or Hearing Impairments often face huge difficulties in accessing campus facilities and, specifically, lectures. This paper presents the innovative ICT solutions provided by CATS, a research project aiming to enhance the accessibility of academic opportunities such as lectures. Namely, a note-taking environment (PoliNotes), an advanced spelling corrector/predictor (PoliSpell), an automatic summarization tool (KEaKI), and a device able to facilitate lip-reading (PoliLips) are described.

Keywords. Hearing Impairments, LD, dyslexia, NLP, lip-reading, summary, mental map

Introduction

During lectures, students with Hearing Impairments lose a large amount of information, delivered by the teacher via her/his voice. Students with Learning Disabilities (LD), on the other hand, face difficulties in taking notes and, once again, lose information. It is thus clear that specific tools are necessary to solve these particular difficulties, maximizing the reception, management, enrichment, and memorization of information, and therefore enhancing the usefulness of lectures. In this paper, we introduce the innovative ICT solutions we designed in the context of the Campus Tools for Students [2] (CATS) project [1].

1. State of the Art

Among the assistive tools for people with LD, particularly interesting are the works on note-taking, error correction/prediction, and automatic summarization of texts. In the following, some of those tools are discussed.

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[2]CATS is funded by the Italian Ministry of Education, University and Research (MIUR). See: http://arcslab.dei.polimi.it/

Nowadays, more and more university classes are given by means of slide-based presentations. In such setting, taking notes becomes quite difficult, in particular for students with dyslexia. Several tools exist, trying to merge slide and notes. Among the others, StuPad [2] provides two different environments, the first one is used to take notes, while the second one supports students during the review of the notes and the individual study. LiveNotes [3] aims at sharing notes among students in a small group, allowing for a collaborative note-taking process. CoScribe [4] supports students in making collaborative handwritten annotations on printed lecture slides. None of these systems, however, is able to merge slides and notes in real time, during the class, while students takes notes.

Spellcheckers able to correct real-word errors are based on stochastic models, trained using particular corpora; once trained, such models do not change while the user uses the system [5,6]. This approach cannot adapt the correction to the current user's errors, a crucial feature in the case of people with dyslexia, where each person tends to exhibit particular error patterns. Only few works try to model the user, however. In [7] some weighted production rules, tailored to a specific user, are used, but the context is not considered. The system described in [8] adapts the errors on the basis of the context, but does not model the user. None of such systems provide an adaptive user interface, which is another crucial feature.

Automatic generation of summaries is a complex task, and several approaches exist. The *importance function* [9] is used to select the relevant sentences to include in the summary. *Sentence compression* [10] selects the "most important" parts of sentences. Finally, *semantics* [11,12] is used to calculate the "distance" among different parts of the text, permitting to aggregate similar sentences. Such systems, however, cannot generate mental maps, which are often used by students with dyslexia to understand and remember the structure of complex texts.

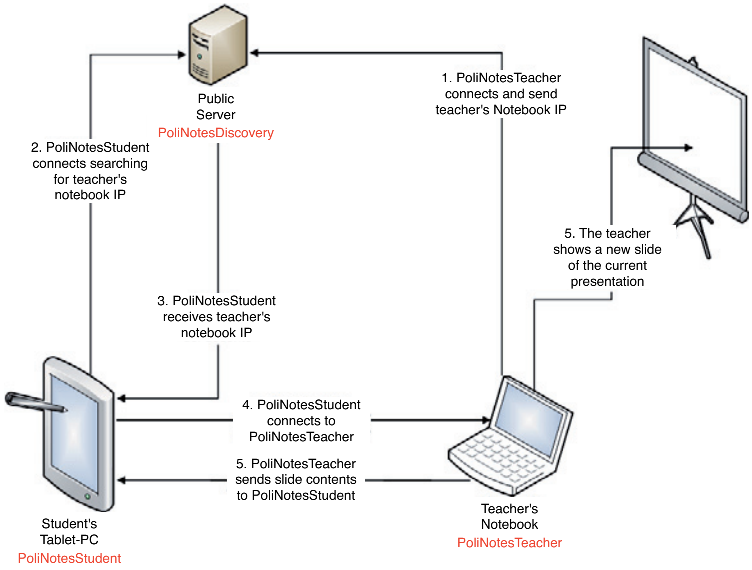
Several solutions have been proposed to help persons with auditory impairment during class attendance [13,14]. Voice recorders –coupled with off-line Automatic Speech Recognition (ASR) applications– are often used, but the accuracy of the ASR is often sub-optimal. Magnetic induction loops can be used with students that wear a compatible implant, but are expensive to deploy. Human-based subtitling services and sign-language interpreters are often too expensive.

2. The tools

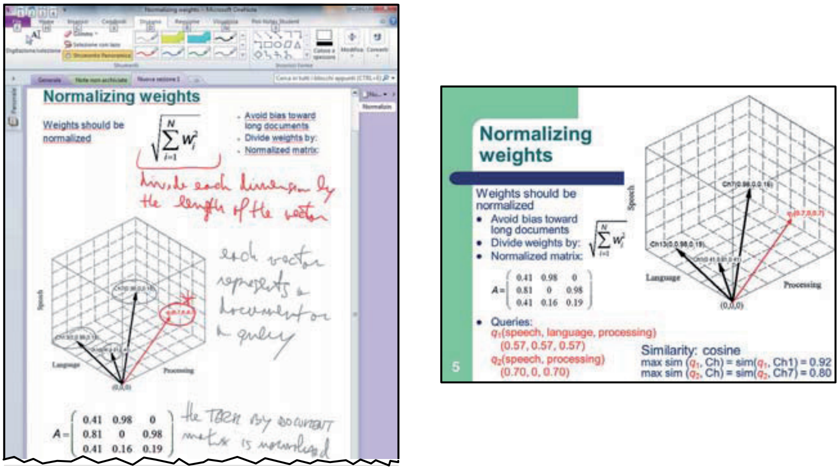
2.1. PoliNotes

PoliNotes [15] aims at providing a powerful note-taking environment, integrating teacher-generated contents and student-generated notes. The slides shown by the teacher are sent, in real time, to the student's Tablet-PC, where the contents are extracted and can be rearranged on an electronic sheet. The tool is composed of two main applications (PoliNotesTeacher and PoliNotesStudent), and a discovery service providing automatic configuration functionalities (PoliNotesDiscovery). The architecture of PoliNotes is based on the publish/subscribe pattern; Fig. 1(a) shows how the three PoliLips components communicate.

PoliNotesTeacher installs as an extension of PowerPoint; whenever, during the presentation, the teacher shows a new slide, PoliNotesTeacher extracts all the objects and



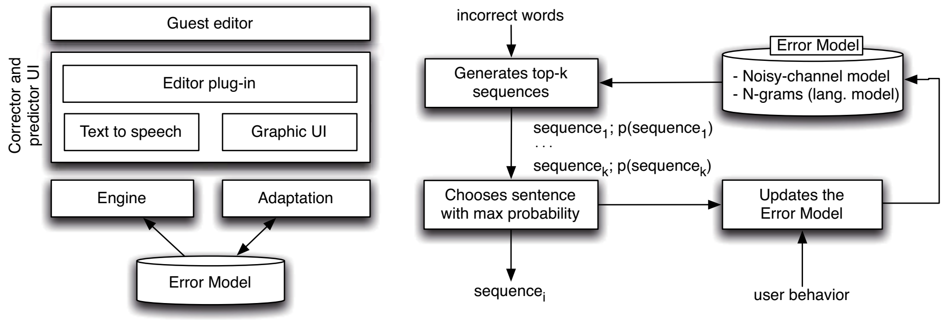
(a) Communications between client and server.



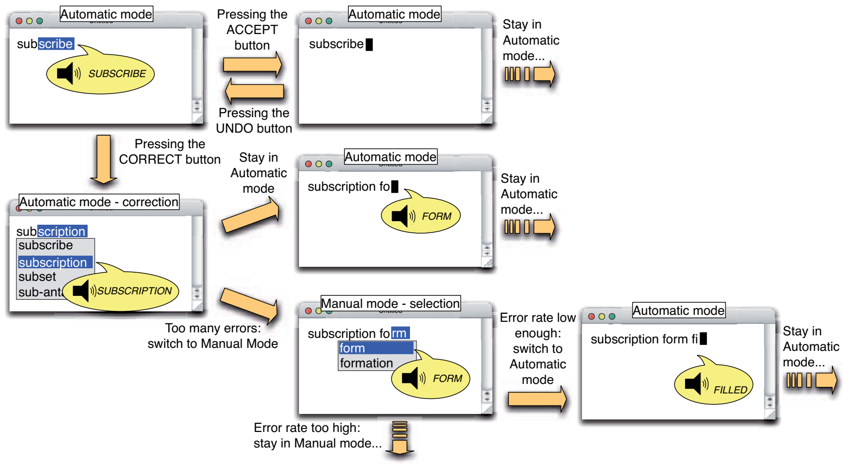
(b) A slide with a graph, and how PoliNotesStudent showed it.

Figure 1. PoliNotes.

sends them to PoliNotesStudent. Whenever PoliNotesStudent, which installs as an extension of OneNote, receives content objects, it shows them inside the current sheet; objects are pre-arranged on the sheet, but students can move and edit each of them using all the OneNote tools; moreover, students can add their own drawings, or hand-written notes, freely mixing slide-based and pen-based contents. Figure 1(b) shows a slide containing text and images; the components of the slide were added to the student's electronic sheet, where she/he rearranged them and added some notes.



(a) Architecture (left) and correction/prediction process (right).



(b) Adaptation of predictor UI (MANUAL transitions not shown).

Figure 2. PoliSpell.

2.2. *PoliSpell*

Figure 2(a) depicts, on the left, the architecture of PoliSpell [16], our corrector/predictor: Engine and Adaptation generate corrections and adjust the Error Model, respectively; the Corrector/predictor UI controls the text-to-speech (a common mean to improve reading comprehension of people with dyslexia [17]) and the Graphic UI modules, which allow users to interact with the corrector/predictor; finally, the module is connected to the Guest editor, by means of the Editor plug-in module.

Figure 2(a), on the right, shows how the process of correction/prediction evolves and how the model is updated. The model for correcting sentences and predicting words consists of a series of HMMs, whose probabilities derive from an *error model*, which contains a corpus-based language model, and a noisy-channel-inspired model. The language model has been trained on several error-free corpora. The noisy-channel model has been trained on corpora annotated with error corrections (from Facebook/Twitter posts); such model also incorporates information, gathered from experts in the field of LD, about particular errors made by people with dyslexia.

When the system is deployed, there is a common model for every users; preliminary static experiments on texts written by persons with dyslexia show the good performance of such basic model. However, since each person makes different mistakes, the system collects the user behavior, by tracking the choices made over the corrections/predictions presented by our system. With such information, the system adapts corrections and predictions performing an online-learning procedure that updates the noisy-channel model (which accounts for the error patterns) and the language model (which regards the writing style).

There are several UI parameters that can be tuned, depending on the user behavior on the system. In particular, one of the key parameter for the spellchecker/predictor is the selection of the automatic/manual mode for correction and prediction.

When the predictor is in *automatic* mode, the system uses text-to-speech to say the first word given by the model (see Fig. 2(b)). The user can choose that word by pressing a particular ACCEPT key on the keyboard. If the first suggestion is not correct, the user can open a list of suggestions, by means of the CORRECT key. Instead, when the predictor is in *manual* mode, the system shows a list of suggested predictions and the user can listen to the suggested words and choose the one that fits.

When in automatic mode, it is possible to switch to the manual mode: manually, by pressing the corresponding MANUAL key, or in an adaptive way if the first word is not selected for several times. Vice versa, when in manual mode, if the error rate drops, then the system switches back to automatic mode. The adaptation mechanism considers the number of not-accepted (i.e., ACCEPT key not pressed) or edited automatic predictions.

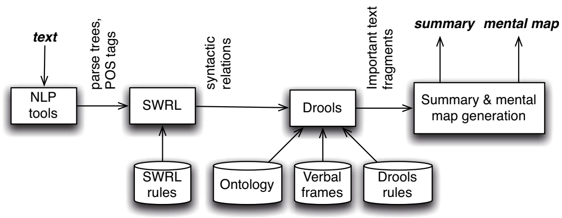
The corrector works in a similar way. Notice however that, unlike prediction, in automatic mode the correction does not require a confirmation (UNDO is available in both cases); we chose such approach because correction is not as error prone as prediction.

2.3. KEaKI

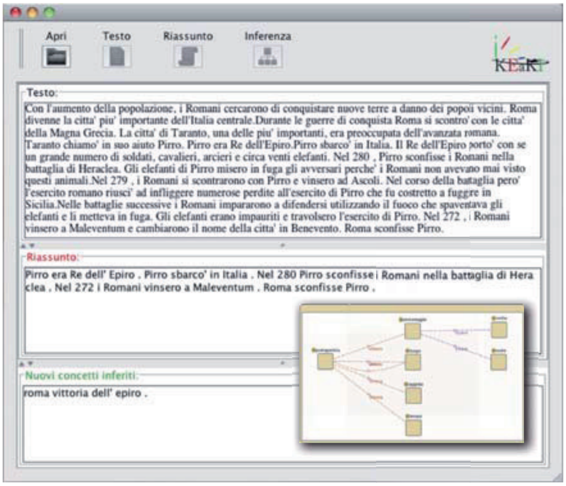
KEaKI is a tool able to generate a summary and a mental map of a text. It is based on an ontology, describing a specific domain (in terms of *roles* and *actions* among them), and a verbal frame database, decorated with thematic roles (matching the ones defined into the ontology). Changing the ontology and the verbal database, the tool is able to adapt to different domains. Figure 3(a) shows the high-level architecture, where a text is analyzed by means of NLP tools (dependency parser and POS tagger), the result of such analysis is further refined by a set of rules executed by the SWRL engine, generating a set of syntactic relations among words; then, leveraging verbal frames and the ontology, a set of rules executed by the Drools engine disambiguates verb meanings and searches for “meaningful” patterns to extract from the text. Finally, such patterns create a summary and are converted to a graphical form (the mental map). See Figure 3(b) for an example.

2.4. PoliLips

PoliLips [18] captures and sends to students’ laptops an audio/video/textual stream composed of a video of the teacher’s face, her/his voice, and a textual transcription performed by an ASR. We argue that each modality could compensate for errors present in or induced by the others (for example, lipreading could compensate for ASR errors); moreover, the resulting system could be able to handle different degrees of hearing loss, and preferences in compensation mechanisms.



(a) Main modules.



(b) Summary and mental map of a text.

Figure 3. KEaKI.

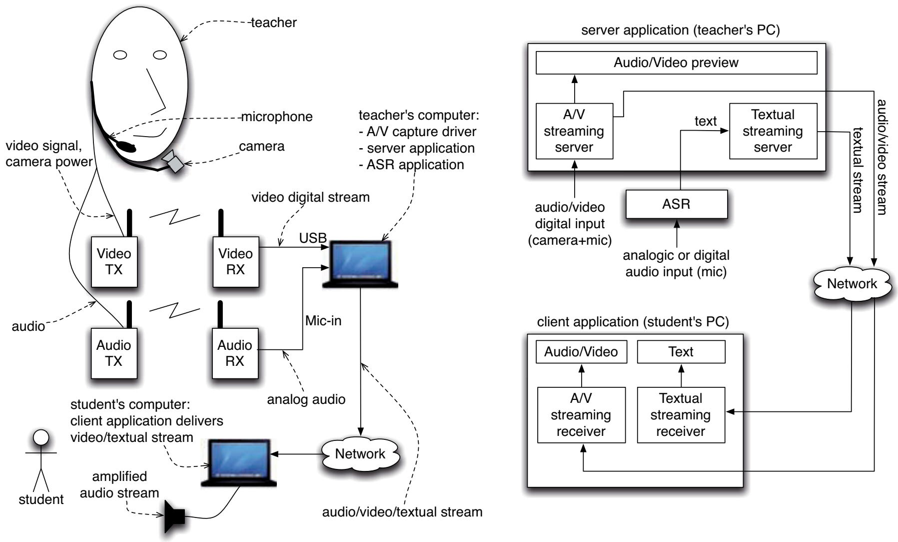
PoliLips is especially useful when the student cannot see the teacher's face (for example, whenever the teacher writes on the blackboard) or the teacher is too far, or she/he is not in front of the student.

The PoliLips hardware consists of a wearable device and a base station (see Figure 4(a), on the left). The wearable device is composed of a tiny video camera coupled with a high-quality, noise-canceling microphone, and a transmitter unit. Audio/video signals enter the transmitter unit, composed of two elements: a video transmitter and a high-quality audio transmitter, both powered by battery packs.

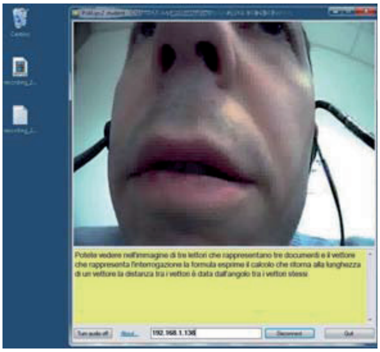
The base station is composed of three elements: a video acquisition box and a high-quality audio receiver. The video acquisition box, which contains a video receiver and a video capture device, digitizes the video signal and provides a stream through a USB connector. The video acquisition box and the audio receiver are connected to the teacher's laptop.

The PoliLips software is composed of two parts (see the architecture shown in Figure 4(a), on the right): the server is installed on the teacher's laptop (along with the ASR), while the client is installed on students' laptops.

The PoliLips server acquires the digital video stream and the audio, combining them in an audio/video digital stream; audio also comes to the ASR, which generates the textual transcription of the teacher's speech. Whenever a client connects, the server sends the audio/video/textual stream. The PoliLips server application also provides a preview



(a) Setting (left) and software architecture (right).



(b) The client application.

Figure 4. PoliLips.

of the stream (so that the teacher can check whether the camera is well positioned and the ASR is working fine).

The PoliLips client connects to the server and displays the audio/video/textual stream, saving them as an MPEG and a TXT files. Figure 4(b) shows the PoliLips client application.

3. Conclusion

We presented a collection of tools for supporting users with LD or Hearing Impairments during classes. The tools were proposed to users after a preliminary evaluation of their functioning, based on the ICF* [19] model (our customizes version of the WHO ICF, which permitted us to describe interactions between students and ICT devices). Each prototype has been tested with our students, providing encouraging results. More controlled experiments, gathering measures about the effectiveness of the tools, are planned.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1179

Supporting Mentoring on the Job through Social Media

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Abstract. Mentoring on the job is often used to introduce/integrate staff into place of employment and is a topic of this paper as an important aspect of work-based and social learning. In this paper the approach of ICT supported mentoring for people with disabilities and examples within the innovation transfer LdV projects IBB2 (www.lebenshil fe-guv.at/ibb2) and DIMENSAAI (www.dimensaai.eu) and the LdV learning partnership MOTION are also presented. IBB2 supports inclusive care of workers with learning disabilities during their job entry by using a mentoring process taking place between the inclusive care worker and a colleague.
DIMENSAAI activities improve participation in education and employment particularly for disadvantaged groups by the use of a social innovative diversity and mentoring training model focusing on social networking and working places in the health and care sector. MOTION supports the building of social networks for improving transition from education to work of people with disabilities by using also social media and mentoring.

Keywords. People with disabilities, mentoring, diversity, ICT, social media.

Introduction

Mentoring is often used to introduce/integrate staff into place of employment. Mentoring is commonly used to describe a guided informal learning process in vocational education in which an existing member of staff or an external one guides newcomers/ less-experienced people or people with disabilities in a task to develop professional skills, attitudes and competencies.

Mentoring involves not just guidance and suggestion, but also the development of autonomous skills, judgments, personal and professional master ship, expertise, trust and the development of self-confidence over the time. It is particularly important for people with special needs to support them in utilization of their resources (knowledge, skill, aptitude) and to socially integrate them also into the work society. The nature of mentoring is “friendly”, “collegially”. Mentoring operates within professional and ethical frameworks (Richert, 2006; Hamburg, 2012).

On the job mentoring is a topic of this paper as an important aspect of work-based and social learning. The mentors consider the mentees’ resources and transfer their own professional knowledge and experience to the mentees and support them (continuously) in their professional environment and development. This mutual harmonization also includes aspects of thought, social integration in the organization and optimal professional resources utilization of the mentees and their workplace fellows (Kram, 1985; Hamburg and Breipohl, 2011).

The cases we give in this paper describe mentoring for people with disabilities within the innovation transfer Leonardo da Vinci projects IBB2 and DIMENSAAI.

The LdV innovation transfer project IBB2 (Inclusive Disability Care - www.lebenshilfe-guv.at/ueber_uns/eu_projekte/ibb_2) is the continuation of the successful EU project IBB. The aim of the IBB2 project was to support inclusive care of workers with learning disabilities during their job entry. The project was coordinated by Lebenshilfe-GUV Graz. Six organizations from five countries (IAT was one of the partners) have worked on the development and trial of the IBB2 model for a period of two years. The result was a support system that is geared toward the needs of all people involved in the process (employers, colleagues, and inclusive care workers). The model is based on three modules which provide an analysis of the future workplace and the legal framework (laws and regulations) on the one hand, and the development of a special Diversity Team Workshop on the other hand, which the inclusive care worker and the new work environment may use shortly before job entry. The final module deals with the mentoring process taking place between the inclusive care worker and a colleague. A timely networking process for all people involved further contributes to the model's successful implementation.

DIMENSAAI (Diversity and Mentoring Approaches supporting Active Ageing and Integration - www.dimensaai.eu) is a European LdV innovation transfer project coordinated by the author which started at the end of 2012. By transferring a mentoring model from former European projects like IBB2 to Germany and other partner countries, the consortium intends to improve participation in education and employment particularly for disadvantaged groups by the use of a social innovative diversity and mentoring training model focusing on social networking and the working places in the health and care sector (Hamburg, 2013a, b). Focus Group Discussions with educators, social actors and representatives of target groups (one of the them are people with disabilities) have been organized in all partner countries to discuss the needs of the target groups for integration into education and work and how a mentoring process could support these processes. The results will be used at the next steps which are the development of a catalogue with competences of a mentor for the target groups, workshops about diversity and the development and testing of the mentoring process. It has been discussed how social networking by using social media can support social learning which is very important for people with special needs. A social network supported by an ICT platform for innovative online training, with forums for information exchange, for solving problems and for collaboration is in the development within the project (www. platform.dimensaai.eu - see next part).

MOTION learning partnership supports the building of social networks for improving transition from education to work of people with disabilities by using also social media and mentoring. Educators, social workers, parents, employers will be attract to participate in the networks together with people with disabilities.

1 ICT Supported Mentoring

In the following we present the approach of ICT supported mentoring particularly through a Web-based system (WBMCS) we use in the two projects developed for using social media which allows mentors and mentees to learn on-line, to communicate and collaborate, and to share knowledge and other different pathways to assess learning processes. Social media, particularly based on Web 2.0, i.e., (O´Reilly, 2005) media which supports social interaction, can take many different forms, including Internet forums, weblogs and wikis.

The technical skills needed to use social media are rather low. Blog software, can replace sophisticated and costly content management systems. Another important characteristic of such applications and "spaces" is the decreasing technical difference, such as the one between teachers and taught, between formal and informal learning processes, between education and knowledge acquisition/management. This gives rise to new integrated and world-wide forms of learning, e.g., in Communities of Practice - CoP (Wenger et al., 2002). Here, people learn in a community of interests without building a hierarchy. A low-cost and easy access virtual room to accommodate formal and informal learning practices, group collaboration and the gathering and exchanging of learning materials in a CoP could be realized in an e-Learning environment based on the social media supporting tool TikiWiki CMS Groupware (Wikipedia, 2012) we use for our WBMCS prototypes.

Referring the range of mentoring relationships which can be supported by social media it is a continuum going from informal mentoring to formal, highly structured and planned mentoring. Informal mentoring is created spontaneously or is initiated by special interest i.e. when the mentee could be a potential employee. Some advantages are a relationship of trust and respect between the partners, high degree of compatibility and cooperation and flexibility of the relation. The most used form of learning in this context is an informal one. Formal mentoring allowing more people to be mentored is often facilitated and supported by the organisation which makes also tools available to participants for an efficient process. Aspects as the difficulties by paring with the risk of poor one and less flexibility of relationships between mentor and mentees and of the mentoring process are disadvantages. Social networks support this types of mentoring. In our projects referring people with disabilities we use more informal mentoring but we decided to use formal mentoring and more on-line support for training mentors and when working with seniors as mentees.

2 Examples

This WBMCS prototypes we developed in IBB2 (Fig. 1) and DIMENSAAI (Fig. 2) support the following processes in a Community of Practice.

- Social networking
- Training of mentors
- Mentoring process including also mentee learning
- Communication

Within MOTION a social network and mentoring of people with disabilities and their parents will be supported by social media.

TikiWiki CMS Groupware, originally and more commonly known as TikiWiki or simply Tiki, is a free and open source wiki-based content management system written primarily in PHP and distributed under the GNU Lesser General Public License (LGPL) license. IAT has tested also Moodle but experience with TiKiWiki as a social media done by the IAT within other projects aimed at people with disabilities (i.e. CLINTEV – www.clinrev.eu) and research show that TikiWiki is more suitable for applications like online collaboration, knowledge sharing/management, wiki, blogging, social networking i.e. within an online community.

For supporting training, the modules are available online, but in addition, a discussion forum for each module enables learners and trainers/experts to exchange and add ideas to the environment. This allows learners to provide feedback to mentors/experts. It also enables them to post queries to which other participants, mentors or other experts can answer. All participants are able to see the initial queries and the discussion stream of answers from other participants and the instructors. This informal collaboration motivates people with special needs to learn. Formal training sessions will be organised so that learners can use the tools provided by the platform to connect each other. A special space on the platform will be developed allowing project partners to use their own language for training and communication.

Our experience with the supporting of mentoring processes by using the WBMCS shows that there are also people with disabilities which would like to act as mentors and also mentees with disabilities who would like to use the system if corresponding assistive functions are added. So we will update the DIMENSAAI prototype use now the “extension” of TikiWiki with MobileTiki that allows to access content from many different devices and browsers. The increase accessibility of mobile phones makes them one of the most affordable means of communication and technology. Tiki mobile is a synonym for the enhanced capabilities of Tiki concerning accessibility and mobility. Tiki has integrated the HAWHAW supporting many devices which are able to interact with the mobile version of Tiki. Blogs and wiki pages are accessible via WAP, VoiceXML and VoiceControl. A blind user on-the-go can benefit from Tiki Mobile, because alternatively he can navigate through content from a cell phone by means of Voice Control. So it is not necessary to use a stationary PC equipped with special hard or software any more. From the received VoiceXML data, the voice browser performs a text-to-speech (TTS) conversion and sends the resulting voice output to your phone. In opposite direction the voice browser attentively listens what you say (ASP, Automatic Speech Recognition) and sends appropriate requests to MobileTiki, e.g. in order to retrieve another wiki page. So the user can navigate through a set of pages by speaking the name of the page in the own phone.

3 Conclusions

The ICT approach we use in the two projects supports different learning abilities of students with disabilities and overcomes limitations in time or space etc. of traditional face-to-face training. It allows the learner to work at his or her own space, speed and depth with support from educators/trainers/mentors and the other learners.

However, in the inclusive vocational training for people with disabilities or seniors by using mentoring, informal and Web-based learning methods by using social media support should be blended with traditional face-to-face ones. Parents should be also involved. Experience from other projects demonstrates also the need for a constant presence of experienced and qualified mentors in the WBMCS. A trust relationship has to be established first (if possible) face-to-face and later online, if the

Figure 1. IBB 2 Prototype.

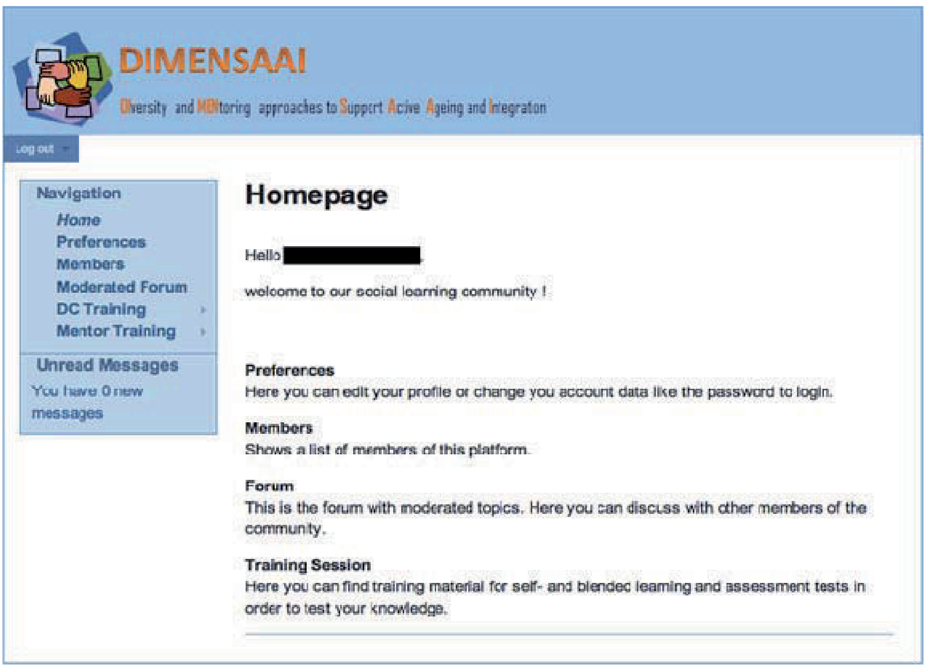

Figure 2. DIMENSAAI Prototype.

WBMCS will be used in the project on a regular basis by the mentors and mentees. The WBMCS should support real mentoring and not be understood as a supervisory tool.

Acknowledgements

This paper describes work within the transfer innovation projects IBB2 and DIMENSAAI and the Learning Partnership MOTION partially supported by the Leonardo da Vinci LLP.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1185

ENABLE – Collection and User Evaluation of ICT-Assisted Learning Tools for Disabled Persons in Europe

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Abstract. ENABLE is a Grundtvig/EU network project in the framework of the Lifelong-Learning-Programme funded by the European Union. The consortium consists of 17 partners from 12 EU and 3 third countries. The major aim is to collect information and communication technology (ICT) learning tools of good practice for disabled persons in Europe and worldwide and associated user evaluations for these tools. This paper gives a first insight into the current state of the data collection performed in the respective workpackage. We have collected more than 150 ICT tools throughout Europe and outside, some primary statistics of which will be presented.

Keywords. ENABLE, Grundtvig, ICT learning tools, disabled persons.

Introduction

Many people with disabilities use assistive ICT to overcome the barriers they would otherwise face. However, ICT has the potential to be both an enabler that increases access and participation and a source of additional barriers, depending on how it is designed and implemented.

This paper describes the first major outcome produced by the ENABLE network project [1] and provides the background data from which most of the other project outcomes are developed. It focuses on the workpackage of data collection, preliminary systematic valuation by users and user organizations, and some initial statistics. This is an important extension to other existing data bases collecting ICT tools for disabled persons as, for ijstance, Rehadat [2]. While there is considerable tacit knowledge at hand about the use of ICT to support learning by disabled people, as well as various anecdotal accounts, this paper describes the first systematic investigation. It is based on data from the 12 network partner countries in Europe as well as three network partner third countries. This enables the consortium to make comparisons and draw conclusions in subsequent work packages and to give indications of best practice.

The following objectives are discussed in the paper in detail, i) data and knowledge on the state-of-the-art on the use of ICT to support learning by disabled adults and innovations, ii) data and knowledge on methodological, pedagogical and end-users issues, iii) data and knowledge on accessibility, usability and other requirements of disabled adults for ICT to support learning and the relationship of these requirements to personal characteristics.

In the ENABLE project, we also compare objectives and influences of adult education centres or distance learning centres in diverse countries to investigate the following issues:

i) The different ways in which ICT is used to support learning, particularly by disabled people, in their organisations,
ii) What they consider good and bad practice and how this good practice is illustrated in their organisations,
iii) The ways in which ICT is made accessible and useable to disabled adults; this includes the use of assistive learning solutions designed specifically for groups of disabled people and learning for all approaches.

The focus of the project and of the data collection is set on learning for disabled adults; however, there may be some discussion of ICT for disabled children, young people and university and college students and non-disabled adults and the possibilities of modifying and adapting this technology to disabled adult learners.

1. Online Questionnaire

An online questionnaire on base of LimeSurvey [3] was developed to support the collection of ICT tools for disabled persons and their evaluations by end users. It consists of 48 systematic questions that can be grouped into six principal sections in order to collect data on the use of different types of learning technologies. An English and a German version of the questionnaire are available via the following URLs ([4], [5]):

- http://umfrage.ftb-net.de/limesurvey/index.php?sid=52659&newtest=Y&lang=en
- http://umfrage.ftb-net.de/limesurvey/index.php?sid=52659&newtest=Y&lang=de.

The written questionnaire was translated by partners into Slovenian, Lithuanian, Polish, and Serbian; other partners mainly used telephone interviews for data collection in their countries.

The questionnaire is anonymous and does not contain personal information that could be used to identify the contributors, with the exception of the name of the contributing organization. The six major sections of the questionnaire are:

Section 1: Basic details of learning technology or tool
Section 2: Target end-users of this technology
Section 3. Knowledge and skills required for the use of the tool
Section 4: Training and documentation
Section 5: Accessibility features and customization
Section 6: Evaluation

The function of the questionnaire is to gather as much structured detailed information as possible on the tools/technologies and on their use, and to combine this information with evaluations by the end users or user groups when available. Partners can include information and evaluation results of the ICT tools online during the lifetime of the project, which they may have been gathering, for example, in round table or individual discussions.

2 Statistics on Data and Data Collection

Most of the 153 tools collected to date were reported only by a single partner and many were reported to be usable in other languages or countries with a clear focus on English.

2.1 Types and Frequencies of Collected ICT Tools

The summary of the types and tools collected in the database is presented in table 1; at present, the database is with 153 entries and 151 so large that only an overview of some processed details, descriptions, and evaluations of the collection can be stated here.

Table 1: Quick summary of the types of collected ICT tools and frequency collected in the database.

Type of the Tool	Frequency
Information or teaching material aimed solely at disabled people	16%
Curriculum material	13%
Communication aids including text-to-speech	13%
Accessible documents and alternative formats	12%
Dictionaries and translators, including sign language	9%
Learning management systems	5%
Classroom and lecture tools	5%
Computer input tools	4%
Screen readers	4%
E-learning creation or presentation software	3%
Literacy and grammar aids	3%
Others	13%

The majority of collected ICT tools is formed by information or teaching material, curriculum material, communication aids, accessible data formats and documents, and dictionaries or translators.

2.2 Types of Impairments

Table 2 presents a breakdown of the types of impairments mentioned in the questionnaire and related to the collected ICT tools.

Table 2: Quick summary of the types of impairment beneficiaries mentioned in the database entries.

Type of impairment	Frequency
Blind or visual impairment	27%
Hearing-impaired	18%
Dyslexia, cognitive impairment, learning disability	13%
All Disabilities	13%
Autism and Asperger's Syndrome	4%
Others	25%

The majority of tools was related to visually or hearing-impaired persons or persons with dyslexia, cognitive impairment, learning disabilities including persons with Down syndrome. Persons with mobility problems are up-to-date underrepresented.

2.3 Education Fields or Subjects

Figure 2.1 below illustrates the distribution of the collected ICT tools to the most popular education fields/subjects, independent of the education level. The majority of is concerned with mathematics, chemistry, geography, and languages, evaluated by teachers or single users. Other fields are often specific and include, for instance, tools for carpenters, tailors, painters, metal workers, hotel workers, or other vocational training subjects.

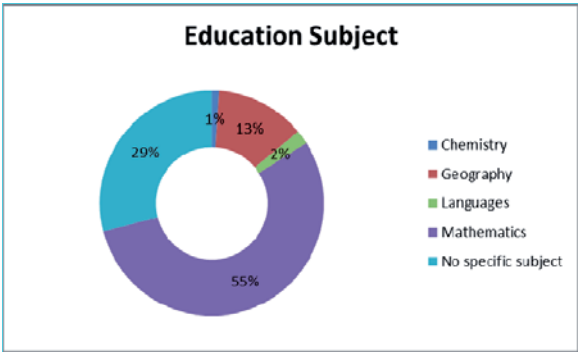

Figure 1: Frequency of education subjects in the database of tools.

Figure 2 shows the distribution of collected ICT tools used at standardized education levels (1-5); for the majority of ICT tools, the level was not clearly stated, mainly because the may be used at more than one level.

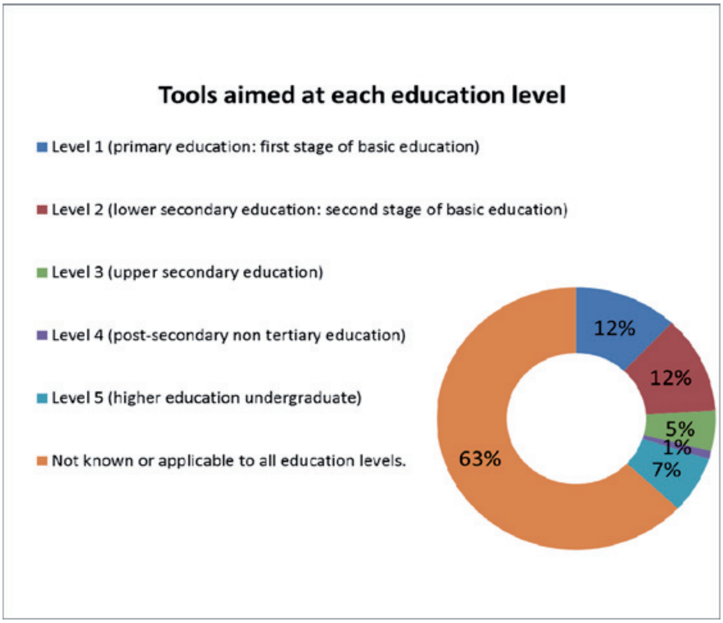

Figure 2: ICT Tools aimed at five standard education levels.

Table 3 shows how the collected ICT tools are distributed to the standard education levels (1-5) and to the major education fields. Blocks without an entry represent frequencies below 1%.

Table 3: Levels of education required for the tools focused on specific subjects.

Level	Geography	Mathematics	Languages	Chemistry
Level 1 (primary education)	6%	6%	29%	
Level 2 (lower secondary education)			22%	
Level 3 (upper secondary education)		12%		12%
Level 4 (post-secondary, non-tertiary education)				
Level 5 (higher education)				
Unknown		1%	11%	

Further, the evaluators could determine the ‘type of learning’ as i) virtual learning, ii) blended learning, or iii) content sharing. Most of the tools were classified as ‘requested level unknown’, but there are still several statements concerning specific types of learning for each education level. These answers indicate that many of the collected ICT tools may be used for any education level or age as long as other requirements as, for instance, accessibility or general intellectual abilities are fulfilled.

3 Conclusions from the Data Collection and Advices for Categorization

The consortium has up-to-date collected more than 150 ICT tools for disabled persons. Most of these tools may be used for any education level or age as long as other requirements as, for instance, accessibility and general intellectual abilities are fulfilled.

A large number of advices to improve these tools from a user perspective was given and will be evaluated in further workpackages of the ENABLE project. The advices were naturally very tool-specific, but there may be an underlying pattern behind the requests.

Most ICT tools were freeware and can be downloaded from the internet or sent on request, but there were others that cost up to 2000€ per license.

Most ICT tools run on PC platforms under MS Windows, some on Apple or on Smartphones, e.g., under Android.

For most ICT tools, details for download, purchase, or maintainance were supplied including respective internet addresses, licence or copyright regulations, necessary input or output devices, and others.

Acknowledgements

We thank the EACEA for financing the ENABLE livelong-learning network (project no. 518537-LLP-1-2011-1-SI-GRUNDTVIG-GNW) and the partners of the consortium for collecting data and evaluations on requested and interesting ICT tools for disabled persons, namely: University of Primorsky, Slovenia; Centrum Rozwoju Inicjatyw

Społecznych/ Civil Initiatives Development Centre, Poland; University of Glasgow, U.K.; Estonian Foundation for the Visually Impaired, Estonia; University of Turku, Finland; German Association for the Hard-of-Hearing, State of Lower Saxony, Germany; Evangelian Foundation Volmarstein, Germany; Athena RC/ ILSP - Institute for Language and Speech Processing, Greece; University College Cork, Ireland; Italian Association for the Blind ISTI-CNR, Italy; Lithuania; Serbia; Arhinet, Slovenia; JISC, U.K.; Macquarie University Accessibility Service, Australia; Sogang University, Korea; University of Belgrade, Serbia.

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Special Session on Power mobility: User experiences and Outcomes

Special Session on Power Mobility User Experiences and Outcomes

The Special Session focuses on outcomes of power mobility as reported by older users. Knowledge about outcomes is of utmost importance, since the final aim of all kinds of assistive device development and implementation processes is to create positive outcomes of device use for the individual user. The Special Session comprises longitudinal pre-post studies from Canada and the Nordic countries showing effectiveness and subjective well-being outcomes of power mobility after four months to one year of use. Effectiveness outcomes concern participation in real life, while aspects of subjective well-being for example are depression and satisfaction with the device. The studies in this session document the actual outcomes of power mobility interventions, yet some of the studies mainly focus on methodological issues.

Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1193

User Satisfaction with the Service Delivery Process of Assistive Devices – an Outcome Dimension or a Quality Indicator?

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Abstract. Previous research has suggested that user satisfaction is a separate construct from e.g. mobility-related participation or quality of life, and should be evaluated in studies of outcomes of mobility devices. However, recent research on powered scooter service delivery process in two different nation contexts have questioned whether user satisfaction with the service delivery process is in fact an outcome dimension, or rather a quality indicator. The purpose of this paper is to discuss this issue.

Introduction

Assistive device outcomes research has been defined as the systematic study of the effects produced by assistive devices in the lives of users and their environments. Examples of outcomes are mobility-related participation, quality of life, and user satisfaction. (1). User satisfaction in assistive technology contexts can be defined as the user's critical evaluation of different aspects of assistive devices and service delivery processes, which is influenced by individual expectations, perceptions, attitudes, and personal values (2). User satisfaction is expected to be influenced by the service delivery process and organisational/structural aspects of the services (3). According to the CATOR taxonomy, user satisfaction is a subjective well-being outcome dimension (4). However, recent research on powered scooter service delivery in two different national contexts has questioned whether user satisfaction with the service delivery process is in fact an outcome dimension (20). Hence the purpose of this paper is to discuss whether user satisfaction with the service delivery process is an outcome dimension in terms of effects on the lives of users and their environments, or rather a quality indicator of a more or less successful service delivery process.

1 Conceptual Models

Conceptual models provide a theoretical basis for advancing scientific knowledge and improving professional practice (5). Edyburn (2001) states that models help practitioners and researchers to understand key variables, relationships, and systems that stimulate advancements in theory, research and development, policy and practice (6). For assistive technology researchers, a conceptual model can provide a framework within which to classify areas of inquiry and to develop predictive models of utilization patterns (7, 8), evaluate design alternatives, predict human performance (9), and analyze data collection systems across states, regions and countries (10).

1.1 Donabedian Conceptual Model for Quality Assessment

The Donabedian model is a well known conceptual model for quality assessment, incorporating three key components: 'structure of care', 'process of care' and 'outcome of care' (11). According to a recent review of frameworks for measuring quality in stroke rehabilitation (12) there seems to be a relationship between the key elements above. Structure predicted both process and outcome of care, and better processes predicted better functional outcomes and user satisfaction.

Structure of care. According to Donabedian, 'structure of care' refers to attributes of the setting in which care occurs, including material resources, human resources, and organizational structure (11). 'Structure of care' refers to more than health care, as Donabedian have broadened the scope to include e.g. rehabilitation and other services (3). For the field of assistive technology, 'structure of care' includes e.g. who is responsible for the provision of assistive devices, type of financing and legislation. Cross-national differences include the systems concerned, the range of competent authorities, type of regulation, financial support, and the content of the product lists (13).

In Norway and Denmark, the municipalities have a fundamental responsibility for rehabilitation, including provision of assistive devices to persons whose functional capacity is permanently impaired due to illness or injury. Since every country determines their policy and organising of services, a variation in the structure inevitably exists – also between the Nordic countries, which is exemplified in this paper (14).

Based on individual rights, in Norway the Act on Social Security covers the provision of assistive devices. In Denmark, under the terms of the Social Services Act, the municipalities have to provide grants for assistive devices and consumer goods for persons with long-term disability. (14). Policy in both countries aims at providing the most suitable but cheapest assistive device, free of charge. There is one exception, though; in Denmark from 2008, depending on the individual functional ability, users are given a grant for 50% of the cost of scooters and must pay the rest themselves if the scooter is defined as consumer goods (like e.g. dish washing machines) and not an assistive device.

Process of care. The 'process of care' refers to what is actually done in giving and receiving care (11), and includes rehabilitation services as long as they pertain to the performance of the professionals as they care for the user (3). In the field of assistive technology the process of care includes the services that directly assist the user in the selection and use of an assistive device (15), and is called the service delivery process. This is a multidisciplinary process involving the competence of professionals like e.g. physiotherapists, occupational therapists (16) and technicians or engineers (17). The service delivery process encompasses assessing the needs of the individual, trying different scooter models, doing driving tests, performing necessary fittings and adjustments in addition to necessary housing adaptations, and instruction in the use of the device. Follow-up services and administrative work (handling applications and documentation of the process) are also important parts of a service delivery process (18). The different steps of the service delivery process are believed to have a great impact on the outcomes of assistive devices (19).

Compared to the Norwegian, the study by Sund et al (20) revealed that in the Danish sample significantly more total time was spent in the service delivery process of the scooters. Also, significantly more time was spent on assessments and administration, and that significantly more time was spent on follow-up services in the Norwegian sample. Studying the samples together, assessment, administration and follow-up services explained 71.1% of the variance of the total time spent in the service delivery process. Structural differences were the main explanation for the results. An important reason for the time differences was the fact that the Danish therapists must decide whether or not the user should pay 50% of the cost of the scooter themselves. This required that the Danish therapists performed the assessments very thoroughly in order to arrive at a correct decision. They also had to spend much time on documenting the service delivery process, while such documentation was not needed in Norway. The study thus supported the assumption that structure and organisational aspects of the services impact the service delivery process.

Outcome of care. 'Outcome' of care (11) includes the end result of particular health care practices and in this case the effects produced by assistive devices in the lives of users and their environments (1). Previous research has suggested that user satisfaction is a separate construct from e.g. mobility-related participation or quality of life, and should be evaluated separately in studies of outcomes of mobility devices (21).

Based on a 5-point rating scale (1=very dissatisfied, 5=very dissatisfied) of the Satisfaction with Assistive Technology Services (SATS) instrument, the study by Sund et al (20) revealed that in both samples, around half of the informants were ‘very satisfied’ and less that 6.0% were ‘dissatisfied’ or ‘very dissatisfied’ with the possibility to get in contact with the professionals, information, coordination between the professionals, knowledge of the professionals, possibility to participate and instruction and training is the use of the scooter. Except satisfaction with the waiting time, there were no significant differences in user satisfaction between the Norwegian and Danish samples. Ordinal regression analysis revealed no significant association between time in minutes spent on ‘assessment’, ‘selection of model’, ‘driving test’, ‘follow-up services’ and user satisfaction. The study did not support the assumption that the process is associated with the outcomes in terms of user satisfaction with the service delivery process, as opposed to the conclusion of the literature review by Hoenig et al (12). Based on the above, we question whether user satisfaction is an outcome dimension in terms of effects on the lives of users and their environments. Perhaps a quality indicator is a more appropriate term showing more or less successful service delivery processes?

2 User Satisfaction – a Response to What?

According to Donabedian (11, 22) the delivery of healthcare consists of three elements: a *technical* part which includes diagnosis, treatment and rehabilitation; an *interpersonal* part, which consists of the psychosocial interplay between the user and the professionals, and, finally, an *organisational/structural* part dealing with admission, coordination and continuity of the services. In literature it is common to find statements that users lack knowledge and understanding about the technical part of the services, and because of this they tend to confuse the technical quality of the services with the interpersonal or the organisational quality, when being asked to rate their satisfaction with the services (23). This was confirmed in a study by Mahtisen et al (2007) (24) among patients undergoing surgery for colorectal cancer (n=336), which concluded that when patients were asked to evaluate technical aspects of care, their evaluations seem to be affected by other aspects of the service they receive in a given healthcare institution. In a postal survey by Lian et al (2005) (n=1764) among 20-70 years old patients, the informants were asked to rate their satisfaction with the services offered by their general practitioner. There was a significant association between a high degree of satisfaction and continuity of care (the same doctor every time the informants needed help). The results also supported that interpersonal and organisational aspects of the services were associated with the informants' satisfaction with the services (25). In a prospective, cross-sectional study by Berg et al (2012) the informants were asked to recall the trauma surgeons and then rate them for satisfaction with interpersonal and technical care. They concluded that patients that are unacquainted with technical aspects of care may make judgments based on satisfaction with interpersonal aspects of care (26). It is considered that the technical quality of the service delivery process is most important in relation to making a good match between the user, the assistive device and the environment, and which results in outcomes in terms of effects in the lives of the users and their environment (4).

3 Conclusions

Since user satisfaction seems to be associated with interpersonal factors, and the outcome in terms of the effects produced by assistive devices in the lives of users and their environments, seems to be dependant on the technical part of the service delivery process, it is difficult to classify user satisfaction as an outcome dimension. Our suggestion is to classify user satisfaction with the service delivery process as a quality indicator and hence an evidence for more or less successful service delivery processes.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1198

Relationships between Effectiveness, Psychological Functioning, and Satisfaction Outcomes of Power Mobility Interventions

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Abstract. A number of assessment instruments are available for assessing outcomes of mobility device interventions, but it is unclear to which degree the outcome dimensions are overlapping. In this study the relationship within and between three categories of self-reported power mobility outcome dimensions each encompassing two dimensions, delimited on basis of the CATOR taxonomy, was investigated utilizing data from a Nordic study, which included 137 persons using powered wheelchair or scooter. The study showed that the outcome dimensions only correlated weakly or modestly, and in some cases no correlation at all was found. This indicates that each dimension constitutes a separate construct, and that assessment of one outcome dimension cannot replace another. Overall the outcome dimensions within each category correlated more with each other than with outcome dimensions from other categories, lending support to the CATOR taxonomy.

Introduction

Assistive technology outcomes research is advancing these years, and aspects such as classification of outcomes [1] and psychometric testing of outcome evaluation instruments are being addressed. In addition, the number of empirical outcomes studies is increasing, and even systematic reviews are performed [2]. This development is very important because sound outcomes research is one of the prerequisites for evidence based assistive technology interventions. In this respect especially costly devices such as powered wheelchairs and scooters, i.e. power mobility, are of interest.

Outcome dimensions investigated and utilised cover a broad range from observed effectiveness to self-reported subjective well-being such as psychological functioning and user satisfaction, but little is known about to which degree these dimensions are related and may substitute each other or constitute separate constructs needing to be examined on their own.

The purpose of the present study was to explore the relationship within and between three categories of self-reported power mobility outcome dimensions each encompassing two dimensions, delimited on basis of the CATOR taxonomy [1]:

1) Effectiveness: mobility-related participation (MRP) repertoire and ease of MRP

2) Psychological functioning: fulfilment of expectations to the power mobility device and the importance of the device
3) User satisfaction: satisfaction with service delivery process (SDP) and satisfaction with the power mobility device.

It was hypothesised that correlation between the outcome dimensions in each category would be stronger than the correlations with the dimensions in the other categories.

1 Materials and Methods

The study was a part of a larger Nordic study on power mobility outcomes. It had a pre-post design and took place in Denmark and Norway.

1.1 Study Participants

Study participants were recruited consecutively from the municipality of Odense in Denmark and from eight counties in Norway. Inclusion criteria were: about to receive a scooter for the first time; 18 years of age or older; sufficient cognitive functions and verbal skills for participation in interviews; living in ordinary or sheltered housing. In Denmark 82 power mobility device users were invited of whom 54 accepted and five dropped out during the study leaving 49 study participants. In Norway, 104 users were invited and 88 accepted the invitation. The final number of participants was 137 in all. Reasons for non-participation were mostly that they did not wish to participate or were too ill. The mean age of the participants was 74 years (SD 12.57, range 35-96), 74% were male, and 85% used a powered scooter.

All study participants gave informed consent, and all principles of ethical guidelines for human research were followed. Formal ethical approval was not required.

1.2 Instruments and Procedures

All instruments utilised had a structured interview format implying self-rated assessments. Data about effectiveness and psychosocial functioning were collected by means of "The Nordic mobility-related participation outcome evaluation of assistive device interventions" (NOMO 1.0) [3], while the "Satisfaction with Assistive Technology Services" (SATS) [4] and the "Quebec User Evaluation of Satisfaction with assistive Technology" (QUEST 2.0) [5] were used to collect data about user satisfaction. See table 1.

In Denmark data were collected by six and in Norway 12 experienced occupational therapist or physiotherapists by means of face-to face interviews, except from the SATS data, where telephone interviews were applied. Prior to data collection the interviewers were trained in this. None of the interviewers collected data from their own clients. The NOMO 1.0 was used at baseline (T1), the SATS at a mean of 2.08 (SD 2.02) months after baseline (T2), and the NOMO 1.0 and the QUEST 2.0 at a mean of 12.52 (SD 2.34) months after baseline (T3). See table 1.

1.3 Data Analysis

Prior to analysis data were prepared:

- MRP repertoire: the difference between number of participation activities at T1 and T3 was calculated: 0.64 (SD 2.33, range -6-8), p=0.002. Data were normally distributed.
- Ease of MRP: Sumscores and means at T1 and T3 were computed, and differences between means calculated: 0.46 (SD 0.80, range -2.63-1.80), p<0.0001. Data were normally distributed.
- Fulfilment of expectations: Means were calculated: 3.72 (SD 0.91, range 1-5). Data were skewed.
- Importance: Means were calculated: 4.15 (SD 0.90, range 1-5). Data were skewed.
- Satisfaction with the service delivery process: Sumscores and means were calculated: 4.28 (SD 0.55, range 3-5). Data were skewed.
- Satisfaction with the device: Sumscores and means were calculated: 4.25 (SD 0.52, range 1-5). Data were skewed.

Table 1. Assessment instruments used.

Outcome dimension	**Instru-ment**	**Number of items**	**Response categories**	**Time in study***
Effectiveness				
Mobility-related participation repertoire	The NOMO 1.0	20	Does/does not	T1 and T3
Ease in mobility-related participation	The NOMO 1.0	Max. 20§	A five-step ordinal scale: "very easy" to "very difficult" and "does not know"	T1 and T3
Psychological functioning				
Fulfilment of expectations	The NOMO 1.0	1	A five-step ordinal scale: "much worse than expected" to "much better than expected" and "does not know"	T3
Importance	The NOMO 1.0	1	A five-step ordinal scale: "not important at all" to "extremely important" and "does not know"	T3
Satisfaction				
Satisfaction with the service delivery process	The SATS	8	A five-step ordinal scale: "not satisfied at all" to "very satisfied" and "does not know"	T2
Satisfaction with the device	The QUEST 2.0	8	A five-step ordinal scale: "not satisfied at all" to "very satisfied" and "does not know"	T3

*T1: At baseline; T2: about 2 months after T1; T3: about a year after T1

§Individual, depends on the number of current participation activities

Subsequently correlations between all outcome dimensions were calculated. For normally distributed data the Pearson correlation coefficient was applied, and for skewed data the Kendall's tau-c. Strengths of correlation were assessed on basis of Dancey and Reidy's categorisation where correlation coefficients of 1=perfect/0.7-0.9=strong/0.4-0.6=moderate/0.1-0.3=weak/0=zero correlation [6]. P-values ≤0.05 were considered to be statistically significant.

2 Results

Of the 15 resulting correlations the strength of one was moderate, while eight were weak and six not correlated at all. The two effectiveness outcome dimensions only correlated weakly, but the correlation to other outcome dimensions was weaker except that the "Ease in MRP" dimension also correlated weakly with "Fulfilment of expectations" and "Importance". The psychological functioning outcome dimensions correlated moderately and best with each other compared to correlation with other outcomes dimensions. The satisfaction outcome dimensions correlated weakly with each other, while device satisfaction correlated a little more with both psychological functioning outcome dimensions. For details see table 2.

Table 2. Correlations between outcomes. N=137.

	Mobility-related participation repertoire r (p-value)	**Ease in mobility-related participation** r (p-value)	**Fulfillment of expectations** r (p-value)	**Importance** r (p-value)	**Satisfaction with the service delivery process** r (p-value)	**Satisfaction with the device** r (p-value)
Effectiveness						
Mobility-related participation repertoire	-	0.17 (0.052)	0.02 (0.772)	0.10 (0.135)	-0.004 (0.944)	0.05 (0.469)
Ease in mobility-related participation	0.17 (0.052)	-	**0.16 (0.016)**	**0.17 (0.009)**	-0.03 (0.626)	**0.03 (<0.001)**
Psychological functioning						
Fulfillment of expectations	0.02 (0.772)	**0.16 (0.016)**	-	**0.40 (<0.001)**	**0.16 (0.016)**	**0.30 (<0.001)**
Importance	0.10 (0.135)	**0.17 (0.009)**	**0.40 (<0.001)**	-	**0.16 (0.013)**	**0.26 (<0.001)**
User satisfaction						
Satisfaction with the service delivery process	-0.004 (0.944)	-0.03 (0.626)	**0.16 (0.016)**	**0.16 (0.013)**	-	**0.24 (<0.001)**
Satisfaction with the device	0.05 (0.469)	0.03 (0.583)	**0.30 (<0.001)**	**0.26 (<0.001)**	**0.24 (<0.001)**	-

3 Discussion

The study showed that the outcome dimensions only correlated weakly or modestly, and in some cases no correlation at all was found. This indicates that each dimension constitutes a separate construct and assessment of one outcome dimension cannot replace another. The a priori hypothesis that outcome dimensions within each category would correlate more with each other than with other outcome dimensions was only partly confirmed.

The correlation between the two effectiveness outcome dimensions was weak, but stronger than their correlation with the other outcome dimensions. This indicates that the two dimensions seem to belong to the same category differing from other categories. Similar findings have been shown in previous studies [7, 8]. The fact that the correlation between the two effectiveness outcome dimensions was weak and not quite statistically significant implies, however, that they are separate constructs giving different kinds of information about the outcomes of power mobility interventions. In fact, *MRP repertoire* can be regarded as an outsider perspective giving information about what the participant does, while *Ease in MRP* is an insider perspective informing about the power mobility users' perception of participation [3].

The two psychological functioning outcome dimensions were the ones that correlated the most, showing some relationship between power mobility users' perceptions of how important their mobility device was and to which degree their expectations to it were fulfilled. Since the correlation was not strong, the two dimensions probably elucidate two different, but related issues to be investigated. In addition, since each dimension only consists of one item it makes sense to ask both questions.

The satisfaction category differs from the other two categories in that one of the dimensions – *Satisfaction with the device* – correlates a little more, but still weakly, with other dimensions than with *Satisfaction with the SDP*. This is surprising, since it could be expected that user satisfaction with the SDP would be closely related with user satisfaction with the device. This result is, however, in line with the findings of Sund et al. [4] showing that *Satisfaction with the SDP* does not seem to be an outcome dimensions as such when defined as "the end result of particular health care practices and the effects produced by ADs in the lives of users and their environments", but rather a service quality indicator. It may thus be considered to revise the CATOR taxonomy in this respect [1]. The fact that the *Device satisfaction* outcome dimension correlates with the two psychological functioning outcome dimensions, even only weakly, supports the CATOR taxonomy where both the satisfaction and the psychological functioning categories are grouped in the same outcome area "Subjective well-being" [1]. In addition, the positive correlation supports the often used understanding of satisfaction as being influenced by individual expectations, perceptions, attitudes and personal values [5].

The study had some limitations. Ordinal data were summed and means were calculated, while it is often argued that this is only feasible for ratio data [9]. In the light of the explorative nature of the present study we claim that this can be defended. Likewise, it may be argued that correlation statistics is not as powerful in detection relationships as for instance application of regression models [10]. Once again we argue that as a first step correlation statistics is appropriate. Finally, data were collected in a Nordic context and may not be applicable in other national contexts.

Given the explorative nature of the present study further studies applying more sophisticated statistical methods are required to confirm the empirical findings of the present study concerning the structure of the CATOR taxonomy [1].

4 Conclusions

The study showed that the relationship between the six investigated outcome dimensions *Mobility-related participation repertoire; Ease in mobility-related participation; Fulfilment of expectations; Importance; Satisfaction with the service delivery process, and Satisfaction with the device*, were mostly weak or not related at all. The strongest correlation was seen in the Psychological functioning category where the correlation was moderate. The correlations between outcome dimensions within each category were as hypothesized a little stronger than with outcome dimensions from other categories except from the satisfaction category where the Satisfaction with the device dimension also correlated weakly with the Psychological functioning category.

The results imply that each outcome dimension constitutes a discrete construct, which cannot replace each other and must be assessed separately. Furthermore, the study provides some empirical evidence for the further development of the theoretical CATOR taxonomy of assistive technology outcomes.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1204

The Impact of Powered Wheelchairs on Activity, Participation and Health Related Quality of Life in Older People

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Abstract. The aim was to study the effect from using a powered wheelchair on old peoples' activity, participation and health related quality of life. Data was collected prior to prescription of a powered wheelchair and after four months use. Sample comprised 35 individuals >65 years of age referred to the Centre for Assistive Technology, Örebro county council, for prescription of a powered wheelchair. A statistically significant improvement with a large effect on IPPA; medium sized improvements on WHODAS 2.0; and small to medium sized improvements in SF-36; were shown. The sample was skewed (males n=28) and changes on WHODAS 2.0 and SF-36 could only be verified for men. In conclusion, a powered wheelchair has a great value for aged people. Further studies are warranted to explore the distribution of sex on powered wheelchair users.

Keywords. Aged, powered wheelchair, outcome, IPPA, WHODAS 2.0, SF 3-36.

Introduction

There has been an increase over the years in studies focusing on wheelchairs. Surprisingly, even though users of powered wheelchairs often have problems in activity and participation there is not much research in this population [1]. Furthermore, studies that have been made in the Nordic countries have concentrated on a relatively wide age range in the population [2, 3]. Thus, evidence of the impact of powered wheelchairs on activity, participation and health related quality of life in older people is sparse. The aim of this study was to explore the value of a powered wheelchair from elderly users' perspective with the following research question:

Is there an effect from using a powered wheelchair on older peoples' activity, participation or health related quality of life?

1. Methods

A pre- and post-intervention design using questionnaires for activity, participation and health related quality of life was used. Data was collected prior to prescription of a powered wheelchair and after four months use. Ethical approval was gained from the

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Research Ethics Committee in Uppsala, Sweden, reg. no 2011/134. Estimation of sample size was made by a power analysis based on change in health related quality of life.

1.1. Participants and Procedure

Clients referred to the Centre for Assistive Technology, Örebro county council, Sweden, for prescription of a powered wheelchair were informed and consecutively asked for participation in this study during the period June 2011 to April 2012. Inclusion criteria were: i) 65 years of age or older; ii) no previous powered wheelchair; iii) living in Örebro county; and, iv) ability to understand and express in Swedish language. At base-line, 42 subjects agreed to participate in the study. During the intervention period five individuals died, and at follow-up two individuals declined further participation. Hence, the sample comprised 35 individuals with a median age of 79.5 for men and 77 for women, with no difference in age between groups (p=0.553).
After agreeing to participate, all participants were interviewed by a trained occupational therapist in their individual homes.

1.2. Instrumentation

In order to capture changes in activity, participation and health related quality of life the following three instruments were used:

The *Individually Prioritized Problem Assessment* (IPPA) [4, 5] is an interview administered instrument that is recommended for use in measuring the effectiveness of assistive technology provision. According to the manual, up to seven subject-specific problems in daily life activities related to the intended purpose of the assistive device are defined and scored by the individual based on the importance of the problem and the difficulty to perform the task. The scores are given on a five-point ranging scale where 1= Not important at all/No difficulty at all, and 5= Most important/Too much difficulty to perform the activity at all. For each problem, the difficulty score is multiplied by the importance score and the sum of these scores divided by the number of problems are resulting in an IPPA score ranging from 1-25. The difficulty at follow-up is multiplied by the original importance score, and the difference in IPPA score between time 1 and time 2 is calculated. A decrease in IPPA score is positive. The International Classification of Functioning Disability and Health (ICF) [6] was used to categorize the problems.

The *World Health Organization Disability Assessment Schedule 2.0* (WHODAS 2.0) is a validated and reliable generic instrument based on the ICF [7]. It is available in 12, 12+14, and 36-item versions for self-, proxy- or interview administration. The 36 WHODAS items cover six functional domains: Cognition, Getting around, Self-care, Interpersonal relations, Life activities, and Participation. For this study, the interview administered 36-item version was used. Because all of the participants were retired from work, the four work-related questions were excluded from the life activities domain. The items are scored on a five point Likert scale ranging from 1 = No difficulties, to 5 = Extreme difficulties/Not possible at all. If less than half of the items in a domain were missing, missing items were replaced by the mean of the domain [8]. Using the SPSS syntax from the manual, the raw scores were normalized to a 0-100 scale creating indices for the six domains and an overall measure for activity and participation. High measures indicate high difficulties/high problems, and, consequently, a decrease indicates a positive effect of a powered wheelchair.

The *Medical Outcomes Study 36-item Short Form Health Survey* (SF-36) is a frequently used generic health questionnaire measuring effects on health related quality of life [9]. The survey is validated for people with different health conditions and tested for reliability. It consists of 36 items out of which 35 are summarized in to eight scales of physical and mental health: Physical functioning, Role-Physical, Bodily Pain, General Health, Vitality, Social functioning, Role-Emotional, and Mental Health. The questions are answered on different scales with 2 to 6 response alternatives. In accordance with the manual, the scores were transformed and normalized to a 0-100 scale to create indices for the different scales. High scores are positive, indicating good quality of life.

In addition, a study-specific questionnaire was used to collect data for sex, age and use of mobility devices.

Dependent and independent sample t-test was used to analyze the data; p-values lower than 0.05 were accepted as statistically significant. The magnitude of the effects was measured according to Cohens' criteria for effect sizes (d).

2. Results

A statistically significant improvement with a large effect on IPPA was found in both men and women (Table 1). The effect was measured by self-reported problems in ICF-domains *Self-care* (d= 2.47), *Domestic life* (d= 2.33), *Interpersonal interactions and relationships* (d=2.11), and *Community, social and civic life* (d= 2.36).

Table 1. Effect from using powered wheelchair on activity and participation as measured by IPPA.

	IPPA 1 mean (SD)	IPPA 2 mean (SD)	IPPA 1 – IPPA 2 mean (SD)	*p*-value	ES (d)
Total (n=35)	19.61 (3.20)	11.94 (3.61)	7.67 (3.39)	**<0.001**	2.26
Men (n=28)	19.43 (3.33)	11.97 (3.72)	7.46 (3.50)	**<0.001**	2.13
Women (n=7)	20.35 (2.73)	11.85 (3.38)	8.50 (3.00)	**<0.001**	2.83

Note: Significant differences in bold. SD= standard deviation. ES= Effect Size

There were significant medium sized improvements on two activity domains, the participation and the total score on the WHODAS 2.0 (Table 2). When making separate analyses based on sex, the results showed that the effect could be statistically verified in men only. Statistically significant difference between men and women was demonstrated in the household activities only, where men had significantly easier to perform the activities when using the powered wheelchair.

Table 2. Impact of powered wheelchair on activity and participation as measured by WHODAS 2.0.

Area	Pre mean (SD)	Post mean (SD)	*p*-value	Effect size (d)
Cognition (n=35)	14.43 (18.93)	15.14 (18.57)	0.755	
Getting around (n=35)	57.14 (19.24)	49.64 (17.21)	**0.002**	0.56
Self-care (n=35)	18.00 (19.07)	17.14 (20.08)	0.763	
Interpersonal relations (n=31)	25.54 (17.87)	20.16 (16.64)	0.184	
Life activities: household (n=31)	36.13 (33.23)	23.23 (23.29)	**0.027**	0.42
Participation (n=34)	33.95 (19.39)	23.16 (16.13)	**0.001**	0.63
WHODAS 2.0 total (n=26)	29.01 (13.96)	22.83 (11.80)	**0.001**	0.73

3. Discussion

The results from this study show the impact of a powered wheelchair on activity and participation, and, to some extent, health-related quality of life in older men. The different measures in this study show improvements in the same areas: the ability to take part in domestic activities, and participation in social activities. This may to some extent be explained by a correlation between WHODAS 2.0 and SF-36 [8]. However, it has earlier been shown that maintaining social relations and being able to take part in social activities are important for health [10]. The results from this study support these findings and indicate that getting around is important for both social function and physical health. These areas are important aspects of daily life and emphasize the impact of the powered wheelchair for old people.

One limitation in this study is the sample. During the data collection period, there was an over-representation of men being prescribed with a powered wheelchair. This resulted in a sample that was skewed (males n=28) and changes on WHODAS 2.0 and SF-36 could only be verified for men. Further studies of the impact of powered wheelchairs in women are therefore needed.

There are different possible threats to the internal validity of the study when using a pretest-posttest design. We cannot e.g. overrule the possibility of the testing itself influencing the scores given at the posttest. Since the IPPA is a very specific test, pointing at the specific influence of the assistive device, this may have led to an over-estimation of the effect of the wheelchair. Future studies using experimental design are recommended to exclude this threat to the validity and give stronger evidence for the benefit of prescribing powered wheelchairs to aged.

The conclusion is that elderly people have a great benefit from a powered wheelchair in everyday life activities. Professionals who prescribe mobility devices to old people have a key position in deciding who will have a powered wheelchair. Further studies are warranted to explore the potential difference in need and what the chances are to get a powered wheelchair depending on sex.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1209

The Natural History and Measurement of Power Mobility Outcomes among New and Experienced Older Adult Power Wheelchair Users: A One-Year Longitudinal Study

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Abstract. The objective of this study was to present the characteristics of and compare new and experienced power wheelchair users over a 1 year period. Sixty-seven older adult power wheelchair users completed outcome measures assessing participation, life space travelled, wheelchair skills, wheelchair confidence, social support, anxiety and depression. Preliminary results of this study indicate that while new power wheelchair users experience trends towards change in many of these areas over time, experienced power wheelchair users do not. Improved wheelchair skills, decreased anxiety, and increased depression were the areas in which trends towards change were observed for new power wheelchair users.

Introduction

A power wheelchair is often used to compensate for mobility impairment in older adults and prevalence of use increases with age[1]. Initiating power wheelchair use in later life involves important challenges that are less relevant for younger users (e.g., familiarity with technology). Power wheelchair use has been associated with increased mobility[2], decreased pain and discomfort[3], and improved participation[4, 5], however it has also been cited as a factor limiting participation[6]. To date, we have limited empirical data and comprehensive understanding of how older adults adapt to their power wheelchairs over time.

1. Objective

The objective of this in-progress research is to describe the natural history of power

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wheelchair use during a 1-year period in new and experienced older adult power wheelchair users. In this report, we present preliminary results of the characteristics of and compare new and experienced power wheelchair users at baseline and 3, 6, and 12 months later.

2. Methods

2.1. Design

A longitudinal (1-year) multi-cohort, multi-site design is being used in this study.

2.2. Participants

A convenience sampling strategy was used to recruit older adult power wheelchair users in two cohorts: those who had at least six months of experience in using a power wheelchair and those who were receiving their first power wheelchair. Individuals who were ≥ 50 years of age and had the ability to operate their power wheelchair independently were recruited from six Canadian cities: Halifax, Quebec City, Montreal, Toronto, London, and Vancouver. A variety of strategies, including recruitment through disability awareness programs, peer support groups, wheelchair seating programs, and equipment vendors were used. A total of 127 participants have been enrolled in this study. We present results from the 14 new and 53 experienced participants who have completed the 1-year data collection.

2.3. Procedure

Data is being collected based on the time of induction into the study at baseline, and 1, 3, 6, and 12 months post-baseline. Sociodemographic and clinical characteristics are being gathered. Primary outcomes being collected in this study include: activity and participation, life space travelled, objective and subjective assessment of wheelchair skills, and wheelchair confidence, as measured by the Assistive Technology Outcomes Profile for Mobility (ATOP/M), Life Space Assessment (LSA), Wheelchair Skills Test (WST), Wheelchair Skills Test Questionnaire (WST-Q), and the Wheelchair Use Confidence Scale (WheelCon) respectively. Secondary outcomes include measurement of social support using the Interpersonal Support Evaluation List (ISEL), anxiety and depression using the Hospital Anxiety and Depression Scale (HADS), and performance of socially defined life tasks as measured by the Late Life Disability Instrument (LLDI). All outcome measures are available in both English and French and are completed at all time points, with the exception of the WST, which is completed only at baseline and 12 months.

2.4. Data Analysis

Descriptive statistics, including means, standard deviations (SD), and frequencies were calculated for the participant characteristics, primary and secondary outcome measures.

3. Results

The participant demographic and clinical characteristics are presented in Table 1. The mean scores of the primary and secondary measures are presented in Tables 2 and 3.

Table 1. Participant Characteristics.

Variable	**Power Wheelchair Users**		
	New (n=14)	Experienced (n=53)	All (n=67)
Age in years, mean (SD)	63.7 (10.1)	60.1 (7.4)	60.9 (8.1)
Sex, male (%)	42.9	49.1	47.8
Diagnosis (%)			
Spinal Cord Injury	14.3	24.5	22.4
Multiple Sclerosis	28.6	15.1	17.9
Stroke	21.4	9.5	12.0
Lower Limb Amputation	7.1	1.9	3.0
Muscular Dystrophy	0.0	9.4	7.5
Arthritis	0.0	3.8	3.0
Other	28.5	35.8	34.3
Months Using Power Wheelchair, Mean (SD)	1.4 (1.9)	152.3 (125.2)	122.2 (127.2)

Table 2. Mean scores of the primary and secondary measures for the new power wheelchair users.

Outcome Measure	**New Wheelchair Users Score: Mean (SD)**			
	Baseline	3 months	6 months	12 months
ATOP/M*				
Activity	47.8 (4.4)	47.1 (3.5)	47.6 (3.8)	47.6 (5.6)
Participation	47.8 (6.1)	48.7 (8.3)	50.0 (8.8)	47.9 (8.4)
LSA	4.1 (0.9)	4.2 (0.6)	4.1 (1.2)	4.0 (1.2)
WST	82.0 (7.9)	N/A	N/A	87.4 (7.1)
WST-Q	84.8 (2.0)	90.6 (9.2)	92.0 (9.1)	88.9 (10.4)
WheelCon	78.3 (17.4)	73.1 (25.3)	75.9 (24.2)	77.5 (16.0)
ISEL	12.6 (4.3)	13.9 (5.0)	13.6 (3.7)	14.3 (4.2)
HADS				
Anxiety	9.2 (5.7)	9.1 (5.4)	7.8 (5.5)	8.4 (5.0)
Depression	6.7 (3.5)	7.4 (4.3)	8.4 (4.3)	7.3 (4.1)
LLDI§				
Frequency	46.1 (7.4)	45.3 (9.9)	44.4 (12.5)	44.9 (10.7)
Limitation	52.1 (15.5)	53.0 (12.1)	49.3 (12.1)	51.2 (11.6)

Table 3. Mean scores of the primary and secondary measures for the experienced power wheelchair users.

Outcome Measure	Experienced Wheelchair Users Score: Mean (SD)			
	Baseline	3 months	6 months	12 months
ATOP/M*				
Activity	47.1 (4.8)	47.0 (4.8)	46.4 (5.2)	46.7 (5.3)
Participation	55.2 (8.5)	53.1 (9.0)	53.9 (9.8)	53.8 (9.0)
LSA	4.5 (0.6)	4.5 (0.7)	4.3 (1.0)	4.4 (0.6)
WST	81.4 (13.4)	N/A	N/A	80.6 (10.2)
WST-Q	84.1 (9.3)	86.0 (11.1)	86.1 (10.7)	86.4 (10.7)
WheelCon	84.0 (13.4)	86.2 (10.8)	85.0 (12.9)	81.5 (15.2)
ISEL	13.2 (3.8)	13.8 (3.7)	13.4 (4.3)	13.6 (3.9)
HADS				
Anxiety	6.7 (4.3)	5.9 (4.3)	6.5 (5.1)	6.2 (4.8)
Depression	5.2 (3.5)	4.9 (3.7)	5.1 (4.1)	4.8 (3.5)
LLDI§				
Frequency	51.0 (8.2)	50.7 (9.1)	49.7 (9.4)	49.6 (10.2)
Limitation	51.7 (8.6)	52.6 (12.0)	52.9 (12.5)	54.2 (13.6)

* T scores; § raw scores.

4. Discussion

This report provides preliminary results of an in-progress study designed to describe power wheelchair use at baseline and three, six, and twelve months later in new and experienced power wheelchair users. Generally, there is a trend towards stability with respect to the primary and secondary outcomes for the experienced power wheelchair users. A trend towards more change between baseline and subsequent data points was observed in the new power wheelchair users. With our present data set, the largest changes occurred in the areas of objective and subjective wheelchair skill, as well as decreased anxiety and increased depression. It is interesting to note that the new users' subjective perception of their wheelchair skills was higher than their objective scores. This finding is consistent with previous research that reported that WST-Q scores were higher than WST scores by an average of 3.8% ($p<0.004$) for adult power wheelchair users[7]. Future directions for this research include completing data collection at all time points and subsequently conducting inferential statistics with the full sample.

5. Conclusion

New power wheelchair users experience a trend towards improved wheelchair skills, as well as decreased anxiety and increased depression between receiving their first power wheelchair and one year later. Experienced power wheelchair users experience little change.

Acknowledgements

This study was funded by the Canadian Institutes of Health Research (AMG 100925). Salary/scholarship funds were provided by the Canadian Institutes of Health Research (PWR).

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Special Session on Predictors, Acceptance and use of e-Health Technology by Older Adults and Professionals

Special Session on Predictors, Acceptance and Use of e-Health Technology by Older Adults and Professionals

HeliantheKort, Utrecht University of Applied Sciences / Eindhoven University of Technology

In the special session attention is given to use of eHealth technology when long term care is needed. This could be care either provided from homecare organizations or by nursing homes or in small scale living facilities. With the knowledge and experience gained in the several presented projects we want to contribute to decrease engineering illiteracy. This by sharing the results and experience of several projects about predictors, acceptance and use of e-health technology by older adults and professionals. The focus of the special session is to gain insight in the predictors for the use of e-Health technology by older adults and by care professionals; know what older adults and professionals do find acceptable in the use of e-health technology and finally look at user preferences for e-health applications. In addition, conditions for implementing use of eHealth technology are described for small scale home settings with an emphasis on how professionals do experience the use of eHealth technology in their daily practice.We also address designers of eHealth technology. An extension of theunified theory of acceptance and use of technology (UTAUT) is proposed in order to give designers tools so they can develop eHealth applications in adjustment to the need of both older adults and professionals. Also key factors based on the Comprehensive Assistive Technology model (CAT) are proposed for design of eHealth applications for people with dementia or for people with cognitive impairments. From earlier studies is know that use of eHealth technology on a large scale might by facilitated trough instruction, education and training of both older adults as well as professionals.Results presented in this session can be used for this purpose.

With the special session we want to contribute to the development of a long term program for practice oriented research on eHealth technology for older adults and care professionals in order to achieve that older adults are not socially excluded from the use of eHealth technology by deficient knowledge and skills and that care professionals are better equipped to use eHealth technology in their daily practice.

Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1217

Observational Study to Explore Predictors and Use of Remote Telecare

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Abstract. Introduction: The demand for care is increasing, whereas the number of people working in professional care is decreasing. Remote Telecare (RT) technology can help to meet the growing demand for care. The purpose of this observational study was to explore the main skills barriers for using RT by healthcare professionals and older adults. Methods: Observation at location, using a standardized observation list for the nurses working in home care organizations and older adults. A comparison was made between nurses/older adults already using RT and nurses/older adults who do not use RT. 22 tasks were conducted to test the skills of nurses and 27 to test the skills of older adults(scale 1to 10). For the statistical analysis the Mann-Whitney U Test was used. Results: 16 nurses and 18 older adults participated. 50% of the nurses and 40% of the older adults already used RT. For nurses, the average of all constructed domains was higher than 8.0. Older adults scored on average a 7.0 or higher for computer use, e-mail and digital navigation. The average of Mobile phone use and TV use was lower. With regard to RT use, only nurses showed significant differences between RT users groups. Conclusion: Digital navigation and advanced computer skills could increase the adaptation/ ease of use of RT for nurses. With respect to older adults, 'Interest in ICT' appears to be a predictor for the use of RT. The results in this study concern an observational study with a small number of participants. Therefore, the findings should be interpreted with caution.

Keywords. eHealth, Remote Telecare, Nurses, Older adults, Observation tasks, Predictors.

Introduction

The aging population is growing [1], and the prevalence of chronic diseases is rising [2]. One in five workers will be employed in the health care sector by 2025, to meet the requirements and expected demand for care of an aging population [3]. To compensate for this upcoming shortfall in health care professionals, eHealth could be the solution for this problem. eHealth embraces the use of electronic communication and information technology to improve the access, efficiency, effectiveness and quality of clinical and business processes utilized by health care organizations, health care professionals and patients [4].

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1 Previous Studies

The use of eHealth has already proven success in many areas [5,6]. The term eHealth applies to a broad range of applications [4]. However, this study focuses on the use of Remote Telecare (RT). RT is defined in this study as an audio-visual connection between a client and healthcare professionals, using communication technologies. With the use of RT, health care professionals and clients communicate via a display screen.

Research indicates that the use of eHealth applications supports older adults requiring long-term care to perform the majority of routine at home [7,8]. At the same time eHealth lightens the load on health care professionals [9-12]. The advantages of eHealth applications toward the health care professionals includes the collection, use and sharing of information to support the delivery of health care [13]. With the term 'healthcare professional' differing occupations are subsumed, this paper refers to nurses working in home care.

In the Netherlands, RT is the most used eHealth application [14]. However, similarly to other European countries [11], the implementation of RT in the Netherlands is slower than expected. This could be because older adults and health care professionals are in general not sufficiently familiar with this kind of technology [14,15].

Previous studies have already been executed on factors influencing the intention to use technological innovations in general or Home Telecare in particular [10,16-18]. However, those studies were based only on 1) professionals *or* older adults 2) intention to use technological innovations. This study involves nurses *and* older adults, and it also looks into the needed skills of several technologies.

1.1 Aim and Objective

This study aims to determine older adults' and healthcare professionals' technology skill level. Moreover, differences between RT users and non-users concerning these technology skills will be explored. These findings could provide insight in predictive factors for the use of RT.

Table 1. Amount of tasks during the observations.

Type of task	Amount of tasks (nurses)	Amount of tasks (older adults)
General technology tasks	17	24
- computer use	5	6
- mobile phone use	3	3
- e-mail use	4	6
-digital navigation	5	5
- TV use	-	3
- technical health devices	-	1
RT related tasks	5	3

2 Methods

To gain insight in the predictors for the use of RT by nurses and older adults, an observation list is developed.

Academics from the CREATE Center and the University of Applied Science Utrecht discussed and identified the possible tasks. Next to the identification of possible tasks, the group discusses the number of tasks included, the time duration of the observation list, how to approach the participants and how to collect the data. Three nurses working in a home care organization and three older adults from older adults organizations in the Netherlands were involved in the fine-tuning of the observation list by adding or deleting some tasks.

2.1 Target Group and Inclusion Criteria

The target group of this project were 1) nurses working in home care 2) older adults (age of 65+) who still lives independently at home. RT experience was not a requirement.

2.2 Practice and Participant Recruitment

Nurses working in home care and older adults were enrolled via their healthcare organizations or older adults' organizations, respectively. Several organizations were approached to enroll nurses and older adults. Organizations received information about the project, the inclusion criteria of the participants and time duration of the observation list.

2.3 The Observation List

To test the general technology skills of nurses working in home care four domains of general technology tasks were constructed. The four domains are computer use, mobile phone use, e-mail use and digital navigation. To test general technology skills of older adults 6 domains were constructed, namely: computer use, mobile phone use, e-mail use, digital navigation, technical health devices use and TV use. Table 2 shows the total amount of the general technology and RT related tasks. The tasks were divided into "difficult" and "easy" tasks. Each task was scored from 1 to 3. Score 1= successful accomplished, 2= accomplished after some tips and 3= not accomplished. In addition to the scores, there was space to write some remarks and comments. The observations took place at home for older adults or at the work place for nurses. The observations took one hour.

2.4 Statistical Procedures

For the analysis of the observation list, the range between different domains was made comparable to each other and the tasks were adjusted to the difference in weight range.

Table 2. Nurses skills: scores on different domains.

Type of task (scale 1-10)	Number of participants	Mean, SD†
General technology tasks		
- computer use	16	7.57, 1.83*
- mobile phone use	15	9.29, 1.0
- e-mail use	15	7.87, 1.80
-digital navigation	15	8.40, 1.45*
RT related tasks	8	10.0, 1.0

† SD= standard deviation
* significant differences between the groups RT users and non-users. $\alpha<0.05$

For the statistical analysis the Mann-Whitney U Test was used.

A probability level of equal or less than 5% was regarded as significant. The statistical calculations were performed using SPSS version 20.0. Additional remarks were handled by a small team of experienced researchers (levels of agreement >90%).

Table 3. Older adults' skills: scores on different domains.

Type of task (scale 1-10)	Number of Participants	Mean, SD†
General technology tasks		
- computer use	12	8.15, 2.74
- mobile phone use	18	6.09, 3.70
- e-mail use	14	7.04, 2.96
-digital navigation	14	7.49, 2.74
- TV use	18	6.08, 1.79
- technical health devices	-	-
RT related tasks	8	7.60, 2.31

† SD= standard deviation

3 Results

There were no significant differences between missing data (n=1) and non-missing data.

16 nurses participated in this observational study of which 50% of the nurses already used RT. Nurses scored on general technology tasks an average of 8.28 (on a scale 1-10) (table 2). By comparing RT users and non-users, results show that nurses using RT scored significantly higher at digital navigation (p=0.014) and computer use (p=0.038).

In total, 18 older adults participated in this observational study and 40% of the older adults already used RT. Older adults scored on the domains computer use, e-mail use and digital navigation use an average of 7.56 on a scale of 1-10. The skills on the domains mobile phone use and TV use were a little bit lower. The older adults scored an average of 6.09 on a scale of 1-10. Technical health devices were not analyzed due to the lack of data. Data shown in table 3. No significant differences were found in all domains between RT use and no RT use for older adults.

4 Discussion

The RT users and non-users were explored. As a result of the observation tasks, nurses scored significantly higher on some tasks (digital navigation p=0.014 and computer use p=0.038) compared to nurses who do not work with RT. With regard to older adults, no significant differences were found between RT users and non RT users.

We still notice that nurses in practice are not really familiar with different kind of technologies. Although, van Merwijk [19] has described ICT as a fundamental component of remote nursing care delivery and Hasman and Albert [20] succeeded in 1997 in suggesting a guideline for the European curricula in health informatics that apply to healthcare professionals and administrative staff. Nurses score on average an 8.28 for the use of general technology. However, during the observation we noticed that the knowledge for using this technology is due to experience with several technologies and not because of early courses. The results also show that nurses with RT experience, compared to nurses with no RT experience, score higher on tasks done on the computer use (p=0.038) and digital navigation domains (p=0.014). This could suggest that better knowledge of general technology predicts the acceptance of RT. In other two upcoming research studies of our research group, these suggestions will be explored.

The technology generation effect hypothesis that older adults are better skilled with technology which they know during their childhood [15] was not supported by our results. Older adults scored low on the domain TV use (mean 6.08). This might be due to participated older adults who had new televisions. They did not know how advanced options worked, relatively. We expected that older adults who use RT would score higher than non-users on the technology skill domains [15]. The lack of this finding could be explained by two important observations: 1: The choice to use RT was not fully made by the participants in some cases. 2: Many non-users of RT were enthusiastic about general technology as well as RT users.

The qualitative observations during the technology skill tests suggested that interest in technology use is a better predictor for the acceptance of RT than technology skill level.

4.1 Strength and Limitations

Observations were undertaken by trained students with supervision of researchers following standard operating procedures. The development of the observation list involved academics and also nurses and older adults.

Coincidence of time and mood of the participants that participated during the observations could influence their response. In addition, the selection of the participants was done by health managers or older adults' organization contact persons; managers could have selected participants who already have prevalence to technology use.

5 Conclusiona

Nurses' skills like digital navigation and advanced computer use could increase the adaptation and the ease of use of Remote Telecare. With respect to older adults, Interest in ICT appears to be a predictor for the use of Remote Telecare. The results in this study concern an observational study with a small number of participants. Therefore, the findings should be interpreted with caution.

Acknowledgements

This study is part of a larger research project which aims to decrease engineering illiteracy among older adults and care professionals. The PETZ project – predictors for the use of eHealth of older adults and care professionals - was funded by the Foundation Innovation Alliance (SIA), project number: 2010-2-004 INT.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1223

Using the Unified Theory of Acceptance and Use of Technology to Explore Predictors for the Use of Telehomecare by Care Professionals

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Abstract. An important goal for health care organizations is supporting older adults who age in place. Telehomecare (THC) technology can help to meet the growing demand for care. Despite the apparent positive effects of this technology, there are still barriers to THC adoption. This study investigates how the Unified Theory of Acceptance and Use of Technology (UTAUT) can be used to identify predictors for THC use by Dutch care professionals. Data were collected from 207 health professionals working in homecare in the Netherlands. Data were fit to the UTAUT model. The UTAUT was extended with three possible determinants for professionals' intention to use THC: concerns about privacy, costs expectancy and technology experience. We conclude that UTAUT can be used to explore predictors for care professionals. More research has to be done that can be used to develop transnational eHealth nursing education programs to make them more adequately prepared for a rapidly changing health care sector.

Keywords. Telehomecare, professionals, Intention to use, eHealth, Predictors, Technology Experience, Technology Acceptance, Homecare, UTAUT.

Introduction

The number of older adults and chronically ill people is rapidly growing. At the same time, the number of healthcare professionals will decrease within the next decade [5]. Consequently, healthcare providers will be unable to deal with the increasing demand for care.

Telehomecare (THC) – and especially providing health care using videoconferencing – can offer a solution by supporting older adults to age in place [13]. Therefore, THC is claimed to be the solution for the care needs of the growing number of older adults. Unfortunately, there are several barriers to implementation [7].

The lack of adequate education on how to use this technology could be a explanation for the low acceptance by professionals [7, 9]. A great number of professionals are insufficiently motivated for THC [11], with the exception of a group

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of early-adopters. However, to increase the uptake of THC, homecare organizations need wider support [4, 10]. Motivated professionals are an important requirement for implementation [4]. The primary goal of this study is developing a theoretical model to examine predictors for the use THC by care professionals.

1 The Unified Theory of Acceptance and Use of Technology

The effectiveness of technology in home care settings highly depends on the acceptance of users [1]. Many research has been done with regard to the adoption of new technologies [2, 3]. Users have to overcome certain barriers before they are motivated to use a new technology [3]. THC is such a new technology for professionals.

A commonly used model for the adaption of technology is the Unified Theory of Acceptance and Use of Technology (UTAUT) [2]. The UTAUT separates determinants and moderators (see figure 1). Determinants, such as 'effort expectancy' or 'performance expectancy', are direct predictors for users' intention and usage. Moderators, such as 'age' or 'working experience', effect the determinants. Consequently, moderators indirectly effect intention to use technology.

2 Method

A set of questions was developed in close collaboration with the American research partner CREATE. Large part of the current survey is based on questionnaires from previous studies [16]. These questions were supplemented with questions based on interviews with home care organizations in the Netherlands that have experiences with THC and certain expectations of the use of THC.

Participants were recruited from homecare organizations located in the middle, west and south of the Netherlands, eight different organizations in total. Two of the homecare organizations already use THC in daily practice. Healthcare professionals were approached through their managers to ask for their participation. Respondents could choose to fill out the questionnaire on paper or digital.

Respondents were asked to answer questions with regard to demographics, such as age, education, working experience and gender. Secondly, technology experience was measured by asking how often the professionals use devices and applications such as skype, a microwave, tablet, internet, email e.g. There were 33 items in total, based on the Computer Preferences and Usage questionnaire of CREATE. Thirdly, a wide range of attitudes toward the use of THC was measured, using 5-point-scale items. Professionals were asked to give their opinion on the following topics related to THC: perceived usefulness, effort expectancy, social influences, concerns about privacy and costs expectations. Finally, professionals' intention to use THC was measured by 5 different items [16].

In December 2012 the Research Centre for Innovations in Health Care at Utrecht University of Applied Sciences hosted an international group of academics to discuss the applicability of the UTAUT model and to find ways to fit the survey in a model that can analyze predictors for the use of THC by care professionals.

2.1 Statistical Analysis

To facilitate data analysis, items of the questionnaire were put together as constructs. Reliability analysis of the constructs has been carried out to examine the internal consistency (Chronbach's alpha > .70). All data analyses were performed with IBM SPSS version 20.0.

3 Results

3.1 Characteristics of Care Professionals

More than 500 healthcare professionals were approached to fill out the questionnaire, 207 responded. Almost 95% of respondents were women. Of the participating professionals 126 do not have experience with THC, and 67 work with THC in their daily practice. Looking at age, the largest group (36.8%) were born between 1960 and 1970. Looking at the different specializations, the largest group (52,3%) is specialized as a district nurse working in a homecare organization. Professionals had on average 18.3 years of experience in homecare practice (SD = 10,95). Most respondents (84,1%) had an average or above average educational grade.

3.2 Theoretical Model: Acceptance and Use of Telehomecare by Care Professionals

In a collaborative workshop all items of the survey have been discussed on how to fit them in a theoretical model. The result of this workshop is illustrated in figure 1. Items that did not fit in the UTAUT, however relevant, were converted into additional determinants. All items, except 'technology experience' and 'costs expectancy' were measured using a 5-point Likert response scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Table 1. Demographic Characteristics of the Healthcare Professionals.

Characteristics	All professionals (n=207)		Professionals without THCE[1] (n=126)[2]		Professionals with THCE (n=67)[2]	
	%	N	%	N	%	N
Gender						
Female	94,5	190	95,1	117	93,8	61
Male	5,5	11	4,9	6	6,2	4
Age						
<23	3,6	7	5,0	6	1,5	1
23-32	14,9	29	16,8	20	10,8	7
33-42	21,6	42	20,2	24	24,6	16
43-52	36,6	71	36,1	43	38,5	25
>52	23,2	45	21,8	26	24,6	16
Mean / S.D. (range)	43,54 / 10,83 (18-63)		42,87 / 11,46 (18-63)		44,78 / 9,70 (18-61)	

[1] Telehomecare Experience (THCE)

[2] The sum of 'professionals without THCE' and 'professionals with THCE' differs from 'all professionals' due the non-respons on the question 'Do you have experience with the use of videoconferencing with clients at the organization where you work at?'

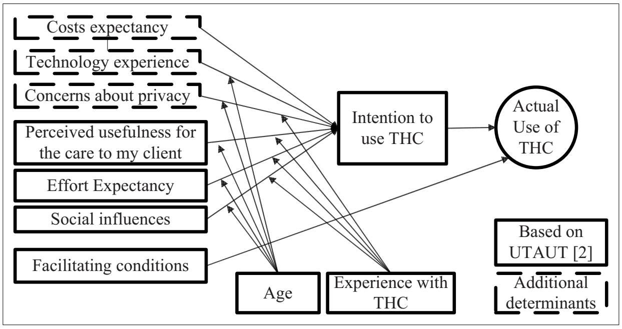

Fig. 1. Theoretical model: acceptance and use of telehomecare by care professionals.

Operationalization of UTAUT Determinants and Intention to Use Telehomecare

Perceived usefulness for the care to my client. Professionals' expectancies of the usefulness of THC for their client were measured with five items. Respondents were asked to which extent they agree with statements such as "telecare will be useful to improve the care of my clients". Higher scores indicate a greater believe in the usefulness of THC. Cronbach's alpha was .83.

Effort expectancy. Care professionals were asked to indicate their agreement with seven items such as "I think telecare will be clear and easy to use". Higher scores indicate a greater believe in the ease of use of THC. Cronbach's alpha was .71.

Social influences. Care professionals were asked to indicate their agreement with five items such as "I am not afraid of being excluded/neglected by colleagues when using telecare“. Higher scores indicate that professionals are less afraid of being judged for using THC. Cronbach's alpha was .72.

Facilitating conditions. The facilitating conditions were measured based on the agreement of the participating care professionals with statements such as "The company I work for will support my use of telecare". Cronbach's alpha was .80.

Intention to use THC. The dependant variable, intention to use THC was measured by asking professionals' agreement with five statements such "I intend to use telecare routinely for the care of my clients" and "After an appropriate training, I am willing to use a telecare device “. Cronbach's alpha was .80.

3.2.1 Operationalization of Additional Determinants

Technology experience. The technology experience of the care professionals was measured based on a list of 33 different devices or applications. The participants were asked how often, on a 3-point-scale, they use these items. The total score of 33 items will be used as one construct. Cronbach's alpha was .83.

Costs expectancy. Users often have inadequate expectations about costs of certain technologies before they actually use it [6]. Expectations could cause worries and become a barrier for individuals to use a technology. Therefore, we asked professionals how much they expect that their clients are willing to pay for the installation (item 1) and service (item 2) for THC. These items together were formulated as 'costs expectancy'. Cronbach's alpha was .77.

Concerns about privacy and security. Care professionals' concerns about the privacy and security related to THC were measured by asking professionals to indicate to which extent they agree with statements such as “telecare will not violate the privacy of my client”. Cronbach’s alpha was .83.

4 Discussion and Conclusion

4.1 Comparing Several Technology Acceptance Models

Results of this study show how data can fit into the UTAUT. The UTAUT, extended with additional determinants, can be used as a predictive model for care professionals’ intention to use THC. In this study the UTAUT has been used to explore predictors. However, it might be useful to consider whether UTAUT is the most convenient model to use. Several studies examined technology acceptance models from end-user perspectives (clients), although only a few looked at it from the perspective of care professionals.

Gagnon et al. [8] use the Technology Acceptance Model (TAM) to examine factors that could influence the decision of professionals to use a new telemonitoring system. The TAM uses two determinants to predict ‘intention to use’: perceived usefulness and perceived ease of use. The results of that study [8] indicate that TAM is a good predictive model for care professionals, although only one of the determinants seems to be significant. Comparing to preliminary results of this paper, we would have missed the ‘social influences’, when we would have used TAM instead of UTAUT to explore predictors.

Sponselee [1] proposes a new model for the acceptance and use of smart home and telecare technology by older adults, the Telecare Acceptance and Use Model (TAUM). The TAUM is strongly orientated towards end-users, mostly older adults. The determinants Sponselee [1] proposes such as ‘needs and dependence’, ‘accessibility’ and ‘personal vibes’ will probably play a smaller role when it comes to professionals’ intention to use THC. Care professionals are a more homogenous group, where personal conditions are more equal. The advantage of TAUM is the strong focus on usage rate. The UTAUT and TAM have a major assumption, namely intention to use leads to actual use. While in practice, not all individuals having the intention to use a technology in fact will use this technology.

Other models, such as the Comprehensive Assistive Technology (CAT) [14] and Human Activities Assistive Technology (HAAT) [15] model are more orientated on the behavior than intention with regard to technology. The advantage of these models is their focus on conditional factors such as user conditions. The CAT model is very clear about the need for adequate skills and education. For this reason, we recommend more research into competencies and skills required for the use of THC.

User conditions can be translated into recommendations for nursing educational programs. Technology plays an increasingly important role in the delivery of care to older adults. Nursing schools should take the responsibility to offer an adequate preparation for the rapidly changing health care sector. Education and training of professionals could be very essential for successful implementation of THC [12].

To conclude, UTAUT can be used to explore predictors for the use of THC, although it would be interesting to create and validate a model particularly applicable for professionals using THC. In future studies it is necessary to address more details on the interaction between the predictors for the use of THC by care professionals, in order to be better able to give recommendations for nursing educational programs.

Acknowledgements

This study is part of a larger research project, which aims at decreasing engineering illiteracy among older adults and care professionals. The Predictors for the Use of eHealth by Older Adults and Care Professionals project (abbreviated PETZ in Dutch), was funded by the Foundation Innovation Alliance (SIA), project number: 2010-2-004 INT. Finally, a special attention goes to Ganna de Jonge, Linsey Pouw, and Masokwe Sablerolles, all three students of the minor Public Health Engineering at the Utrecht University of Applied Sciences. We are grateful to them for making reports during the collaborative workshops.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1229

Remote Telecare in an Aging Dutch Sample: Critical Factors Predicting Their Intention to Use

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Abstract. eHealth technology and remote telecare (RT) in particular have proven benefits for older adults who want to age-in-place. Although, RT is not fully adopted on a large scale by the Dutch senior population. This empirical study aims to predict the willingness to use RT by Dutch seniors with computer experience by means of a web based questionnaire. Demographic variables, experience with computers and other technology and expectations of RT are the input for the predictive regression model. Findings from the analysis (n=166) suggest that expected enhancement of motivation for self-care, expected usability, level of support needed and level of education are the main predictors for seniors' willingness to use RT. The found predictors will be used to construct a pilot course for seniors to introduce RT and exploring facilitating conditions that might contribute to a successful adoption.

Keywords. Remote telecare, older adults, Intention to use, computer experience.

Introduction

The number of older adults that independently live at home is increasing rapidly in the Netherlands. In 2013, there are 875,000 single-person senior households. In five years from now, this number increases to 950,000 and to 1.2 million in 2025 [1]. In the near future, healthcare will further shift from institutional care to care provided at home. The Dutch government promotes this shift due to the increased pressure on the national healthcare services [2].

An increasing number of eHealth services have been developed to support age-in-place. Especially remote telecare (RT) services are upcoming in the Netherlands. RT is defined as a service bringing health and social care directly to a service user, generally in their own homes, supported by information and communication technology [3]. Research has shown that smart home technology such as RT seems to be welcome by older adults only if they see clear benefits of RT use to themselves [4].

This study is part of a research project that aims to increase engineering literacy

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among older adults and healthcare professionals. The predictors for the use of eHealth in older adults and care professionals project (PETZ) has an international scope. The collaboration of researchers from the USA and the Netherlands enables us to compare results and explore cultural similarities and differences between samples from two different countries.

1.1. Aim and Research Question

A significant amount of research evaluated different RT services [5], even in a Dutch sample [6]. However, there are still opportunities in studying predictors for RT adoption in a specific user group such as independently living older adults who have experience with the use of a computer and internet. In recent work from Lim [7] different technology generations are described. The technology available between someone's age between 10-30 plays a critical role in the ability to learn and adopt new technology. From this point of view, we expect that relatively older seniors from the so called *electro-mechanical technology generation* (born before 1939) have more difficulties in adopting RT than the relatively younger older adults from the *display technology generation* (born between 1939-1947) [8]. This study aims to predict computer experienced older adults' intention to use RT.

1.2. Research Model

The model used in this study to fit the predictors for the use of RT is derived from a generally accepted technology acceptance model [9]. This model is adapted to previous used models that were used to predict acceptance of computer communication technology [10] and other eHealth services [11,12] and is displayed in figure 1. In another paper from our research group this model is described in more detail and is used to find predictors for the willingness to use RT by health care professionals [13].

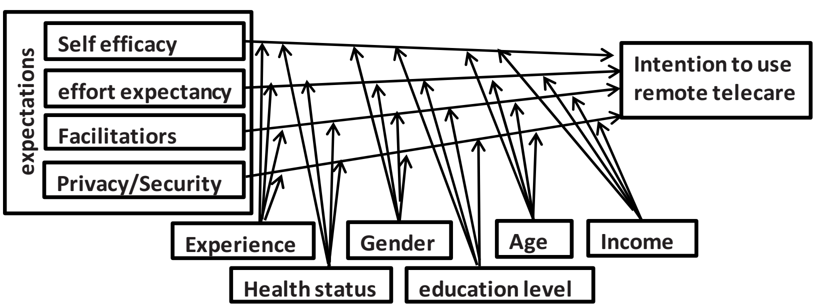

Figure 1. Theoretically used predictive model in present study.

2. Method

2.1. Sample, Recruitment and Measuring Instrument

A client organization in the Utrecht region recruited subjects from an e-panel consisting of approximately 2000 clients. The way of recruitment (via email) and the measuring instrument (web-based questionnaire) specified our sample to computer, internet and email experienced seniors who are members of one or more client organizations. From all respondents who started the questionnaire (n=218), 183 completed it. Because in this study we aim to find predictors for willingness to use RT only in older adults (aged 65+), questionnaires with unreported age or an age under 65 years (n=17) were excluded from our statistical analysis.

The sample consisted of older adults ranging in age from 65-90 years (mean = 71.1; SD = 5.5). The age distribution of the drawn sample is significantly different than expected from the average Dutch senior population, $\chi2 = 31.8$; $p < .001$. In the drawn sample, the age distribution is skewed to the relatively younger older adults compared to population means. Also, there are relatively more men in this sample (54.6%) vs. 44.4% in the total Dutch older adult population, $\chi2 = 7.2$; $p = .007$ [1]. Moreover, the respondents were relatively high educated (51.5% completed higher education) in comparison to reference values of people aged between 55-64 (senior population means were not available), $\chi2 = 76.5$; $p < .001$) [14]. These differences can be explained by the fact that our sample is experienced in using a computer. Several studies have shown that age, education and gender correlate with computer use [15, 16].

Multi-item scales were used, based on previously found predictors for willingness to use general technology [10,17] or other eHealth services [11,12]. Some scales were constructed based on predictors found from telephone interviews with founders of Dutch experimental RT pilot projects that started between 2004 and 2011 [18]. Some questions were adapted to fit to the older adults' living situations and cultural standards. All scales were either constructed or modified by at least two experienced researchers and were piloted by at least one fellow researcher, two older adults and two heads of client organizations. Constructed or modified scales were translated in English and back translated in Dutch.

2.2. Statistical Analysis

Descriptive statistics are conducted to examine frequencies, means and standard deviations of the theoretical variables. Demographic data are compared with population reference values by means of a Chi^2 (χ^2) test. To reduce the data and simplify analyses, confirmatory principal component analyses was conducted for all multi-item scales. Factor constructs were not used if the Kaiser-Meyer-Olkin measure of sampling adequacy was <0.6 or Bartlett's test of Sphericity was insignificant, implying that a factor analysis does not have sufficient constructual value. For the variables Activity Support, Health Technology and General Technology, mean scores were uses for the regression model. Stepwise linear regression was used to predict willingness to use RT with the other variables from table 1. Due to many incomplete questionnaires, Little's Missings Completely At Random test was executed to showed that the missing values were completely at random. All data analyses are performed with SPSS version 20.0.

Table 1. Questionnaire Variables.

Variable	Items (n)	Source	Answering type
Descriptive statistics, Area, Gender, Age, Education, Culture, Income	6	Classification according to national statistics [1]	Single questions
Health Status			
Perceived General Health	4	RAND-36 [19]	5-point scale
Physical Functioning	10	RAND-36 [19]	3-point scale
Physical Limitation	9	CP&UQ [10]	Yes/No
Activity Support	13	RAND-36 [19]	Yes/No/NA
Experience			
General Technology	33	CP&UQ [10]	5-point scale
Health Technology	10	TEQ [17]	5-point scale
TC	1	CP&UQ [10]	Yes/No
Expectations			
Privacy/Security	8	Own work	5-point scale
Motivation for Self-Care	5	Own work	5-point scale
Facilitators	7	Combination [11,12]	5-point scale
Ease of use	4	Combination [11,12]	5-point scale
Usability	11	Own work	5-point scale
Self-Efficacy	6	Self-efficacy Scale [20]	5-point scale
Intention to use RT (outcome)	5	Combination [11,12]	5-point scale

3. Results

For the variables Physical Limitation and Facilitators no factors are distillated because of the KMO test criterion mentioned in the statistical analysis. Health related use of technology and the previously mentioned variables show poor reliability. For that reason they are excluded from the regression model.

From the stepwise linear regression, four steps were made to find the best fit predictive model. The fourth model had significant explanatory strength ($p < .001$). Four predictors are found that explain up to 58.4% of the variance in willingness to use RT. Motivation for Self-Care is by far the strongest predictor for willingness to use RT. Other predictors are expected Usability, the level of support during daily activity and highest completed Education Level. Table 3 gives an overview of the variables and constructs distillated from the principle component analyses that were uses in the model. Furthermore, internal consistency of the multi item scales are shown and the standardized beta weights (β) is shown.

Table 2. Regression model: constructs, explained variance, reliability and standardized beta weights.

Variable/construct	Variance explained (%)	Cronbach's α	β
Descriptive statistics			
Area	NA	NA	.00
Gender	NA	NA	-.12
Age	NA	NA	.06
Education Level	NA	NA	**.11***
Culture	NA	NA	-.10
Income	NA	NA	-.01
Health Status			
Perceived General Health	79.0	.90	.10
Physical Functioning	73.1	.96	.11
Physical Limitation	NA	.59	NA
Activity Support	NA	.91	**.22****
Experience			
General Technology	NA	.82	-.04
Health Technology	NA	.58	NA
RT	NA	NA	.01
Privacy/Security	49.3	.85	.09
Motivation for Self-Care	76.5	.84	**.61****
Facilitators	NA	.50	NA
Ease of use	86.9	.95	.07
Usability	54.6	.93	**.24****
Self-Efficacy	54.3	.81	-.03
Willingness to Use RT (outcome)	64.5	.86	NA

Model summary: $R^2 = .604$, adjusted $R^2 = .584$. *$p < .05$. ** $p < .01$. NA: not applicable.

4. Discussion & Conclusion

The data from this study show that Motivation for Self-Care is a strong predictor for RT adoption in computer experienced older adults. That means that if older adults believe that they can better manage their daily life activities or live longer at home with the use of RT, they are more likely to adopt a RT service. This main finding is consistent with both quantitative and qualitative results from studies [4,11]. Furthermore, expected Usability is a significant predictor in our study, just as another study that examined predictors for a tele-monitoring application use by healthcare professionals [12]. In our sample with a restricted age range, Age was not found as a predictor in contrary of our hypothesis based on earlier work [10].

From present study it can be concluded that an eHealth tool should enhance self-management of computer experienced seniors for a better adoption of the tool by this target group.

The results of the collected data in this study will be input to develop a course for older adults to use RT when necessary for self management of a chronic disease.

Acknowledgements

A grateful acknowledgement goes to the Foundation Innovation Alliance, SIA RAAK project number: 2010-2-004 INT. Finally, a special attention goes to CliëntenBelang Utrecht, the client organization that recruited the subjects for this study.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1235

To Create Added Value of Smart Home Technology in Small Scale Senior Accommodations

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Abstract. Smart home technology has been introduced as a potential solution to support ageing in place, to enhance the quality of life of residents, or to decrease the workload of professionals. The ability of smart home technology is to monitor the activity of daily living and safety of residents. The aim of this study is to get insight into the use of smart home technology and implementation in healthcare facilities. Preliminary results show that healthcare facilities have become aware of the added value of smart home technology in small scale senior accommodations to enhance the quality of care and to contribute to the quality of life of residents. Further research is needed to explore how smart home technology contribute to the quality of life and how it influence the workload of professionals.

Keywords. Healing environment, smart home technology, domotics, healthcare facilities, small scale senior accommodations.

Introduction

In the Netherlands and other Western Countries future demographic changes require large scale introductions of technology and concepts into care services to improve quality and efficiency levels [1]. Moreover, older adults prefer to stay at home independently as long as possible and be active in society. Within the next decade the number of professionals and formal and informal carers will be insufficient to deal with the increasing demand for care [2, 3]. In order to ensure that healthcare remains available and affordable for everyone, significant advances must be made in terms of efficiency [4]. Thus, there is a clear societal need to delay the demand for professional care and to stimulate architectural and technological solutions [2].

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At the other hand, in the field of healthcare we see a growing attention to the built environment in relation to health and well-being [5]. A growing body of research in evidence-based design (EBD) demonstrates that elements of the physical environment correlate with health-related outcomes [6]. Concepts as healing environment, MAYO clinic, Eden alternative and life enrichment care are used by healthcare facilities. A healing environment can be defined as a place where the interaction between client and staff produce positive health outcomes within the physical environment [7]. Smart home technology (SHT) are part of the healing environment concept and has to deal with the integration of technology and devices and innovations available to simplify our daily living. The SHT applications are basically focused on comfort and leisure [8]. In the field of healthcare SHT are mainly introduced to monitor the activities of daily living and safety of residents, and in detecting changes in their daily routines [9].

Apart from the introduction of SHT, in the Netherlands healthcare organisations have become responsible for their own real estate investments from 2011 onward. In short, the finance system is changed from institutional based towards performance based. Therefore, healthcare facilities should be aware of the consequences of real estate decisions. SHT might add value to real estate because this can create flexibility and multiple functions inside the building. In addition it can be seen as a tool for management to express and put into practice their vision on care in their real estate. In the Netherlands, the Dutch Ministry of Health, Welfare and Sport (MINVWS) encourages the use of SHT in small scale senior accommodations (SSSAs) to support ageing in place, to enhance the quality of life of older adults, or to decrease the workload of professionals [2]. Within a national programme SSSAs were supported to implement SHT [10]. In total thirteen initiatives participated in the national programme. An initiative could be defined as collaboration with a care organisation and housing corporation or welfare organisation. Participating initiatives of SSSAs were supported from 2009 onward in design and implementation of an ICT infrastructure. Furthermore, they were supported to have appropriate requirements for SHT, and writing a social business case (SBC). The SBC is a structured social cost-benefits analysis in which social and economic benefits come together [11].

1. Purpose

The aim of this study is to get insight into the added value of SHT in healthcare facilities. Furthermore, the study explores the consequences of SHT for implementation in the design and construction of healthcare facilities.

2. Method

Thirteen initiatives were evaluated for use of SHT in the Netherlands between October 2011 and the end of March 2012. The initiatives have been started at three several moments. The first group started from 2009 onward, the second group started in 2010 and the last group in 2011. At the moment of the evaluation not all initiatives finished their SHT project. The evaluation consists of a mix of qualitative research methods: (i) an initial screening of documents, (ii) semi-structured interviews, (iii) on-site visits, and (iv) observations in experience sessions. These methods are used to make the results of the evaluation study more reliable [12].

2.1. An initial Screening of Documents

An initial screening of the documents is performed by a team of researchers before the on-site visits took place, namely, (i) process, benefits and costs compared with the expectations as written in the social business case (SBC), (ii) the requirements for SHT, and (iii) the design and construction of the ICT infrastructure.

The purpose of the initial screening is gathering important preliminary information about vision, policy and aims of the initiatives to SHT. Moreover, to get insight into which SHT applications were implemented in the organisation.

2.2. Semi-structured Interviews

The semi-structured interviews took place before the on-site visits. A team of researchers interviewed a board member or a representative of the board. The initial screening was integrated into the interview. The questions are based on the principles of the seven A's consisting of awareness, availability, accessibility, affordability, acceptability, appropriateness and adequacy [13].

2.3. On-site Visits

The on-site visits took place six months after the implementation of the SHT. The researchers visited the projects of the healthcare facilities in order to analyse the contribution of SHT to the quality of care and the quality of life of residents. The on-site visits were based on the initial screening and the interviews and the focus was on:

- The aims as written in the social business case;
- To figure out the selection criteria for the SHT applications and ICT infrastructure;
- What are the do's and don'ts of the use of SHT according to the intiatives.

3. Results

In general, preliminary results show that initiatives have become aware of the added value of SHT in SSSAs to enhance quality of care and to contribute to the quality of life of the residents. The first results illustrate that the SBC is useful for the initiatives to understand SHT and the impact on their organisation in a holistic way.

Table 1 shows, for the total number of initiatives, an overview of do's and don'ts of the use of SHT in SSSAs.

Table 1. Overview of do's and don'ts of the use of SHT in SSSAs.

Do's	Total number of initiatives N=13	Don'ts	Total number of initiatives N=13
Implementation		**Implementation**	
User centered approach	3	Don't use SHT if not necessary	2

To have an actual list of requirements	1	Don't use SHT if it is not part of the care model	1
Regular maintenance	1	Don't let technical suppliers in full control	1
Trial period before occupation	2	Don't be led by technology	3
Demonstration dwelling	1	Don't led one external person be responsible for the whole project	1
Helpdesk	1	No testing of SHT	1
Camera surveillance	1	No in front funding	1
'Super Users'	1		
Agreements		**Agreements**	
Clear agreements for short- and longterm	1	Don't have clear agreements with supplier	3
Write down the agreements	1		
Being in charge	2		
Training / Education		**Training / Education**	
Increase level of knowledge to be a discussion partner for suppliers	1	No attention to training or education	3
Education /training of staff	5		
Organisation			
Vision driven	9		
To be aware that SHT is part of ICT	1		
Integration of ICT and Home Automation infrastructure	1		
Work in a multidisciplinary team			
Trust	3		
System integrator	2		
Risk analysis	2		
Openness and Transparency	1		
Communication			
From the start onward interaction with staff	4		
Staff, family and client are involved in the process	5		

From the point of view of nine initiatives the most important lesson in the use of SHT in SSSAs is to have a clear vision as well as to work from this vision and don't be led by technology only. Another aspect is to take care of education or training of staff. Education or training give staff trust in the applications they have to work with.

It is noted that it is useful to have clear agreements with the supplier of the SHT, in order to anticipate to misunderstandings during the implementation of SHT applications.

4. Discussion

The results show that the selected SHT applications are mainly introduced to (i) monitor safety of residents, (ii) to communicate at a distance, and (iii) to support professionals in their daily work. Furthermore, to create added value of SHT healthcare facilities should be aware of:

- Target audience; it is important to know which SHT applications are useful for the residents and the care professionals beforehand to integrate the right applications into the built environment [7]. SHT applications address needs of all stakeholders including end users, their family and professionals [8].
- Model of care; healthcare facilities should be aware of the possibilities of various SHT applications that fits to their care model.
- Vision; healthcare facilities have to formulate an integrated vision on health, housing and SHT. An integrated vision could be support during the implementation process of SHT.

5. Conclusion

This study aimed to get insight into the use of SHT and the implementation in healthcare facilities. As such it provides insight on the awareness of the possibilities of various SHT and the implementation of SHT in a holistic way. In future studies we expect to get insight into the relation between the possibilities of various SHT applications and the policy of care organisations. Furthermore, more research is needed to explore the contribution of SHT to enhance the quality of life of residents and to decrease the workload of professionals.

Acknowledgements

The Dutch Ministry of Health, Welfare and Sport (MINVWS) is thanked for its financial support.

The thirteen initiatives are thanked for their contribution to the evaluation.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1241

Comparing Experience on Implementation of Health Care Technology

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Abstract. In order to gain insight in the success of implementation of healthcare technology, experience of two cases compared, focusing on the technology and acceptance by healthcare professionals. Determinants from a published literature study are used, together with the factors of the Technology Acceptance Model. These are illustrated by the examples of practice-oriented research in order to help future implementation projects.

Keywords. e-Health, implementation, technology acceptance, gerontechnology.

Introduction

Implementation of health care technology is not easy to accomplish. If we could answer the question why there are so many challenges in this process, we might be able to predict success or failure. Broens and others [1] conducted a qualitative literature review in order to identify determinants that had influenced the implementation of telemedicine interventions. The identified determinants, which would influence the future implementation of interventions, were classified into five major categories: Technology, Acceptance, Financing, Organization and Policy. Each category contains determinants that are relevant to different stakeholders in different domains. Holden and Karsh [2] found that the Technology Acceptance model (TAM) predicts a substantial portion for the use or acceptance of health IT, but also that the theory may benefit from several additions and modifications. The available literature covers a broad area and describes a wide range of applications. Studies testing the TAM in health care settings often add variables to the model, in order to understand the factors that might cause behavioral intentions or actual use of health IT, or to understand causes of other factors, such as attitudes.

To gain insight if described determinants are relevant to future new interventions with health care technology, especially concerning older adults and professionals without previous experience with e-health, is also a challenge. Sharing the results and experience of several projects about acceptance and use of e-health technology by older adults and professionals, can contribute in understanding what are the predictors in this domain. It may also increase our knowledge how to assist health care professionals to use technology in their daily practice. Practice-oriented research within projects, such

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as described below, can help us to understand how to promote the success of implementation and how to explain the difficulties in implementing e-health technology in practice. Experience from two projects will be compared, focusing on the technology and acceptance by health care professionals, using described determinants in literature.

1. Methods

Rotterdam University of Applied Sciences, Centre of Expertise Innovations in Care, was involved in two innovation projects with gerontechnology, together with SME's and health care organizations. Both projects involved designing, implementing and evaluating new e-health technology within this domain.

In this paper these cases will be compared, using described determinants in literature by Broens and others [1] and literature concerning the Technology Acceptance Model by Venkatesh and Davis [3] and Holden and Karsh [2].

1.1. Two Cases

In the project Monitoring at Night [4] a night watch monitoring system for new group living homes for people with dementia, was designed for the use by a nursing assistant. At night, a nursing assistant is responsible for residents with dementia in four homes. The system is used to alert staff in case a resident needs assistance, for example because of a high risk of falling, agitation, panicking or wandering. IP (Internet Protocol) cameras, connected to a variety of sensors, will be activated in case of an event by sensors and live video and sound is sent to a mobile device of the nursing assistant on duty. Staff can also steer the camera at distance and decide if and how urgent the resident needs assistance.

The innovation project Vital Link [5] included designing and implementing an integrated system for care domotics and communication within a new apartment building (54 apartments), where older adults can live independently. All residents are in need of care and support because of chronic conditions, up to nursing home care. The integrated system includes a videophone, which is used by the residents, nursing staff and a specialized nursing home physician for both planned and unplanned care.

In both cases a human centered approach was taken, based on the extended five stage user centered design/research model [6]. Practice-oriented research was conducted throughout the five stages, including the implementation and evaluation phase. For the Vital Link, the evaluation is not yet fully completed. The results of this research are used to compare with the determinants as described in literature.

1.2. Determinants within Technology and Acceptance

Both cases have a new concept of health care in common, where the technological interventions support the professionals in their daily practice. Broens and others have conducted a qualitative literature review, from which they have identified determinants, classified in five major categories: Technology; Acceptance; Financing; Organization; Policy and Legislation [1]. In this paper, we concentrate on Technology and Acceptance because of the overlap with the factors within the Technology Acceptance Model, especially the update the TAM2 by Venkatesh and Davis [3].

Technology

- Support
- Training
- Usability
- Quality

Acceptance

- Attitude and usability
- Evidence based medicine
- Diffusion and dissemination

The review of Broens [1] showed that a major issue for acceptance was the availability of support to users. In both projects the importance of the support in the implementation and operational phase, was confirmed by care professionals in the evaluation. In Monitoring at Night team leaders (nurses) confirmed that they were confident in installing the IP cameras themselves because of the intensive support in the early phase, even though at first, they were sceptical about their own competence. Without the high level of support this would have been a high risk of abandoning the system. In Vital Link, support was available by practical and technical assistance on the spot and at distance, provided by the caretaker and also by students of health care technology.

Training of staff is also an important determinant. Staff in Monitoring at Night had a more extensive training programme than staff in the Vital Link. This could explain why there were more acceptance issues concerning the nursing assistants in using the videophone for their planned and unplanned care. The physician involved in the Vital Link reported that nursing assistants did not use the videophone when appropriate or used it in an incorrect way so they could not be seen by the other user. She puts this down to still feeling unfamiliar with the equipment, which could be helped by repeated training, and also by attitude, which can have different causes. Repeating training, certainly when staff changes, is a good thing.

Of course usability is a major factor in success. Confirmation was found In Monitoring at Night where the interface was designed to be carried around etc. Within the project Vital Link, a mobile device with the same functions as the video phone was not (yet) available within the designed system. Nursing assistants have to change devices and are bothered by this, whereas the physician is more used to plan her activities the most efficient way. Until a new suitable mobile device can be integrated, planning and changing work procedures could be incorporated in training.

In both projects care professionals were concerned about the determinant quality before the implementation phase. Quality, or Output Quality in the TAM2 in Figure 1, was tested before practical use in the implementation phase in both projects. Extended testing and sharing the results can help acceptance. In the project Vital Link, the absence of part of the supporting infrastructure, needed for video communication between residents and their family, combined with difficulties caused by telecom providers, eventually led to dropping this application for the duration of the project. Not because of lack of feasibility but because of the fear of dissatisfaction in case of more problems. This underlines the importance of output quality.

The category acceptance contains the determinants attitude and usability; evidence-based medicine; diffusion and dissemination.[1] Usability equals Perceived Ease of Use in the TAM2. Acceptance equals Intention to Use.

Based on the experience in these two innovation projects attitude and usability certainly are important determinants. In the TAM2, factors under Subjective Norm influence attitude towards technology. In Monitoring at Night the factor Job Relevance played an important role. Even when testing the prototype of the system in daily practice of a nursing home, the attitude of the nursing assistants was positive. They did not want the prototype to be taken away after testing, saying: “But this system is made for our job!” In the project Vital Link the physician mentioned she could do her job better when she saw the non-verbal signs of understanding, compared with giving information by telephone. Her attitude was also positive.

In both projects acceptance was promoted by paying attention to the factors of the TAM2, including the above described determinants support, training, usability, quality, attitude and usability. Overall the technology was accepted by care professionals and certainly not abandoned.

Since the technology in these two cases support the health care professionals instead of introducing a new intervention, evidence based care did not play an important role. The determinants diffusion and dissemination however, can be recognized as important in the case Vital Link. Contrary to the first case, the lacking of a stimulating role model for the nursing assistants, may have caused the slow adoptation within the work process. In Monitoring at night, the enthusiasm and successful evaluation of the nursing assistants in the test environment, has been cited while introducing the system within the new group living homes. Of course the lessons learned during implementation, will be used in future projects and will also be disseminated.

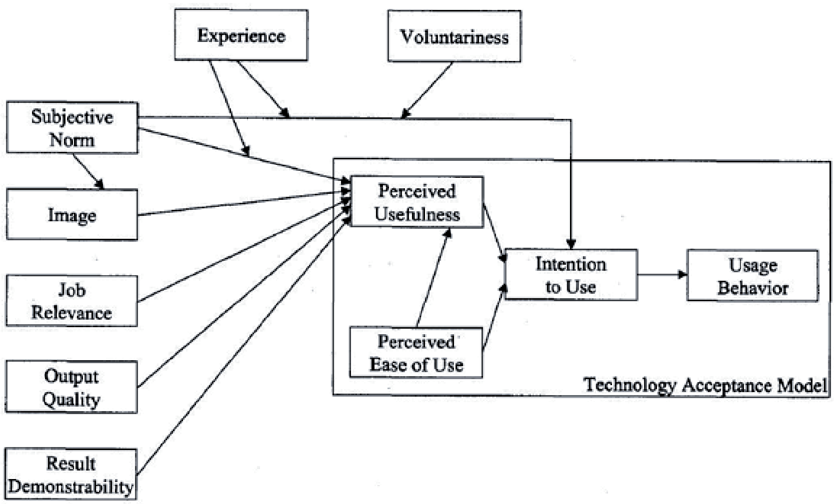

Figure 1. TAM2.

2. Discussion

Identifying determinants, looking back on two cases, is perhaps not as important as adding variables to the TAM2, in order to better understand the causes of success and failure.

In analyzing more studies that aim to provide assistance to health care workers by the introduction of technology, it is possible to validate and adjust the TAM2 model. This has already led to the TAM3 [6] with added variables on perceived ease of use. Such a model must not only be used to understand and evaluate the implementation of new technologies. It has also the possibilities to support the development, the managerial decision making and the implementation process. Once we actively use the knowledge and insights as will be provided by further research on the determinants of perceived ease of use in TAM3, it will increase the successful implementation and use of technologies in health care.

An improvement for further study may be to investigate whether the determinants and variables, related to understand the causes of success and failure, for acceptance by health care professionals, are the same for older persons. From both case studies we gained insight that acceptance was much influenced by perceived added value by the older persons. More precisely, added value compared to other devices and other possibilities they already had. Another insight was that involvement of older adults in the process of designing, testing and implementation was also important. A third aspect was the way in which older persons were challenged to use the new technology and to explore additional possibilities.

The process of implementation and adaptation of technology according to the experiences of users, both health care workers and older persons, is a circular process. It needs communication between health care technology professionals, health care professionals and older persons. For this to happen, it is necessary that professionals already get used to this way of working during their education.

3. Conclusion

The experience of two innovation projects underlines the determinants as described under the categories technology and acceptance by Broens and others [1]. These determinants and the factors in the TAM2, acceptance (Intention to Use) and attitude (Subjective Norm) can be illustrated by examples from the results of practice-oriented research. More research concerning the TAM3 is needed, concerning perceived ease of use.

Most of the lessons learned in the mentioned projects also relate to determinants and acceptance factors. Sharing these examples, now and in the nearby future, can be beneficial to other implementation projects. As Broens stated, when the technological intervention gains maturity, the determinants shift from being specific to one implementation case, to more generic problems in the domain.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1247

Key Factors for a Framework Supporting the Design, Provision, and Assessment of Assistive Technology for Dementia Care

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Abstract. Assistive technology (AT) products and services are increasingly used to support persons with dementia (PwD) and their caregivers, in terms of healthcare, safety, autonomy, leisure and social participation. Studies conducted in this area have tended to focus on usability engineering and AT acceptance, rather than on AT provision and follow-up plans. In other fields of disability, efforts have been made to integrate AT modeling frameworks into delivery practices, including the selection and assessment of AT over time. In the context of dementia, probably because of the relative novelty of the use of AT, only a few works have stressed the need for a comprehensive framework to guide users, practitioners and product developers in decision-making regarding the conception, evaluation and provision of AT. In this paper we provide preliminary guidance for the definition of such a framework. For doing so, first we review two existing AT models, chosen because of their applicability in the field of dementia: Hersh & Johnson's "Comprehensive Assistive Technology" model and Scherer and colleagues' "ICF core set for Matching Older Adult with Dementia and Technology". Then we discuss some implications of the use of AT models and frameworks for clinical practice, specifically their incorporation within the integrated care systems increasingly adopted worldwide. Subsequently, we propose a set of key factors that should be considered for building tools to support AT design, provision and assessment in the context of dementia: the progressive nature of the disease, the clinical heterogeneity observed among PwD and the subsequent need for personalized care plans, the dynamics of function allocation between PwD, AT and caregivers, and the role of fluctuating symptoms and preserved abilities in this population. Finally, we suggest some directions for further research in this field.

Keywords. Assistive technology, dementia, design, delivery, assessment, integrated care.

Introduction

Alzheimer's disease and related dementias are one of the most important causes of disability among older adults and a major predictor of nursing home placement in this

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population [1,2]. Dementia covers a group of symptoms including progressive cognitive and functional decline, challenging behaviors and other psychological manifestations (e.g., apathy, agitation, social withdrawal, or wandering), which place persons with dementia (PwD) at a high risk of disability and dependence. Due to dementia symptoms and common age-related health issues PwD have a wide variety of continuing care needs. Consequently, these persons may require different health and social services to support them in everyday life actions such as housework, handling medication, social interaction or behavior management [3]. These services may combine personal assistance and Assistive Technology (AT).

AT has the potential to promote autonomy, quality of life, social participation and aging in place for PwD. AT products and services can also meet several needs of formal and informal dementia caregivers. Indeed, a wide range of AT applications are either commercially available or under active development for these purposes (e.g., telecare services, health-monitoring systems, wandering technologies, memory support devices, social assistive robots) [4-6].

However, effective design, provision and assessment of AT for PwD still poses many challenges in terms of usability, acceptability, training needs, access to services, continuous follow-up, ethical and societal issues [7-8]. Moreover, with the increasing generalization of integrated care pathways in dementia, which focus on medical and social care coordination, multidisciplinary case management, common tools for screening, individualized service planning and periodic reassessment of the situation of PwD [9], an important question emerges: how can AT solutions be effectively incorporated within a global care plan that responds to the individual needs of each PwD?

In order to provide PwD with optimal care and support through AT, it is fundamental to move our focus away from mere technology development and user engineering issues to look at how AT can best be implemented within a holistic care plan. This implies defining a comprehensive framework to guide the design, procurement and subsequent evaluation of AT solutions for PwD, structured around a multidimensional assessment of user's needs. In other fields of disability, different frameworks for the delivery and outcome assessment of AT have been proposed and validated [10-11]. However, only a few works have addressed this issue in the context of dementia [11-12].

In this paper we provide preliminary guidance for the definition of such a framework. First, we review some advantages and limitations of two existing AT models chosen for their adequacy with the field of dementia. Second, motivated by the increasing maturity of integrated care pathways in many countries, we acknowledge the need to consider AT provision for PwD within a holistic care system and reflect on how AT modeling and assessment tools could help in this regard. Then, we review key factors linked to the dementia situation that should be emphasized by these tools to better respond to the needs of all stakeholders involved and suggest some directions for further research in this field, with the aim of synthesizing existing models and tools to create a versatile yet practical AT design, selection and assessment framework that can be easily put to use in different national and local contexts.

1. Assistive Technology Modeling Frameworks

AT modeling frameworks [10-12,17-18] can serve a *descriptive purpose* including the gathering, organization and analysis of data related to the person, context, activity domain and AT itself, which can be useful for AT selection and advisory processes, as well as a *predictive function* by allowing the identification of relevant features pertaining to AT adoption. Thus, some models are more oriented towards the selection of AT solutions whereas others are more focused on the assessment of AT outcomes at a single point in time or through repeated assessments. A few of them can also be used to support AT design [18]. Although several AT models and frameworks exist in the literature, for the sake of clarity we review only two of them that appear particularly suitable for dementia care.

1.1. Comprehensive Assistive Technology (CAT) Model

Hersh & Johnson's CAT model [18] is inspired from the Human Activity Assistive Technology (HAAT) Model proposed by Cook & Hussey [17] to improve the understanding of how AT can help to enhance human performance. It was developed in response to the need of widening the flexibility and applicability of a modeling framework for AT. A social model of disability and User-Centered Design approaches have both strongly influenced the CAT model, which can be best described as a biopsychosocial tool. It comprises four components: person, context, activities and AT, offering a detailed analysis for each of them. Some of its applications are: the identification of accessibility barriers; the analysis of existing AT solutions; the formulation of guidelines for AT design; end-user assessment, device provision and AT profile and outcome measurement over time.

The CAT model's flexibility and openness make it easily adaptable to the context of dementia care and to any integrated care plan. It provides a common language for users, medical and social care staff and AT designers, making it a highly valuable tool in a context in which many AT solutions are emerging, as is the case with dementia. It also offers a detailed description of factors related to AT, which can be of practical use for all stakeholders, covering activity specification (e.g., task and user requirements), design issues (e.g., design approach and technology selection), system technology (e.g., interfaces and technical performance) and end-user issues (e.g., ease and attractiveness of use, mode of use, training requirements and documentation). Currently, the major limitation of the CAT model is the unavailability of practical assessment tools, which limits the applicability of this model in a real-world context. Other frameworks such as the MOADT described below provide such tools and could thus be deemed more useful, but they have other important drawbacks that could be overcome by leveraging the strengths of the CAT, in particular its flexibility.

1.2. ICF core set for Matching Older Adult with Dementia and Technology (MOADT)

Based on the International Classification of Functioning, Disability, and Health (ICF) [19] and the Matching Person and Technology (MPT) Model [20], Scherer and colleagues [12] proposed an ICF core set for Matching Older Adult with Dementia

and Technology (MOADT). This model offers a unified language and framework to help determine the best match between a PwD and AT solutions. The ICF core set for disease and disability assessment of dementia particularly emphasizes activities and participation as well as personal and environmental factors. To make it more user-driven, the model integrates a self-evaluation of his/her own functioning by the user as well as his/her views and expectations regarding a particular assistive device using some screening tools from the MPT Model [20]. After conducting a multidimensional assessment of the situation of PwD, professionals from a Center for Technical Aid can use the MOADT to help select an AT device that matches the user's needs and preferences, provide it, conduct follow-up assessment and offer AT support.
Because it uses the international criteria of the ICF, this tool enables a standardized assessment and the sharing and comparison of data among different stakeholders and countries. However, it appears highly dependent on an ideal assessment context, which makes it difficult to use in diverse national and local environments. First, because it is based on the ICF, the MOADT is a complex model (e.g., highly structured training required, long administration time). Second, different countries often have their own multidimensional geriatric assessment methods, and the rigorousness of the MOADT can make it incompatible with such tools. Thus, we propose below a synthetic approach which would bring together the strengths of the MOADT and the CAT to create an accurate yet flexible and practical tool for the inclusion of AT in the personalized care plans of PwD.

2. Implications for Clinical Practice: AT and integrated Care

In order to effectively meet the needs of PwD, AT solutions must be incorporated within *personalized and multidimensional care plans*. More generally, integrated care pathways are being progressively adopted to improve social and healthcare plans for PwD (e.g., avoiding the duplication of information, repeated assessments for the patient, complex and long procedures…).

By including AT selection and assessment processes within a global integrated care system, practitioners could benefit from previously gathered data through standardized geriatric assessment tools to describe the basic factors of AT models (i.e., person, context, AT, activities) without the need to conduct repeated assessments. Moreover, AT adoption and AT outcome assessment over time can be effectively coupled with the periodic assessment of patient needs suggested by integrated care models.

Integrated care models could provide new perspectives for achieving a better AT service level because a general care plan will help to better allocate resources and solutions (personal and technological) to respond to each user's needs. Both, the CAT and the MOADT models offer a set of valuable tools that should be examined in regard with existing screening methods currently used in various integrated care systems for dementia across different national and local contexts. This exercise will allow the identification of the dimensions that are currently well informed by standardized procedures and of those for which a specific assessment tool should be built and validated, particularly with respect of AT specifications.

3. Key Factors to be considered in an AT Framework for Dementia Care

Through our clinical practice we have identified a number of factors that are particularly salient in the situation of PwD but not necessarily properly identified and taken into account by professionals dealing with AT (manufacturers, procurers, case managers…). We thus argue that these factors should constitute the primary focus of future practical tools geared towards these professionals, to maximize efficiency:

- The *progressive nature* of dementia and the wide *clinical heterogeneity* observed among PwD [13]. AT solutions need to be adaptive, flexible and highly customizable. In particular, people progressively become less and less able to learn how to operate new devices. Thus, providing ways to predict likely future AT needs before they become too critical should make it possible to procure AT devices at a time when users are still capable of learning how to use them.
- *Caregiving situation:* PwD increasingly rely on the support of others; most frequently on informal caregivers [14]. The integration of AT into the preexistent caregiving situation should be supported with tools to optimize function allocation (i.e., redistribution of tasks and efforts) between human and AT, depending on the user but also on the skills and preferences of the caregivers, which are rarely thoroughly examined.
- *Fluctuating symptoms* are observed in many PwD in terms of cognitive functioning, behavior, and arousal [15]. This highlights the need for the inclusion of at least some basic form of artificial intelligence in AT for PwD, in order to take into account day-to-day changes in their needs and capabilities and adapt accordingly.
- *Preserved abilities:* PwD retain some cognitive and psychological capacities throughout the course of the condition. Following a biopsychosocial approach, AT for PwD should be designed based upon the strengths and desires of the person and not upon his/her deficits, in order to stimulate the user and promote autonomous activity. Future tools should thus facilitate the identification of these strengths instead of focusing only on the deficits that need to be compensated for; the solution that yields the best long-term outcome might not be the one which provides the highest level of compensation but instead makes the most use of these preserved abilities.

4. Conclusions

A modeling framework for AT in the context of dementia could provide a structured method to examine different individual and contextual factors that may influence the acceptance of AT solutions, their effectiveness and their adoption. The two frameworks here described support the multidimensional assessment of users' profile and subsequent selection of adequate AT. The MOADT model by Scherer and colleagues has the advantage of being an ICF-compliant tool specifically conceived for dementia care. However, the CAT model by Hersh and Johnson appears more flexible to support different AT processes, in particular the identification of new areas of research for AT design. Future research in the field should consider the examination and synthesis of these models in relation with the screening and intervention procedures recommended by integrated care models currently used in the field of dementia, with a focus on a few key factors that are not yet well understood by professionals in spite of their importance for PwD.

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Special Session on Remote Care

Special Session on Remote Care

Innovation in care can be organized by the introduction of technology as a tool in the process of care delivery. The introduction of technology has become an important driver in the innovation of medical care. Now the use of internet technology has become a driving force, in long term care and in mental health care as well. Technology can reduce the distance between a client and a care provider. In modern European society scarcity of care providers is not only influenced by the physical distance but also by demographic factors. Due to the graying of the population it is becoming difficult to obtain adequate care and support when needed. This has led to the development of “remote care”. Using “remote care” another potential is created: it enables the adequate and timely information on a client’s health statusthat facilitates the delivery of appropriate care when it is needed, which may strongly support the quality of care.

The introduction of technology as a tool to support a specific process will lead to a drastic reorganization of procedures and practice. This also occurs in long term care. Expectations, procedures and protocols have to be redesigned to make care delivery supported by technology effective. From idea, through experimentation, towards implementation, the process of re-design of current practice requires commitment of potential users, clients and technology- and care providers. Different approaches can be followed. The aim of this session is to present examples of applied research in which several steps of the development of new care applications are discussed. Starting from the selection of the appropriate technology, through identification of user requirements and the ‘building’ of the application and finally its implementation in practice.In this session we start with the presentation by Peetoom et al. who investigated the daily functioning of elderly in the home environment.Their aim was to obtain insight into which monitoring technologies exist, what the characteristics are and what is known about the outcomes. Effective application development starts with the exploration of user requirements. Van de Dijk et al. present their results on the requirements of older COPD patients for eHealth support at home. Their intention was to create a remote care application to promote self-management and to increase quality of life. Another example of development of a care related application is given by Willems et al. Using a sequence of research and co-creation cycles the development of a stroke rehabilitation application is described. The choice of technology to be used in the development of specific applications is of vital importance. M.Betke gives a description of a database that gives details on remote user sessions. Analysis of these data may give rise to an improvement of the user-technology interaction. The development and implementation of remote care in regular practice is a complex process. As a final presentation Van der Vlies et al. describe a technology transfer tool that may support researchers as a guide through the innovation process.

Taken together these presentations cover the route from idea up to the implementation of remote care. An area in which technology acts as a supportive means to care delivery. In 2013 this area is becoming important to the delivery of quality of care.

Chair of the session

Luc de Witte and Charles G.Willems

Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1255

Technology Transfer within the Telecare Technology Innovation System

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Abstract. Telecare technology is not common yet, although it is perceived as promising. Most studies on telecare technology transfer present a case involving the use of a single methodology and approach during some steps of technology transfer. Technology transfer models cannot be sensibly constructed if they don't consider the whole innovation process, therefore, the aim of this research is to introduce a model for the mapping of telecare technology transfer in an innovation system as a whole and assess its usability by mapping drivers and barriers as experienced in the transfer of a documented telecare technology introduction. We started from the basic System Innovation (SI) Framework as introduced and expanded by Klein Woolthuis and applied it to one of the cases published in Technology and Disability; 24(3): 'ACTION'. The SI-approach provided a structured overview of the complete innovation system and helped uncover the source of the success and the roots of the challenges.

Keywords. Technology Transfer, Innovation systems, older adults, ACTION

Introduction

About 90% of persons aged 55 and older would prefer to stay in their current residences as long as possible because older adults value their independence. However, aging in place is not only a way to meet personal needs it is also a societal necessity as pointed out by the European Health Telematics Association: without changing the way elder citizens are supported in 2020, almost 20% of all working people will have to work in health services [1]. This will lead to a scarcity of professional resources. Telecare technology is expected to enable fewer health professionals to fulfill the increasing need for care as healthcare is provided from a distance.

Although perceived as promising, telecare technology is not common yet [2] except for reactive emergency response systems, which are mainstream in some countries such as the UK and the Netherlands [3]. In general however, some commercial telecare systems are available but proof of cost effectiveness is still absent [4], this implies the technology transfer has reached the sixth of eight steps [5] but did not yet reach the last step 'the launch of a proven technology'.

Most studies on telecare technology transfer present a case involving the use of a single methodology and approach during some steps of technology transfer. Sometimes the method is developed during research and sometimes models are used which originate from domains other than telecare technology [5].

Perhaps the most influential theoretical model that describes the product adoption process is the Technology Acceptance Model (TAM). It was developed in the 1980s to predict the acceptance of computers [6] and has since been used frequently in the domain of health information technology [7]. It states that the intention to use a system is dependent on Perceived Usefulness (PU) and Perceived Ease-of-Use (PEoU) but TAM does not predict actual use. Recently, in order to be able to better predict the actual use of telecare by older adults, TAM has been adapted to TAUM: Telecare Acceptance and Use Model [8]. TAUM goes beyond the intention and includes the actual use. Both TAUM and TAM help evaluate the technology once it's there but these models lack clearly defined steps that help engineers to design acceptable technology.

'Human centered design' [9] and 'inclusive design' [10] provide guidelines for engineers who design assistive technology. Both are processes in which users are at the center of the design. Involving users in defining the requirements and evaluating the design will increase the likelihood that the technology will be usable and easy to use. The process of both 'human centered design and 'inclusive design' stops once a technological solution is available that is expected to be accepted and used. Even though the inclusive design process was recently altered and now includes 'building a business case' it does not nearly cover the whole 'transfer of new technology from the originator to many users benefitting'. It is expected that many users will benefit, but economical, societal, and political circumstances influence the technology transfer as well.

"*Technology transfer models cannot be sensibly constructed if they don't consider the whole innovation process and indeed that any individual project is occurring in a competitive space*." [5]

Aim of this research is to introduce a model for the mapping of telecare technology transfer in an innovation system as a whole and assess its usability by mapping drivers and barriers as experienced in the transfer of a documented telecare technology introduction.

Method

"... technology transfer occurs in a competitive space and does not occur in a vacuum nor is it pragmatically a simple sequence of steps." [5]

For the description of the system in which telecare technology is transferred we started from the basic System Innovation Framework as introduced and expanded by Klein Woolthuis et al [11]. The System Innovation (SI) approach emphasizes that innovation is both an individual and a collective act, resulting from technology transfer between multiple actors and organizations rather than from the independent actions of single users or organizations. The SI framework supports the identifying of drivers and barriers for technology transfer at various levels of the innovation system.

'Lock-in' is a central concept in the SI approach. Lock-in means that a particular technology is dominant, not because its costs are lower or its performance is better, but because it benefits from the system, for example: users are accustomed to the 'old' technology (e.g. qwerty vs. the more ergonomic dvorak key-boards), the required infrastructure is lacking (e.g. hydrogen-fuel cell cars), etc. By doing so Klein Woolthuis builds on the research of Smith:

"*... technological alternatives must not only compete with components of an existing technology, but with the overall system in which it is embedded. Technological regimes or paradigms persist because they are a complex of scientific knowledge, engineering* *practices, process technologies, infrastructure, product characteristics, skills and procedures which make up the totality of a technology and which are exceptionally difficult to change in their entirety*." [12]

The SI-framework has been used for analysis of various innovations such as a transport system for fresh fruits [11], market opportunities for sustainable products [13], and sustainable technologies in construction [14].

In the SI-framework the characteristics of the innovation system are positioned at the left-hand side whereas the actors that created the system, and thus can also remove barriers or create drivers are positioned at the top. The list of system characteristics are considered to be the same for all innovation systems [14]:

- Infrastructural failures (concerning the physical infrastructure, such as railroads, telecom);
- Institutional failures: hard (e.g. laws, regulation) and soft (e.g. norms, values, implicit rules of the game);
- Interaction failures (too strong or too weak networks);
- Capability failures (e.g. entrepreneurship, adequate labor qualifications and the like);
- Market demand: demand quantity and demand quality (the presence of buyers that demand a high quality stimulates innovations);
- Market structure: market power (free market - monopoly) and entry barriers (e.g. high initial costs);
- Externalities: split incentives (actor A invests, actor B profits) and transparency (the market price does not account for the external effects of an economic activity: e.g. pollution).

The actors in an innovation system depend on the type of technology and therefore the list of actors varies. When comparing the actors in the SI-frameworks of i) the transport system for fresh fruit, ii) sustainable products, and iii) sustainable construction technologies, we found them to have the following actors in common:

- User/buyer: the actor that pays, uses, owns, and profits from the innovation;
- Suppliers: the actor that invented, manufactures, and sells the innovation;
- Knowledge institutes: universities and technology institutes providing knowledge and possibilities for knowledge transfers.

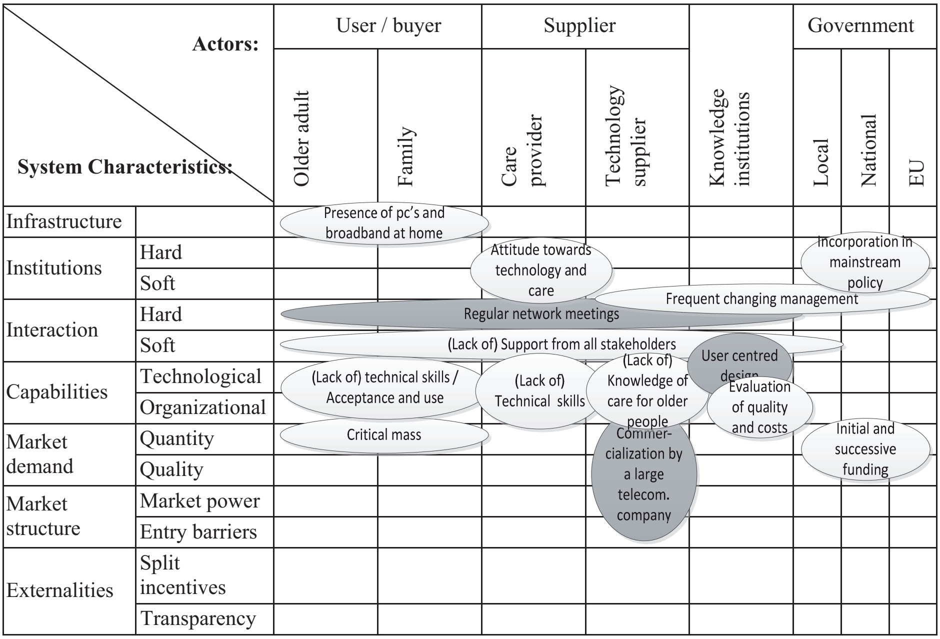
Other actors mentioned actors are: governments, consultants, banks, etc.

Results

As an example we applied the SI-framework to one of the cases published in Technology and Disability; 24(3). The case study of 'ACTION' [15] was chosen at random. The ACTION telecare technology includes the ACTION station (a personal computer) and a call center. This technology provides access to web-based educational programs, support from other ACTION families and dedicated care practitioners via the use of an integrated videophone system. The support service was designed together with frail older people and their family carers.

By categorizing relevant actors at the top of the framework the complex buyer-supplier relationship becomes clear. In fact there are two suppliers: the actor that provides the technology and the actor that provides the care. Also the 'user/buyer-function' is divided amongst two actors: the (older) patient and his or her family. Besides these four actors, knowledge institutions and governments were involved in the technology transfer as well, see table 1. Table 1 also shows the five success factors and seven challenges as distinguished by Magnusson and Hanson.

Table 1. Success factors (grey) and challenges (white) for the technology transfer of ACTION mapped in the SI-framework.



Magnusson and Hanson distinguish five critical success factors [15] for ACTION:

1. User centered, participatory approach; indicating the organizational capabilities of the designers, and sufficient interaction between the designers and potential users.
2. Innovative appeal and flexibility as technology based service; this success factor is interrelated with the first one, it shows that the outcome of the user centered design process successfully met user needs and requirements. Which resulted in acceptance and use.
3. Research based; this success factor too is interrelated with the first two. It refers to the capabilities, knowledge and knowhow of the designers involved.
4. Ongoing support by all key stakeholders; this success factor shows the importance of the regular network meetings. This created a network of interacting actors. Should there have been too little interaction this support would have been absent.
5. Commercialization of the service by a large telecommunication company; this indicates sufficient market demand and also the existence of entry barriers. Apparently, a sufficient economy of scale needs to be reached in order for the system to be profitable.

Besides the five success factors Magnusson and Hanson also distinguish eight challenges [15] for ACTION. It are these challenges that hinder further technology transfer:

1. Organizational complexity. It "is not just about installing and using the technology itself, rather it involves changing the way in which people work and think": this implies that in order to support older adults by empowering families rather than 'doing' for them involves a change of soft institutions. A second organizational threat is too little interaction between ACTION and existing care services.
2. Attitudes. This challenge is intertwined to the first issue pointed out under 'organizational complexity': specifically the norms and values (soft institutions) of care professionals are a barrier to technology transfer. "The last thing a sick older person … needs … is a technology based service".
3. Support from all stakeholder groups. The fourth strength proves to a challenge as well. Frequent changes at management level in the municipality disrupt the interaction which results in less support.
4. Evidence of cost effectiveness: actors involved lack the capabilities and the infrastructure to collect sufficient data and compare the outcome with a suitable comparator.
5. Mainstreaming/creating a critical mass: municipalities are wary of investing in more than 20 users. It is necessary to change hard institutions.
6. Solid business plan & model. Staff turnovers frequently disrupted the interaction. Writing a business plan required the capability (knowing how) to write a business plan, but also the capability to understand the technology and the way it supports care for older adults. The business case itself proved to depend on the absence or presence of a infrastructure of private payed personal computers and broadband.
7. Policy. This challenge is related to challenge number 5. There is a need to change policy (hard institutions) at all levels in order to enable this technology.
8. Financing: Government funding is necessary to overcome market imperfections, invest in the innovation and by doing so make the business case sound. Government can be convinced to do so by pointing out externalities. Also, should the market demand have been big enough, there would have been a commercial organization willing to invest themselves.

Discussion and Conclusions

The SI-approach provided a suitable framework for mapping drivers and barriers for the success of the technology transfer of ACTION and resulted in a structured overview of the complete innovation system. The framework helped uncover the source of the success and the roots of the challenges. It also showed some of the success factors to be intertwined and some of the challenges to have multiple facets and causes.

Based on the SI-analysis we may say that by including users in a human centered design process the engineers of ACTION were successful in designing a technology that is accepted and used. The two key success factors proved to be the user centered design and the sufficient interaction with stakeholders involved (e.g. regular network meetings). The technology transfer, however, is slowed down because of influences from the economical, societal, and political environment. Specifically changing the hard and soft institutions proved difficult.

"*The idea was that the social model is one that assumes that the development of assistive technology is something that has to be driven by the goal of achieving an inclusive society – and so there are moral, financial, business and scientific issues to* *understand and manage.*" [5]

Concluding we may say that the SI-framework proved appropriate for analyzing telecare technology transfer. It covers those parts of the technology transfer which are out of reach of TAM and human centered design: moral, financial and business issues. As such, it covers the whole 'transfer of new technology from the originator to many users benefitting'. However, it cannot replace the models mentioned earlier since it does not provide the detailed insight needed when designing or evaluating telecare technology: the models are complementary. Also, some elements of the SI-framework proved complex in use. Specifically the constructs of 'hard and soft institutions' and 'hard and soft interaction' raised questions while using the matrix. These could be avoided by making two changes in the framework:

1. Rename 'hard institutions' into 'law and regulations' and rename 'soft institutions' into 'social norms and values'. The first change results in more understanding without any loss of quality. This is not true for the second change. Soft institutions include besides 'norms and values' also culture, the willingness to share resources with other actors, the entrepreneurial spirit within organizations, industries, regions or countries, tendencies to trust, risk averseness etc. However the increase in usability of the SI-framework outweighs this reduction in accuracy.
2. Stop distinguishing 'hard' and 'soft' interaction when using the framework to analyses technology transfer. Technically 'hard' and 'soft' interaction are different, like hard and soft institutions are different [16] but at a glance they seem to be two extreme values of the same variable. By treating hard and soft as two values of the same variable the accuracy of the framework is reduced but the framework gains in usability.

Currently, the authors are using the simplified SI-framework to identify the barriers and drivers for implementation of video communication telecare technology in the Netherlands by evaluating three projects and the surrounding innovation system.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1262

emPower, an Infrastructure for Remote Assessment of Interfaces for Individuals with Severe Motion Impairments

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Abstract. This paper proposes the development of *emPower,* a service-oriented architecture that provides the infrastructure for an online community of users with severe motion impairments, serves as a broker to resources on the internet, and manages a database for logging the information about remote user sessions. The data logs collected by emPower enable the analysis of the motion patterns that may be used to improve mouse-replacement interfaces.

Keywords. Augmentative and alternative communication (AAC), mouse-replacement system, camera-based assistive technology, motion impairments, web-based services.

Introduction

A stroke, a traffic accident, or amyotrophic lateral sclerosis can lead to severe paralysis and drastically change a person's life. Individuals with severe motion impairments use "augmentative and alternative communication" (AAC) technology to be able to communicate, live with dignity, and enjoy life. The objective of this paper is to describe an architecture called EMPOWER that may become an important tool to help evaluate and improve AAC technology by providing a remote technology assessment platform.

Research on user acceptance of AAC technology is typically confined to a small number of case studies. Participants with severe disabilities are found in the researcher's neighborhood, for example, a local school or nursing home. The study usually takes place in the participant's environment, since travel to a research facility may be difficult for him or her. Because the proposed EMPOWER infrastructure will enable *remote* user evaluation studies, where the researcher does not have to be present, these studies can involve many more participants with severe impairments. Quantitative research and statistical analysis, involving hypotheses pertaining to measurements obtained from more than just a few participants, will then become possible.

The need for an assessment platform that involves a larger group of participants became obvious during the author's thirteen-years experience in creating and improving the Camera Mouse, an ACC mouse-replacement technology that is used by nonverbal

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individuals with quadriplegia in homes, schools, long-term-care facilities and hospitals worldwide. The Camera Mouse is an interface system that tracks the computer user's movements with a video camera and translates them into the movements of the mouse pointer on the screen [3]. The interface can interpret the pointer dwell time as a left mouse click. It is available at no cost at `http://www.cameramouse.org` [5] and has recently reached the 1,500,000 download mark.

A beta version of the Camera Mouse, called "Camera Mouse Suite," is also available for free download on the internet [4], which includes the Camera Mouse team's most recent work: (1) an optical-flow-based version of the Camera Mouse [1], (2) a version that uses Active Hidden Models (AHMs) as the tracking mechanism [9,11,10], (3) an interface that interprets eyebrow raises for input of scan-based text-entry systems [11,17], and (4) an interface that provides full pointer control via blink and wink detection [20].

User studies involving several participants with motion disabilities in a few computer sessions have been conducted to evaluate the Camera Mouse and assistive communication software that uses the Camera Mouse as an interface [1,3,6,7,8,11,14,15,18,19, 20,21]. The EMPOWER platform has the potential to involve an order of magnitude more participants in hundreds of computer sessions.

1. The EMPOWER Architecture

The proposed EMPOWER platform has a service-oriented architecture [12] that provides web services, including a database for logging the session information of remote users and for analyzing motion patterns of users to improve their interfaces (Fig. 1). As a community service, the EMPOWER server will offer downloadable software for people with motion impairments, in particular, camera-based interfaces (Interface Layer), assistive applications (EMPOWER APPS) and mediator software (EMPOWER WARE).

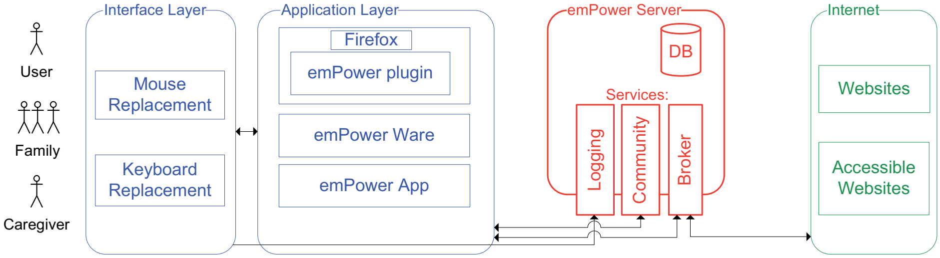

Figure 1. Overview of the EMPOWER Architecture for web services and remote interface assessment.

The EMPOWER architecture will use a modular, service-oriented approach that enforces logical boundaries between components and minimizes dependencies [12]. The architecture will include the EMPOWER SERVER that will offer three web services for community interaction, internet resource brokerage, and data logging support. The web services will be implemented in the popular Representational State Transfer (REST) architectural style [13], using the open source Tomcat Web Server.

The EMPOWER Server will have a MySql database to store community and logging information. The logging data will include information about user activity and software performance during the remote interface evaluation sessions. An example of the former are mouse movement patterns. Examples of the latter are the most popular configuration settings of the interface device and the frequency of mouse-pointer reinitializations due to feature loss. Analysis of this data is likely to reveal the most urgent research needs for improving assistive interfaces which, when addressed successfully, may in turn have the most significant impact on users' lives.

2. Interface and Application Layer

The Application and Interface layers of EMPOWER will be located on the remote client computers. The Application Layer will consist of software that enables integration of the popular freeware ZacBrowser [24] and a web browser plugin for Firefox, which will render web pages accessible, following the guidelines for web accessibility [22,23]. The Application Layer will also contain the proposed EMPOWER WARE, mediator software that transforms commercial application software into software that is accessible to people with severe motion impairments [21] and EMPOWER APPS, which is assistive application software [2]. The Interface Layer will provide access to the Camera Mouse Suite [4].

3. Broker Service

The EMPOWER SERVER will also contain a Broker Service that will act as an intermediary between web services that are now mostly inaccessible to nonverbal people with quadriplegia, e.g., Twitter, Flickr, or Facebook, and the EMPOWER APPS. The Broker Service will attempt to shield users from the constant version changes of internet resources (such changes have caused much grief to users with cerebral palsy when popular resources suddenly became inaccessible [16]).

4. Logging Web Service

The EMPOWER **Logging web service** will receive and store detailed information about the usage of the Interface Layer over long periods of time. In the sign-up process, which has been approved by the Institutional Review Board (IRB) of Boston University, users and caregivers may enter optional information, including their name, email, town or country. The sign-up information about each user will be stored in the database of the EMPOWER SERVER. Upon registration, logging information about software usage will be sent from the user's remote location to the EMPOWER SERVER. Messages will have time stamps and will be of a particular "event type" to represent image coordinates of the tracked features, mouse-pointer positions on the screen, mouse-click events, feature-loss events, and interface settings. To preserve user privacy, the EMPOWER SERVER will, by default, not collect any information about the specific application software that a remote user will use or any of the images that the computer-vision algorithms will interpret. The user will have a choice of selecting the frequency of the application-agnostic data collection. The default will "none," and there will be options for "frequently" and "infrequently."

5. Concluding Remarks

Implementation of EMPOWER has started. Populating the database with sufficient client data to mine will require active efforts in recruitment on AAC websites, in particular, `www.cameramouse.org`. Data logging and assessment of other AAC interfaces, in addition to the Camera Mouse, are also planned.

Acknowledgements

The author would like to thank her students and collaborators who have contributed to the development Camera Mouse and the assistive software described. Samuel Epstein is especially acknowledged for his work on EMPOWER.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1267

Developing a Care at a Distance Application to Support Stroke Patients

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Abstract: Objective: With the increase in life expectancy and growth in the number of frail elderly, the demand for complex care will increase. The rehabilitation of these patients takes place in the hospital or in rehabilitation clinics. If possible a transfer is made to the clients home situation as soon as possible. The use of technology as part of the rehabilitation process could facilitate a quick transfer to home. This paper reports on research initiated to develop a web-application that is supportive to the rehabilitation of stroke patients by means of care at a distance. **Main content of the paper**: A sequence of research and co creation cycles is described by which the development of a stroke rehabilitation application is designed. Literature search, focus groups, creative sessions with care professionals were used to identify potential approaches. Fine tuning to determine realistic approaches in terms of acceptance by users leaded to the idea to focus on the support of clients in the phase of therapy during which a transition to the home situation is prepared. Coping with energy management to prevent fatigue appeared to be a crucial factor. Delivering care at a distance in combination with a graded activity program was identified as being the most promising approach. The development of technology to support this kind of approach in combination with care provision is described. **Results:** A treatment protocol was identified by which the transition of a stroke patient from the nursery home towards his own home can be supported using the principles of care at a distance. **Conclusion:** The use of care of a distance to support the transition of stoke patients from the rehabilitation clinic to home clearly has potential. It represents both the introduction of a care protocol as well as the introduction of technology to support the activities of care professionals and patients.

Keywords. Telemedecine, stroke patients, care at a distance, rehabilitation.

Introduction

With the increase in the life expectancy, the number of elderly and at the same time the amount of frail elderly will increase. As a result, the demand for complex care will grow in the next decade. At this moment, there are about 2.4 million people in the Netherlands aged 65 years or older. In the year 2035, 54,1% of the Dutch population will be over 65 years. At present a incidence of 30.000 new stroke clients is noted. Epidemiologic research indicates an increase up to 44% by the year 2025.[1] Due to the demographic changes with the increase of chronic diseases and co morbidity in elderly, there will not be enough health care providers available to meet the growing demand of care of elderly. Therefore there is a need to reorganize the Dutch health care system in a more efficient way. In this process, innovative technologies can play an important role in order to sustain care workers and to decrease the workload.[2]

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Since care at home is preferable to most elderly and in most cases is less expensive than institutionalize care, systems using advanced technology to support people at home could benefit to both client and care provider. Modern communication technology techniques enable the simultaneous use of video and voice communication which can even be distributed throughout a regular TV (CareTV). CareTV may also become supportive to homecare workers themselves. It can serve as an easy accessible feedback system, while being active in an ambulant way for instance by consulting a colleague or by getting access to patient files on a remote way. There are indications that electronic communication devices, may help to improve feelings of loneliness in elderly.[3] In 2005, Proteion Thuis, a Dutch home care organisation in the province of Limburg, the Netherlands, started an implementation project to implement CareTV. The CareTV video network allows clients to communicate 24 hours a day, 7 days a week with a nurse practitioner with a video and voice connection. Earlier investigations have shown that CareTV may be used to reduce loneliness in frail elderly [4] This finding stimulated us to continue our research into the direction of support for people after stroke. Therefore, the aim of this project is to evaluate the potential of care at a distance to support stroke patients. Research questions are:

1) What is best moment in stroke rehabilitation to use care at a distance
2) What kind of care at a distance application has to be organized to exert effect
3) How to position such a care at a distance application in routine practice
4) What are the requirements of use to design such an application?

1 Methods

Using a co-creation approach investigations were directed towards the development of a Stroke related application. The analysis was done by two subsequent groups of bachelor Occupational Therapy students as part of the development of a bachelor thesis. Analysis of literature was combined with desk research and focus group sessions. Participants involved in care delivery to stroke patients in the region North Limburg were invited to participate in several group sessions. These were directed towards the identification of a suitable approach. The cyclic approach resulted in the identification of a graded activity program, directed towards the stimulation of physical exercise, that appeared to be most effective. The first group identified the potential of a combined formal consultation and a distance support approach. The second group analyzed in detail a graded activity program designed to support professionals in supporting their clients using traditional methods and translated that towards a protocol that delivers support by means of care at a distance. Procedures and materials were transformed to fit in such an approach.

2 Results

a) identification of potential applications

A critical analysis of user characteristics and the analysis of clients behavior and as a function of disease development was made. During progression of the disease structuring the day becomes an important aspect. Facilitating the client in performing activities. Energy management becomes important in determining what the activities may be that a client may successfully perform during the day. Being in control of their own potential is becoming an increasingly important issue. This led to the choice of supporting the client in their own environment using technology and care support. Based on literature analysis and discussions with professionals several idea's for new applications were identified. [see table 1]

Table 1. Overview of the different idea's generated.

	idea	Potential content and use
1	Information on stroke	Giving insight in the own clinical situation and advice how to cope with that
2	Supporting ADL activities	Video instruction films, information on assistive technology
3	Supporting re-integration in work process	Specific information on what to do to re-enter professional activities
4	Structuring day and week	Day planner that distinguishes between different activities (must do or like to do) in relation towards physical cognitive ability to perform that activity
5	Week planner (physical and emotional burden in relation towards potential)	Organizing activities in relation to emotional and physical value for the client and efforts coupled with realization
6	Exercise scheme for physical activities	Instructions and programs to support physical training functions to restore arm and hand functions

Using these raw idea's a refinement was performed by describing the content of the application, the way it will be presented to the end-user, the conditions required to deliver the application and the expected benefits were described. Using this material a group session was organized in which different professionals and potential users were invited to comment on the identified potential applications. This group session concluded that most benefit could be expected from the application no 5 that aims to restore the balance between ambition and functional capacities during the day. To organize this a use case and use scenario's were organized as a next step.

b) refinement from a use perspective

Next a workshop was organized in which further support was organized amongst professionals and client representatives that eventually will work with the application. The discussion was centered amongst the question how the application can be centered in a rehabilitation context. Furthermore the preconditions were determined that are important in using this kind of application in daily practice. These were translated into design criteria.

The result of this step was also a decision to use the application as part of the distance support of the client by means of a rehabilitation professional. Based on client characteristics and care delivery related aspects it was concluded that the best moment to use this application would be the period during which the client is transferred from rehab clinic towards the own home. During this time support at a distance will render most positive effects.

c) designing the use protocol

At this stage it becomes important to describe the exact nature of the care protocol that is used to guide the client. When a client is treated after stroke to regain the capacity to take his/her own responsibility to live in the own environment a gradual reduction of care support is used. However even in the home situation the care support is often needed to get adjusted to the new living situation. Research has shown that a combined multidisciplinary treatment gives good support.[5] A combination of support of graded activity (to stimulate physical activity performance) combined with cognitive training (directed towards the understanding of the development of fatigue and learning to cope with it in daily routines) gives adequate results. A protocol was identified that delivers positive results in this client group. It consists of a 13 week training by several professionals (occupational therapists, physical therapist, neurologist).[6] This protocol was analyzed from the perspective of care at a distance. It appears feasible that during this 13 week period the preparation of the transition to the home environment and the continuation of treatment can be organized by means of a care at a distance procedure. A complete training protocol is designed specifying the activities of the client as well of the rehabilitation coach (occupational therapist and or physiotherapist). [see table 2]. Also the conditions to use the technology as part of the care at a distance protocol is described. The resulting protocol was discussed with the stroke treatment unit in Midden Limburg. This approach was considered to be a positive enrichment in treatment of clients. To be able to use the principles of graded activity treatment in an at home situation, some adjustments of the originally tested protocol had to be made. This involved the use of the technology by which the professional guides the client during the 13 steps of the treatment replacing a face to face contact. Also the information exchange between client and professional had to be digitalized, thereby taking into account the computer skills of stroke patient. Using this result it became possible to implement the protocol into practice. The first development of the technology is done by a simple internet web page used to communicate between client and professional and support exchange of data. Later on transition towards a mobile application will become possible. At the stage of writing this abstract the implementation of the protocol in practice is organized.

3 Conclusions

Stimulating stroke patients by means of care at a distance appears to become a feasible approach. But before we are really able to obtain its real value several aspects have to be sorted out. In this paper we have described the process of development of care at a distance from idea up to experimental setup. Critical in this stage of the design of new applications is the interaction between care providers, technology developers and client representatives. This results in a complex process. By fine-tuning the developmental approaches in close relation with potential users of the resulting technologically supported application it will be possible to develop an application that can be embedded into clinical practice. And hopefully this may lead to an improvement of the service that meets the needs of the client in an more appropriate way.

Table 2. Content of the 13 week training period by means of a care at a distance protocol.

Step/ week	*what*	*how*	*where*
0	diagnosis	Face to face	Nursery home
1	Education Graded activity	dialogue	Nursery home
2	Defining goals	client	At home
	Discussion with therapist	Group session[2]	Nursery home

[2] Group session is between the client and therapist in a face to face meeting

3	Setting smart targets	client	At home
4	education	client	At home
5	Activity registration	client	At home
6	Feed back + activity registration	client	At home
	Discussion with therapist	Group session	Nursery home
7	Evaluation / diagnosis	client	At home
8	Design planning activities	client	At home
9	Evaluation planning activities	client	At home
	Feed Back by therapist	Group session	Nursery home
10	Education: relaxation	client	At home
11	Education : coping with environment	client	At home
12	Education Fatigue	client	At home
13	evaluation	Group session	Nursery home

Acknowledgements

The authors like to thank the contribution of the students that contributed to this research during the preparation of their bachelor thesis and the active support of Anja Kuperus and Aglaia Zedlitz in keeping us on track.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1272

eCOPD: User Requirements of Older People with COPD for Ehealth Support at Home, a User-Centred Study

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Abstract. BACKGROUND: For people with chronic diseases such as COPD (Chronic Obstructive Pulmonary Disease), eHealth provides new opportunities for self-management. Although sufficient research on COPD self-management exists, COPD telehealth research is primarily based on 'care at a distance' as directed by health professionals and technicians; it is less based on user needs of older people. OBJECTIVE: Aims were to explore the requirements of older people for eHealth support, and through this to promote self-management and enhance quality of life. METHODS: An explorative user-centred design approach was used, combining focus groups (n=17) with surveys (n=69), involving COPD patients aged 55 to 90, to elicit key criteria for eHealth support.
RESULTS: Respondents provided specific needs and wishes for eHealth; they reported activities and problems for which they could use support. For them, eHealth should increase their sense of security, provide opportunities for questions and alerts, and increase confidence in their knowledge and abilities. CONCLUSIONS: Older people do want self-management support at home, to stay more independent and active. A user-centred design approach enables older persons to identify key requirements for eHealth support. Additional research will be conducted to complete this approach, to contribute to recommendations on form and contents of 'eCOPD' self-management support.

Keywords. COPD, chronic disease, older people, eHealth, self-management, UCD

Introduction

Being a non-reversible and progressive chronic disease, Chronic Obstructive Pulmonary Disease (COPD), including chronic bronchitis and emphysema, is estimated to be the third leading cause of death worldwide by 2030 [1]. COPD is an under-diagnosed and life threatening lung disease that may progressively lead to death [1]. Because of the slow development of the disease, it is most frequently diagnosed in

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people aged 40 years and over. Based on demographic changes and on changes in health care systems the burden of chronic respiratory diseases such as COPD will worsen, mainly because of tobacco use and population ageing [2]. Although long term decline in lung function may not be reversible, effective management including for instance smoking cessation and pulmonary rehabilitation can reduce symptoms, increase physical fitness and improve quality of life [2]. With COPD patients decrease of airway conductance and loss of elasticity causing symptoms such as coughing and shortness of breath, it is important to support patients to uphold healthy behaviours, in motivating and activating them to remain as active and independent as possible [3].

To support this, eHealth may provide new opportunities for self-management of COPD-patients, and through this to decrease hospital admissions and to increase quality of life [4, 5]. In this, self-management is a term applied to educational programmes aimed at teaching skills needed to carry out medical regimens specific to the disease, to guide health behaviour change, and to provide emotional support for patients to control their disease and to live functional lives [4]. There is sufficient scientific evidence to recommend self-management interventions for patients with COPD [5]: self-management education is associated with improvement in quality of life and a reduction of health service utilisation such as in hospital admissions [4]. However, more research is needed to increase our understanding of the relative effectiveness of specific components and how best to support patients in self-management, and data are still insufficient to formulate clear recommendations regarding the form and contents of self-management programmes in COPD [5].

Similarly to self-management programmes, home telehealth is found to reduce rates of hospitalisation and emergency department visits [6,7], with less studies on home telehealth for COPD, with less focus on self-management. Mostly, 'home telehealth' includes home telemonitoring and telephone (or videophone) support, and is to be characterised as 'remote care delivery', or monitoring that occurs between the patients in their place and the health-care provider located somewhere else [6]. COPD telehealth research seems to be primarily based on 'care at a distance', as directed and organised by health professionals and technicians. In recent years, research on COPD telehealth has increased, especially after the European Commission Communication on telemedicine, describing 'telemedicine' as the provision of healthcare services at a distance [8], highlighted not only the potential of telehealth in the management of COPD, but also the pressing need for good-quality research in this field [9]. Still, research on home telemedicine services is mainly directed to the support of health professionals, for instance results of shared electronic chronic patient records (ECPRs) suggest that telemedicine help to support health professionals caring for patients with chronic disease [10]. Likewise, CHRONIOUS, an open disease management Platform, amongst others intended for COPD [consisting of modules such as remote sensors interacting with lifestyle interfaces (PDA, monitor touchscreen), a literature search engine, a rule based decision support system and a machine learning module] allows the monitoring of chronic diseases, to help clinicians in taking decision for cure purposes [11]. In short, COPD home telehealth, or telemedicine, is not so often based on user needs of lay users, let alone be based on the needs and wishes older COPD patients themselves.

Putting older patients requirements first is important, facing increasing demand for care with decreasing capacity of care while changing care processes, in the light of the importance of self-management - for instance as aimed for by the Dutch government in health care reforms such as 'Health 2.0' [12], defining eHealth with the

Dutch Council for Public Health and Healthcare (RVZ) as "the use of new information and communication technology (ict), and particularly internet technology, to support and improve health and health care" [13]. Given the growing need for the support and self-management of COPD, and the increasing possibilities of self-management support via eHealth, it is important to explore the user needs, wishes en requirements for eHealth support of older people with COPD.

1. Objective

The aims of this study were to explore the requirements of older people with COPD for eHealth support and through this to promote self-management and co-management, to reduce health care use and to increase quality of life. The findings from the study are being used in collaboration with Carintreggeland, Home Care & Nursing Care, in Hengelo, The Netherlands (situated in the east of The Netherlands). The goal is to contribute to the (re)design and implementation of an 'eCOPD' (eHealth for COPD) self-management system that supports older people at home.

2. Methods

An explorative user-centred design (UCD) was used, combining focus groups (n=17) with surveys (n=69), to elicit key criteria for eHealth support. Data were collected in several sessions involving COPD-patients aged 55 to 90. First, using an explorative qualitative user-centred design, focus groups (n=17) were conducted in 2011, to evoke barriers and facilitators for eHealth self-management support. In the focus groups (in three groups) in two consecutive workshops, both open and semi-structured questions were used, combined with more creative research methods: a scenario-based approach, mindmapping and the creation of 'Big 5's (of 'necessary activities', 'problems' and 'attractive activities') were used, to elicit user needs, wishes and requirements for eHealth self-management.

For the focus groups, a targeted selection of independently living participants was taken, to reach COPD patients not living in a nursing home or staying in a hospital, through physiotherapy practices and special exercise groups for COPD in the east of The Netherlands. Inclusion criteria were: age 55 and older, with the diagnosis of COPD, living independently at home and mobile. Exclusion criteria were: not mastering the Dutch language, cognitive limitations or mental diseases.

The focus group study was followed by an exploratory research, with three surveys in 2012, using pre-structured questionnaires. Also the surveys had a targeted selection, through physiotherapy practices, special exercise groups for COPD and, adding to this, also home care in the east of The Netherlands (for the first survey also Germany, these results were excluded here). The surveys had similar inclusion and exclusion criteria. The first survey used more open questions (n=23, of which n=12 in NL, that we refer to in this study), the second survey (n=32) and the third survey (n=25) included more closed questions to review and confirm or refute the first results.

3. Results

All of these older COPD-patients valued face-to-face support most. Most respondents had the prerequisites for an eHealth system, this was the highest in the focus groups: all (n=17) use mobile phones, almost all (n=16) own a computer or laptop, most (n=15) use internet e-mail, all know how to use this technology in general, although some knowledge important for using eHealth lacks. In general, the respondent characteristics of the focus groups were comparable to those of the surveys (Table 1), with the main exeption of 60% of respondents in home care (in Survey III).

Table 1. Respondent characteristics.

	Focus groups (2011)	**Survey I *(2012)***	**Survey II *(2012)***	**Survey III *(2012)***
Characteristics *(of n)*	n=17	n=12 NL (of n=23*)	n=32	n=25
Age *(mean±sd)*:	70±5 yrs.	70±8 yrs.	71±8 yrs.	77±10 yrs.
Gender *(% m-f)*:	65% -35%	33% -66%	81% -19%	44% -56%
Living situation:	100% living independently (l.i.)	100% l.i.	100% l.i.	40% l.i., 60% home care
Social situation:	65% with partner (p) 35% single (s)	35% p., 65% s.	81% p., 19% s.	-
COPD *(stages, of most)*:	*most:* moderate COPD	moderate-severe	moderate-severe	moderate-severe
COPD *(years, of half)*:	half have COPD ≥ 10 years	≥ 12 years	≥ 12 years	≥ 26 years

Note: n=12 NL (of n=23 in total), of which n=11 in German, which results were not included here.

Most respondents indicated that they do (yet) not need eHealth support; they however could imagine future eHealth support. Especially independently living respondents (in this eastern part of The Netherlands), of them most single respondents, are quite positive about eHealth. Respondents living within home care facilities (in Survey III) are much less positive.

Respondents did provide specific needs and wishes for eHealth; they reported activities and problems for which they could use support, also categorised in 'Necessary activities', 'Problems' and 'Attractive activities'. For instance, in the group 'Big 5' of 'Attractive activities' most popular in the focus groups were 'movement' (walking, cycling, swimming, fitness - also noted under 'necessary activities'), 'active hobbies/gardening', 'going out' (music, theater), 'vacation' (travelling, day trips) and 'babysitting grandchildren'. Mostly noted in the group 'Big 5' of 'Necessary activities' were 'personal care' (getting up, dressing, showering, washing), 'exercise / keeping fit' (walking, running, cycling, fitness) and 'medication use'. Mostly noted in the group 'Big 5' of 'Problems ' were 'Coughing, chest tightness' (also wheezing, fatigue, pneumonia), 'walking' (incl. walking and talking, walking with oxygen and running), 'season/weather change' (rain, cold weather) and also 'medication use'.

Respondents expressed specific requirements in physical, cognitive/emotional and social areas. For instance: "You know what would be useful? That we, as people with COPD, if we do not feel good, that we have some device that detects that. Because we are going to the general practitioner, for what?" (C17), followed by an idea of a fellow participant: "I go walking, then I come 'under 88' (…)*[Authors note: saturation]*. Precisely, and then you have to stop" (C12). Activities in the focus groups resulted in concrete and practical ideas, that were prioritized by the three focus groups and then were elaborated on with proposed functionalities for design, with groups suggestions for specific tools and technology (Table 2), which were then used in the surveys, to confirm or refute these first results.

Table 2. Proposed functionalities for design (Results of focus groups).

Nr.	**Group ideas** *(prioritized by the group)*	**Functionalities** *(with group suggestions for tools / technology):*	**Focus on monitoring(eM)** *and / or* **Coaching(eC)**
Group 1:			
1.	**'Question hour'**	Mentoring / coaching: Answering difficult questions *(e.g. via internet)*	eC
2.	**Learning to cope with illness**	Early detection / recognition: Acknowledging / recognizing disease *(e.g. through peers)*	eM/eC
3.	**Contact with peers**	Social support / motivation: Sharing experiences *(e.g. via chat)*	eC
4.	**Questionnaire**	Safety control / monitoring: 2 different needs: 1) continuously / frequently 2) only in special circumstances *(possibly via the internet or a special device*)	eM
Group 2:			
1.	**Asking questions / 'contact point'**	Mentoring / coaching / motivation: Coaching at a distance, check with an expert, for reassurance, guidance and encouragement *(possibly via computer of telephone)*	eC
2.	**Alarm**	Alert / help: If you can not get out of bed and/or speaking is difficult *(alarm button, e.g. by phone or watch)*	eM *(alarm)*
3.	**(Saturation) measurements**	Signalling: Signalling exceeding limits, both indoors and outdoors *(e.g. device with vibration function)*	eM/eC
Group 3:			
1.	**Signalling problems**	Mentoring / coaching: When someone is not well, asking them questions, or indicating complaints yourself, lung function measurements *(with a portable device)*	eC
2.	**Warning during activities or exercises**	Signalling: Warn before limits are reached, both indoors and outdoors *(e.g. device with vibration function)*	eM/eC
3.	**Alarm**	Alert / help: When 'red': direct contact *(e.g. by telephone)*	eM *(alarm)*

Group results of focus groups were tested on the respondents of the surveys in the form of questions and in the form of multiple answer-categories in the more closed-questions surveys. In the surveys, the results of the focus groups could be confirmed.

Respondents underline the importance of technology stimulating to maintain and extend existing physical & cognitive/emotional abilities. For these older respondents, eHealth should increase their sense of security, provide opportunities for questions and alerts, and increase confidence in their knowledge and abilities.

4. Discussion

Main validity threats of this study are the following:

1. Targeted selection of participants:

- specific patient groups, relatively mobile and ADL-independent, consciously maintaining physical and emotional condition.
- bias of (physical) training: dependent of rehabilitation and of professionals

2. Use of more creative explorative methods (such as mindmapping) in the focus groups, to translate needs into functional and non-functional requirements.
3. Use of the collaboration of bachelor students for the surveys (under supervision), thus setting time and quality limits.

5. Conclusions

Older people do wish support for self-management at home, to stay more independent and active. eHealth can offer support in maintaining and improving their quality of life. A user-centred design approach enables older people to identify key requirements for eHealth self-management support. Further research will be conducted (see also Figure 1), to complete this user-centred design approach, with other user groups or supporting groups, such as informal caretakers, and through this to contribute to recommendations on form and contents of 'eCOPD' (eHealth for COPD) self-management support. Based on the outcomes of this and further research, an 'eCOPD' self-management system will be (re)designed and implemented, in collaboration with Carintreggeland in The Netherlands, to support older people with COPD.

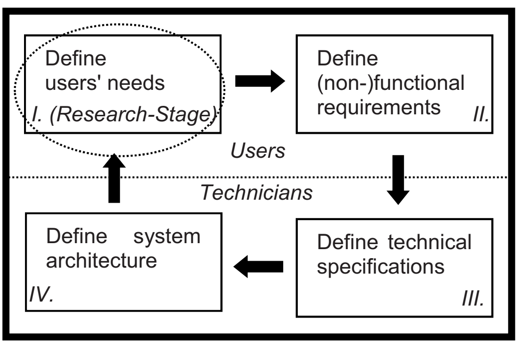

Figure 1. eCOPD user needs research as Stage I in a user-centred design-cycle

Acknowledgements

The corresponding author wishes to thank Carintreggeland, Home Care & Nursing Care (Hengelo, The Netherlands), for the collaboration. Parts of this study are carried out building on the commitment of undergraduate students and collaborating colleagues of Saxion University of Applied Sciences (Enschede, The Netherlands), the Schools of Health Care and Social Work and the Research Centre for Health, Social Work and Technology, which is a common component of a PhD Studies at a University of Applied Sciences in The Netherland. (Of BA Social Work 2012-2013: R. Nijhuis and M. Kamphuis, under the collaborative supervision of Mrs. M. Bratti-van der Werf;

of BA Physiotherapy 2011-2012: I. Becher, L. Becking and K. Ikemann, under the collaborative supervision of Mr. A. ten Brinke, M Musc.; of BA Physiotherapy 2011-2012: L. Boers, L. de Bruin and M. van der Gronden, under the collaborative supervision of Mrs. C. Oude Essink; and of MA Advanced Nursing Practice 2010-2011, under the collaborative supervision of Drs. S. Bombeld, with the collaboration and commitment of Ms. J. te Lintelo, at that time as a master student ANP).

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1279

Literature Review on Monitoring Technology and Their Outcomes in Independently Living Elderly People

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Abstract. *Introduction* Monitoring technology may be one of the key solutions to achieve a more efficient health care system and to allow elderly people to live longer independently. The use of monitoring technology may allow timely and well targeted interventions to intercept potential crises by detecting changes in health status. This is necessary as solutions are needed to deal with the growing complex care demand of elderly people. *Aim* Obtaining insight in which monitoring technologies exist, what the characteristics are and what is known about the outcomes by performing a systematic electronic document search. *Methods* A systematic electronic document search was performed in scientific databases and Google Scholar. Articles were included when reporting on monitoring technologies that detect activity of elderly people in the home environment with the aim of prolonging independent living. *Results* Results of the review on characteristics, purposes and reported outcomes of monitoring technology are presented in this paper.

Keywords. Monitoring technology, daily functioning, elderly people, independent living.

Introduction

Through advances in sensor and telecommunication technology monitoring technology may be one of the key solutions to achieve a more efficient health care system and to allow elderly people to live longer independently [1,2]. This is necessary since the growing number of elderly people, e.g. in the Netherlands, places a substantial demand on health care services whilst resources are scarce to deal with this complex care demand, such as availability of professional caregivers [3,4]. This review focuses on daily activity of elderly people at home since immobility or a general reduction in functional health may represent disease and may in turn, jeopardize independence and well-being [5, 6].

In 1995, Celler et al. presented the first telemonitoring system that determined functional health status of elderly people in a remote way, by continuously and passively monitoring interaction between elderly people and their living environment for a longer period. To accomplish this, activity monitoring was achieved by means of magnetic switches in doors for recording movement between rooms, infrared sensors to identify activity in specific areas of the room, and sound sensors to determine the type of activity. Hence, it became possible to respond earlier to activity changes, and thus changes in functional health status, by comparing presented activity to the 'normal' activity pattern of the elderly person. The use of monitoring technology may therefore allow timely and well targeted interventions to intercept potential crises [5]. Health care services often fail to support elderly people in a timely way as they do not recognize the gradual transition from a healthy to a frail elderly people [5,6].

Several other monitoring technologies emerged in subsequent decades to detect daily activity, changes in health status or to detect injury, e.g. fall detection. However, to our knowledge an overview is lacking of which systems exist to monitor activity and what the functionalities and outcomes are of using these monitoring technologies in the home environment of non-institutionalized elderly people. This insight is valuable as knowledge is needed about available and appropriate interventions to deal with the growing complex care demand of elderly people and scarcity of resources. Therefore, a systematic electronic document search was guided by the research question: *What kind of technologies exist to monitor activity of non-institutionalized individuals in the home environment, what are the characteristics of these monitoring technologies and what is known about the outcomes of using monitoring technologies to detect activities of daily living?*

1. Methods

1.1 Search Strategy

An electronic document search was conducted in the scientific databases of Pubmed, Embase, Cinahl, Cochrane and Psychinfo. Our search was complemented with a search in Google Scholar for conference publications and journal articles.

1.2 Key Terms

The following key terms are used as combination in the database search: ('Activities of daily living' [MESH], 'aged' [MESH] and 'independent living') and 'Gerontechnology' or 'Smart home', or 'Ambient assisted living' or 'Sensor motion detection' or 'domotic*' or 'In-home monitoring'. The search focused on the presence of key terms in the title or abstract of an obtained reference. The key terms are used as free text words in Google Scholar.

1.3 Inclusion and Exclusion Criteria

Articles were included when reporting on monitoring technologies that detect activities of daily living (ADL) or events of elderly people in-home with the aim of prolonging independent living. Articles were excluded when it focused on monitoring vital signs for disease management in elderly people. Articles focusing on monitoring of children were excluded since we focus on prolonged independent living of elderly. Articles were subsequently excluded when it had no links to identification of daily activities or focused only on environmental control.

1.4 Study Selection

The list of retrieved titles was first filtered by removing duplicates. The remaining titles were assessed by two reviewers according the selection criteria. The agreement between the reviewers for each title and abstract was calculated with Cohen's kappa. A score above 0.41 was deemed appropriate [7]. Titles meeting the criteria received two points. Titles not meeting the criteria received zero points and when there was doubt, one point was given. Abstracts were thereafter assessed when the sum score of a single title equalled two or more points. Again, abstracts received 0, 1 or 2 points according to the selection criteria. Disagreement was solved by extensive discussion.

1.5 Data Extraction

When the sum score of an abstract equalled two or more points, the full article was retrieved and scanned for characteristics of the described monitoring technology, purpose of applying the monitoring system, study characteristics and outcomes of using the monitoring technology. This paper focuses on the characteristics, the purpose and outcome of the found monitoring systems.

2. Results, Conclusion and Planned Activities

The electronic document search yielded 942 references, which were independently scored by two reviewers. The Cohen's Kappa for agreement was 0.465. Subsequently, two reviewers assessed the remaining 342 abstracts and concluded that 161 articles were eligible for scanning articles on the characteristics of described monitoring systems, their main purpose and outcomes. Eight articles were subsequently excluded on the basis of scanning full articles: one French article and seven articles which did not meet the inclusion criteria. In total, 153 full articles were included.

Analysis of the articles revealed five main groups of monitoring technology: the use of in-home passive infrared motion sensors, body-worn sensors, pressure sensors, video monitoring and sound recognition. In two articles, the monitoring technology was not specified. For seven articles it was not possible to classify them into one of the five main groups and were therefore individually specified.

Within the five groups, subgroups were identified and also three predominant purposes of applying monitoring technology in-home could be defined: fall detection, monitoring (ADL) activity and detecting changes in health status. Changes in health status are often indirectly derived from activity levels.

The majority of the articles focused on using PIR sensors to detect (ADL) activities (see table 1). Passive infrared (PIR) motion sensors are placed on walls or ceilings of rooms (e.g. bathroom, bedroom) and aim to detect falls, (ADL) activity of residents and changes in health status. This is accomplished by detecting the presence of residents through changes in temperature, in combination with sensors that measure stove use, temperature, opening of window or doors. As a result, it is possible to recognize patterns in daily activity and to generate alerts if deviations occur. In addition, 28 articles focused on employing PIR sensors in fall detection and 17 articles on detecting changes in health status. Window sensors were also frequently described in combination with other sensors to detect falls (N=13), (ADL) activity (N=16) or to monitor changes in health status (N=4)

The second group of monitoring technology consists of body-worn sensors to measure daily activities. Accelerometers are the most common described wearable monitoring system to detect falls (N=20), (ADL) activity (N=19) or changes in health status (N=2). Accelerometers are more specific in measuring activity than passive infrared sensors by detecting postures as standing, sitting, bending. Accelerometers can be positioned on the trunk, waist or hearing aid to measure (linear) accelerations in bodily movements to detect activity [8]. Gyroscopes are used to measure angular velocity in bodily movements and are useful in detecting fall events [1]. Four articles described the use of gyroscopes in fall detection. Only one focused on monitoring (ADL) activity with gyroscope sensors.

Pressure sensors are the third group to detect the presence of residents on chairs or beds. For instance, bed sensors are employed to detect movement or presence of an individual in bed. In total, seven articles described the use of bed sensors in detecting falls and eight articles focused on monitoring (ADL) activity. Sensors can also be present in furniture, e.g. chairs [10]. This application was described in two articles related to fall detection and in five articles related to monitoring (ADL) activity.

Video monitoring and sound recognition are two other methods of monitoring. Video monitoring is used to detect and locate residents in their homes. The method is similar to PIR sensors but uses silhouettes instead of changes in temperature to detect activity. Video monitoring was in eight articles described as means of detecting falls. Fourteen articles focused on monitoring (ADL) activities by means of cameras.

Sound recognition uses microphones to detect classes of daily activity, for instance the sound of doing the dishes or fall of an object or person [11]. Fall detection by using sound recognition was in four articles described. Monitoring (ADL) activity was also described in four articles.

Table 1: Characteristics of monitoring systems, their purpose.

Purpose of monitoring → **Type of monitoring system ↓**	**Fall detection** (N articles)	**(ADL) activity monitoring** (N articles)	**Monitoring change in health status** (N articles)
Passive infrared motion sensors			
- placed in rooms	28	70	17
- window sensors	13	16	4
- door sensors	1	11	0
Body-worn sensors			
- accelerometers	20	19	2
- gyroscopes	4	1	0
Pressure sensors			
- bed sensors	7	8	0
- in furniture	2	5	0
Video monitoring	8	14	0
Sound recognition	4	4	0

In addition, outcomes of research regarding the use of monitoring systems to detect activity were examined. Table 2 presents an overview of performed research for different types of monitoring systems. Results show a wide range in types of research performed, ranging from testing algorithms on existing datasets (N=5) and performing laboratory tests (N= 55), to pilot studies (N=34) and longitudinal effect studies to determine effectiveness (N=8) of the systems. Research into the effects of PIR sensor technology in real-life settings seems to be the most developed area. Research into the use of body-worn sensors is upcoming with the main part focusing on testing their application by monitoring activities performed in a laboratory setting to demonstrate the use of the technology (N=17), such as falls. Notable is that research is often multidimensional by using more than one type of monitoring system in research to detect activity.

In conclusion, this paper presents results of a literature review regarding what kind of technologies exist to monitor activity of non-institutionalized individuals in the home environment, what the characteristics are of these monitoring technologies and what is known about the outcomes of using monitoring technologies to detect activities of daily living.

The results demonstrate a growing interest in employing different kinds of monitoring technologies aiming at detect fall events, activities of daily living and changes in health status with the aim of prolonging independent living of elderly people. Overall, the characteristics of monitoring technologies can be subdivided into five main areas with several subgroups. The results also show a wide range of conducted research, from developing appropriate algorithms and testing them on healthy volunteers to randomized controlled trials on the effects of the systems on a more efficient health care system and prolonged independent living of elderly people.

Table 2: Overview of performed research into the use of monitoring systems.

Purpose of monitoring → **Type of monitoring system ↓**	**RCT/ long-itudinal effectiveness study** (N articles)	**Pilot** (N articles)	**Case report** (N articles)	**Real data testing** (N articles)	**Laboratory testing** (N articles)	**Description Technology** (N articles)	**Qualitative study** (N articles)	**Testing algorithm on existing data** (N articles)
Passive infrared motion sensors	8	22	11	0	10	6	3	2
Body-worn sensors		4		5	17	2		
Pressure sensors				1	3			
Video monitoring				2	4			2
Sound recognition		8		2	21	4		1
Combination of technologies*								

*Monitoring systems are often used in combination, e.g. PIR sensors and accelerometers.

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Special Session on (Semi-automatic) User Interface Generation

Special Session on (Semi-Automatic) User Interface Generation

Needs and wishes regarding the interaction with ICT solutions change over time and vary between older adults. They depend on the user's physical and mental capabilities and his/her preferences. Thus the user interface is considered critical to the success or failure of an ICT product or service.

Since many years researchers and developers try to automatize the process of user interface generation with different approaches. The aim is to create more than just operable user interfaces based on an abstract description describing only basic interaction elements.

With different transformation processes, including context and user information, these adaptation processes should deliver appreciable and usable interfaces, some taking care of accessibility issues, others hardly or not all.

Several languages and procedures have been developed, with different application areas. Some of these approaches were stopped at prototype stage, others are widely adopted and some are still under development.

We invited to share ideas, findings, experiences and knowledge about how users with all kinds of abilities and special needs can interact in an easy way with automatic generated user interfaces.

Papers in this session address one ore more of the following topics

- Prototypes of highly innovative and intuitive automatic generation user interfaces
  - Speech in/output
  - (Multi)Touch interfaces
  - Mobile Devices
  - Pervasive and ubiquitous methods
- Multimodal user interfaces description languages
- Adaptive and self adapting user interfaces
- Best practice examples of large scale and long term usability trials
- Approaches for the standardisation and interoperability of user interfaces and underlying systems
- Other topics dealing with the accessibility and usability of automatic user interface generation

They cover some of the following criteria

- Detailed description of the automatic generation process of UIs
- Detailed descriptions and illustrations of the user interface
- Statistical evaluation with a high number of users

- Long time evaluations
- Lessons learned

Martin Morandell has graduated in computer science with focus on Assistive Technology (AT) and graduated as academic expert in a four-semester university course on AT. His focus is on Ambient Assisted Living, HCI for older adults and people with cognitive impairments, AT for visually impaired end-users as well as on how to apply AT in a successful and lasting way. Joining the AIT Austrian Institute of Technology GmbH in 2008 he works as a project manager and takes part in international projects on AAL. He also offers trainings on AT for people with disabilities and gives lectures. Currently he attends master courses in law and business for technicians at the JKU-Linz.

Christopher Mayer, PhD in applied mathematics has joined the biomedical engineering group of AIT during his studies. He has graduated in 2004 and received the doctor's degree in 2007 at the Vienna University of Technology. His research focus is on the one hand on smart home environments, sensor integration and the analysis of data from sensor systems by means of different pattern recognition technique and on the other hand on user interaction. Furthermore he is project coordinator of the AAL JP project AALuis and involved in various international AAL projects (e.g. universAAL, NovaHome, E-MOSION).

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1289

Abstract User Interface, Rich Grouping and Dynamic Adaptations – A Blended Approach for the Generation of Adaptive Remote Control User Interfaces

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Abstract. User interface generation can provide a way out of the "one-size-fits-all" dilemma for accessibility of mainstream devices. By taking a user's preferences, the capabilities of their device and environmental parameters of use into account, user interfaces can be generated that are well suited for a particular user in a particular user context. In this paper, we describe a multi-staged process for the generation of adaptive user interfaces for the remote control of devices and services. A proof-of-concept prototype (GenURC) is currently being implemented, and will be used for empirical studies on dynamic user interface adaptations for persons with disabilities.

Keywords. User interface generation, adaptive user interfaces, adaptiveness, user interface adaptation, use context, GenURC, Universal Remote Console (URC), abstract user interface, rich grouping.

Introduction

Today, the vast majority of user interfaces for Web applications and on other platforms are hand-crafted for mainstream users and are carefully tweaked to meet the designer's imagination of a very concrete look and feel, and bearing a deliberate branding mark. The result is that there is usually only one user interface available for mainstream applications. Unfortunately, this "one-size-fits-all" approach does not meet the needs of many people with disabilities and older users.

The huge variety of needs and preferences of users with disabilities and older people, and recent trends in mobile computing emphasize a growing need for preparing highly-customized user interfaces for a specific user, using a specific interaction device on a specific software platform, within a specific situation. We call these parameters "context of use", and distinguish between the following parts:

(a) *Personal needs and preferences.* This encompasses parameters such as preferred language, a default font size and zoom factor, contrast scheme,

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whether a screen reader should be used, keyboard settings such as sticky keys, toggle keys, and thresholds for timeout settings in dialogs.

(b) *Device and platform characteristics.* This part is about screen size and resolution, output modalities, pointing and other input devices, operating system, browser type and version, JavaScript support, etc.

(c) *Environmental parameters.* This includes all situational conditions that affect the user's ability to interact with an application, such as time of day, ambient light and noise levels, distractions in the environment, usage mode (e.g. sitting, walking, driving, lying), etc.

Some of these parameters are static (they do not change over time) and only bound to a specific person, while others are inherently dynamic (they change from time to time, perhaps even during a session of use). For the generation of user interfaces that adapt to contexts of use, we need to look at all parameters, but can do this in a staged process. In the first stage, at development time, the user interface elements can be arranged into hierarchical groups of coherent clusters. We do so in a hierarchical fashion to facilitate navigation over multiple layers (e.g. following the One-Window Drill-Down pattern [1]). In a second stage, also before runtime, we can take into account personal needs and preferences that do not change with time (e.g. preferred language). Finally, at runtime we account for dynamic parameters, such as the available output and input modalities, the size and resolution of the screen (if there is a screen), and situational conditions.

This process is based on existing technologies, mainly the Universal Remote Console (URC) framework [2] for specifying an abstract user interface and a grouping structure of its elements, and the notion of a user preference set, as developed by the Global Public Inclusive Infrastructure (GPII).[2] In our proof-of-concept implementation (GenURC), we focus on user interfaces for the remote control of appliances and services.

Figure 1 illustrates the three stages of our user interface generation process. In the remainder of this paper, we will describe these stages in more detail.

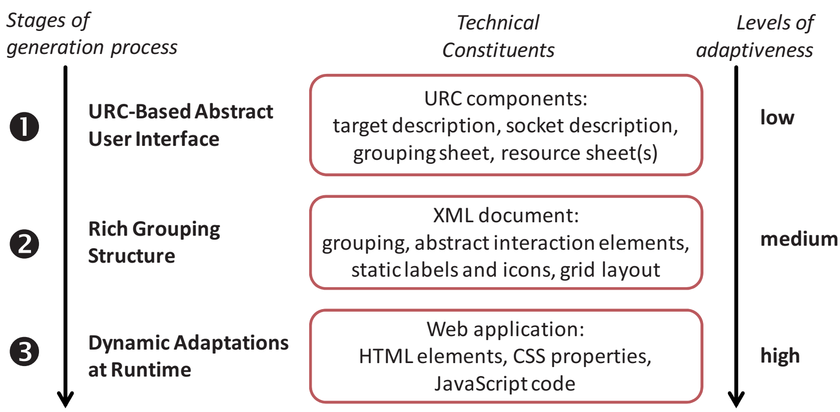

Figure 1. Stages of user interface generation, their technical constituents and pertinent levels of adaptiveness.

[2] www.gpii.net

1. Related Work

In the 1980s and 1990s, User Interface Management Systems (UIMS) (e.g. COUSIN [3], HOMER [4]) featured a separate user interface management layer so that the user interface could be adapted to the runtime platform (desktop) and other parameters of use. These systems were influenced by the Seeheim model [5], in which a user interface is separated into modules controlling presentation, dialog control and an application interface model. UIMS and similar approaches have not been widely adopted for various reasons. One of them is that designers want to control the look and feel of the interactions at a lower level than the UIMS abstraction allowed [6].

More recently, the User Interface Markup Language (UIML) standard by OASIS [7] has been designed to allow for the generation of platform-specific user interfaces, driven by rules for presentation and behavior that are unique for each runtime platform. UIML does not provide a vocabulary for user interface components, and the development of such a vocabulary, together with an appropriate set of rules, is cumbersome. Also, UIML does not facilitate fully context-driven user interfaces since adaptation happens before runtime.

Other approaches focus on the automatic generation of user interfaces with dynamic runtime adaptation mechanisms. Using the Pebbles [8] approach, an author provides an abstract user interface description which is used to render a control interface on a mobile device at runtime. The SUPPLE system [9] is similar, but uses a constraint-based algorithm to solve an optimization problem for a concrete layout at runtime. More recently, the MyUI approach [10] has combined abstract user interface models based on state transitions with interaction design patterns at runtime. Although these approaches can facilitate useful adaptations at runtime that may increase the level of accessibility for users with disabilities, they lack the ability for a designer to control the end result of the rendition process.

UsiXML [11] is an emerging standard for the description of user interfaces via four layers: task model, abstract user interface, concrete user interface and final user interface. It comprises user and context models for dynamic user interface adaptations at runtime. A future version of UsiXML is currently being developed as a W3C standard within its Model-Based User Interface (MBUI) working group.[3] In its current form, UsiXML is just a user interface description concept and does not provide for automatic generation capabilities at development time and adaptation strategies at runtime. However, (future) work around UsiXML could bring about interesting solutions in this area.

The Fluid project [12] with its "user interface options" component offers a way for authors to make their Web pages adaptable to their users along some presentational aspects such as font size, line spacing and button size. The author just needs to include some code into their web pages and follow certain guidelines; no abstract user interface models are involved. This approach works well for users and devices that need some "tweaking" of the Web page, but does not cater for radical changes in device characteristics (e.g. screen size) or user needs (e.g. simplified user interface).

The Global Public Inclusive Infrastructure (GPII) is a world-wide effort on building an infrastructure for personal and accessible user interfaces that adapt automatically to a user's preferences and context of use ("one-size-fits-one" approach

[3] http://www.w3.org/2011/mbui/

for user interfaces). As part of GPII, the European Cloud4all[4] project contributes to the revision of the AccessForAll framework [13] (ISO/IEC 24751) for the description of personal preferences. GPII builds upon existing technologies, including AccessForAll, Fluid and Universal Remote Console (URC). As described in the following sections, our work contributes to the GPII effort.

2. URC-based Abstract User Interface

The Universal Remote Console (URC) framework (published as ISO/IEC 24752 [2]) is a technology for specifying a user interface in two parts: a "user interface socket" that defines the components of a user interface in abstract terms (variables, commands, notifications), and any number of concrete ("pluggable") user interfaces that can plug into the socket to realize a concrete user experience at runtime. Pluggable user interfaces may be hand-crafted or automatically generated.

The URC approach has been designed and proven to be useful primarily for the control of electronic devices and services, such as used in smart home and ambient assisted living environments [14][15][16]. In many cases, concrete user interfaces have been specified as Web applications (HTML, CSS, JavaScript), but other user interface technologies (such as Java, C#) can also be employed without restriction. The URC framework facilitates a "one-size-fits-one" approach for user interfaces, allowing for personal and device-specific user interfaces that have been prepared before runtime in a manual or automatic fashion.

In addition to a user interface socket description, the URC standard requires a target description, a grouping sheet, and one or more resource sheets to be specified for a target application. The target description contains details about the target application, such as its unique name and its user interface socket(s). The grouping sheet defines a hierarchical presentation structure of the socket elements. Resource sheets contain labels and other atomic resources of any kind (text, image, audio, or video). Language-specific resources are typically split up into multiple resource sheets, so that all resources for one language reside in a single resource sheet.

The target description, socket description, and grouping and resource sheets are theoretically sufficient for creating a "bare-bone" user interface that is fully functional. However, their inherently externalized structure (i.e. groupings and labels pointing to the user interface elements rather than vice versa), the modality-neutrality of the user interface, and its built-in optionality (i.e. choice of language) bear a high level of abstractness and complexity.

3. Rich Grouping Structure

By anticipating some concrete context parameters (such as preferred language and assuming a visual presentation mode), we can compile the set of URC components (target description, socket description, grouping and resource sheets) for a concrete target application into a less abstract format that we call "rich grouping structure". In this format, the user interface is specified as a set of hierarchical groups with abstract interaction elements (e.g. text input, select-1, select-1-boolean, select-n, trigger) and

[4] www.cloud4all.info

static icons and text labels, laid out in a grid-based manner. In our proof-of-concept implementation, this rich grouping information is specified in an XML-based language.

The rich grouping information can be seen as a user interface that is specific ("personal") to a user, but without being specific to the device and situational parameters of use. It deliberately leaves some leeway for final adaptations based on a concrete use context at runtime. For example, a select-1 abstract interaction element could be presented as a set of radio buttons, a dropdown menu, or a set of push buttons. Also, the fitting of the hierarchical groups into individual screens ("pagination") is highly dependent on the screen size and the concrete font size and zoom factor chosen by the user at runtime.

4. Dynamic Adaptations at Runtime

Based on the rich grouping structure, we can make final adaptations at runtime when all context parameters are known, including the device characteristics and environmental conditions. These adaptations may include, but are not limited to:

(a) choice of concrete widgets (e.g. rendering a select-1 abstract element as a set of radio buttons);
(b) choice of child mode for each group, i.e. how its subgroups are displayed (e.g. link to an external page, display as inline content, or display as expandable/collapsible content);
(c) settings for font size, zoom factor, font face, line spacing, button size and other visual properties of the concrete user interface;
(d) choice of navigation style (e.g. direct pointing or focus-based); and
(e) support for device and platform-specific input mechanisms, including specific keyboard shortcuts.

In our proof-of-concept implementation, a generic script running in a Web browser loads the rich grouping information. The script then generates the contents of the Web page (HTML elements) and its presentation (CSS properties) based on the rich grouping information and the parameters of the concrete use context.

Our proof-of-concept implementation allows an expert to make manual decisions before runtime on some aspects of the dynamic adaptations, to facilitate controlled conditions for the conduct of user tests. These decisions are noted as annotations (e.g. attribute values) in the rich grouping file with the rich grouping information.

In the following, we describe a selection of specific aspects of runtime adaptation that we plan to explore via empirical studies and our proof-of-concept implementation.

4.1. Visual Enhancements

People may need visual enhancements or changes to an interface because of disabilities or circumstances. People with low vision may prefer text with high contrast in a large font. Other people may prefer light text on a dark background. People with dyslexia prefer to have control over the colors of text and background and over the font face used to display text [17].

Some visual preferences can be accommodated easily without significantly changing the form or presentation of the interface. Other changes, such as a much increased text size, may necessitate other changes to an interface to better fit the screen. For example with a large text on a small display, a list of choices may be better provided as a dropdown menu rather than a list of radio buttons through which a user must scroll while losing sight of the rest of the context of the interface (see fig. 2).

Figure 2. Two sample user interfaces for the control of a digital thermostat. (a) On the left: User interface with a drop-down menu and a toggle control for setting the operating mode and the temperature unit (Fahrenheit vs. Celsius). (b) On the right: Variation of (a) with sets of radio buttons in place of the drop-down menu and the toggle button. Notes: (1) Although shown as rendered on an iPhone here, the user interfaces generated by GenURC run on any Web-based platform, including desktop computers. (2) A textual description is available for each of the screen shots.

4.2. Navigation Enhancements

Some people cannot use a touchscreen or other pointing method to directly select and manipulate controls on a screen. These people need an alternative method to access and interact with all of the elements on a screen. A navigation-style interface allows people to access information and functionality on a screen when they cannot see it or physically provide pointing input. With navigation interfaces, users navigate the elements of a screen by moving a highlight or focus cursor. Once on a desired element, they activate or otherwise interact with it. Different users have varying needs when interacting with a navigation interface.

People who cannot see a screen have different needs than those who can see. A person who cannot read the screen needs all information about the interface provided to them in speech or braille—this is provided as they move to each element. They need to be able to navigate to all elements (both passive and interactive elements). In contrast, people who can see the screen but must use a navigation interface only need to be able to move the focus to interactive elements.

Some people have such limited physical control that they can only use one or a few customized switches to navigate an interface. In order to be more efficient, these users may need controls grouped in a manner different from other users. These people may need an interface with fewer elements on each screen that spans several screens rather than one where everything is on the same screen. People with motor impairments may be more likely to make mistakes with entry. They need an interface that makes it easier to correct mistakes. Such an interface may have confirmation steps after a selection is made or provide the user with the ability to cancel, reset, or submit the information entered on a screen rather than automatically changing settings as soon as a new value is entered.

4.3. Cognitive Enhancements

All interfaces place a cognitive load on users who must figure what the interface does, what input they can provide, and how they interact with it. Interfaces that are “simple” or “intuitive” have better usability and lower cognitive loading than more complex interfaces. The complexity of an interface has many potential factors, which may lead to different preferences for different users.

Widgets can be limited to those with which a particular user is familiar and comfortable. For example, a user might not understand how a set of radio buttons works, thinking that they can choose as many options as they want. This person may prefer a dropdown list widget or having a set of options provided on a separate screen. A person might prefer on/off switches to checkboxes. Another person may find toggle buttons and switches harder to understand than checkboxes. Limiting the set of widgets may be important for people who cannot see the screen and those who prefer to have a consistent interaction rather than having many different but functionally equivalent widgets that they must interact with in different ways.

The visibility of elements may have an effect on the usability of an interface for some people. Some people prefer simple, uncluttered interfaces with relatively few commands or options on a screen. Others may prefer to be able to see everything that they control on the same screen. Widgets that hide choices, such as dropdown lists, may be more difficult for some people to use if they cannot remember or guess the other options from the control’s label. Some people have difficulty with the concept of scrolling an interface and might prefer interfaces that fit on a single screen.

5. Conclusion and Outlook

In this paper, we have described a 3-stage process of user interface generation, with more static adaptations (based on static context parameters) happening at an early stage, and more dynamic adaptations (based on dynamic context parameters) happening at runtime. In the first stage, an abstract user interface is specified via the components of the URC framework. In the second stage, a "personal" but still somewhat abstract user interface is specified as a "rich grouping structure". In the third and final stage, a Web application is generated dynamically from the rich grouping structure, taking the parameters of a concrete use context into account.

A proof-of-concept prototype (GenURC) is currently being implemented, with the ability for experts to manually determine dynamic adaptations before runtime for the purpose of experimentation. We plan to conduct a series of empirical studies on various aspects of dynamic adaptations. Regarding GenURC, we plan to further develop its capabilities for dynamic adaptations based on our empirical studies.

We are looking into ways of describing the various context parameters that affect the final adaptation of a user interface at runtime. Currently, the Cloud4all project and other projects within the Global Public Inclusive Infrastructure (GPII) are contributing to the revision of ISO/IEC 24751 by devising a registry-based approach for specifying a user's preference set, device capabilities and use conditions at runtime. It is our goal to adopt the new ISO/IEC 24751 style of context description in GenURC once it has reached a sufficiently mature status.

In summary, the blended approach consisting of an abstract user interface, rich grouping structure and dynamic adaptation facilitates a wide variety of user interface adaptations, as required to accommodate an all-inclusive user population by a "one-size-fits-all" approach. Also, due to the openness of the URC framework, this approach allows for additional hand-crafted user interfaces which are regarded as essential by mainstream product designers. This is an important aspect for the adoption of this approach by mainstream industry which would facilitate a maximum level of accessibility to electronic appliances at home and beyond for people with disabilities and older persons.

Acknowledgements

This work has been funded by the US Dept of Education, NIDRR, under Grant H133E080022 (RERC on IT Access), and by the European Commission, under FP7 Grant Agreement 289016 (Cloud4All). The opinions herein are those of the authors and not necessarily those of the funding agencies.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1298

A Framework for the Automatic Adaptation of User Interfaces

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Abstract. Older adults benefit from information and communication technology solutions and services in the Ambient Assisted Living (AAL) domain. Unfortunately offered user interfaces for these ICT solutions often do not take the special needs, preferences and the physical and mental capabilities of older adults into account. The project AALuis focuses on solutions to increase accessibility, adaptability and usability of user interfaces in the AAL domain. The general idea is to build a layer which can be used for different platforms to connect different types of user interfaces on different I/O devices with various AAL services. The layer shall take the burden from the service developers to design a target group friendly user interface by providing mechanisms for an automatic user interface generation. First results have shown that the chosen approach is very powerful, but as well that the automatic user interface generation process needs optimization and additional semantic information to be able to build richer user interfaces.

Keywords. Ambient Assisted Living, Human-Computer Interaction, User Interface, Framework, Task Model, Automatic Adaptation

1. Introduction

Older adults benefit from ICT solutions and services in the AAL domain. By using ICT older people may increase their independence and live their life as long as possible in their own, well known surrounding. ICT also offers the opportunity to integrate older adults with their full and active participation in society [1]. However, ICT acceptance mainly depends on provided user interfaces (UIs) and interaction possibilities. Unfortunately these UIs often do not take the special needs, preferences and the physical and mental capabilities of older adults into account. The project AALuis[2] focuses on solutions to increase accessibility, adaptability and usability of user interfaces in the AAL domain. Moreover AALuis connects different types of AAL services with different types of user interfaces and offers thereby a service interaction in the user's preferred way [2].

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[2]http://www.aaluis.eu/

2. Objective

One of the main goals of the project is the development and testing of an user interface generation layer, which can be run in standalone mode or can be deployed within already existing AAL middleware platforms. Its main purpose is to cover the requirements of two target groups: the non-technical users, namely older adults and their beloved ones, as well as technical users, such as service developers and deployers [3]. The layer shall take the burden from the service developers to design a target group friendly user interface by providing mechanisms for an automatic generation. For the non-technical target group AALuis will offer accessible, adaptable and multimodal user interfaces for the interaction with AAL services. Beside the multimodal interaction, the layer will be able to handle multiple device types and will offer older adults freedom of choice concerning user interfaces and the interaction with AAL services [4][5].

3. Technological Methodology

The project development aims at a solution which can be integrated into various existing AAL middleware platforms relatively easy. To accomplish this goal an OSGi [6] based layer has been developed which can be embedded into existing platforms like HOMER (HOMe Event Recognition System)[3] [7][8][9] or universAAL[4] [10]. The main components are described in the following sections.

3.1. Service Integration and Communication with the Service

The layer can interact via two interlaced communication channels with internal services provided by the OSGi environment but also with external web services, which are not located in the AALuis layer nor the current used AAL middleware platform. External web services are dynamically transformed and bound to internal OSGi services, making them easily accessible. In figure 1 (top right) the dynamic transformation of the external web service into an internal OSGi service using the Web Service Description Language (WSDL) [11] file is illustrated.

The service integration into the AALuis layer requires two additional files, i.e. the task model and the task binding description. The task model describes the service activities and the possible interaction steps between the service and the user. AALuis uses the ConcurTaskTree (CTT) notation as task model language. The CTT notation distinguishes between interaction, system, user and abstract tasks [12]. Interaction tasks are performed by user interactions with the system. These tasks are represented in the final UI as control elements or user input elements. System tasks are performed by the application itself. They can receive data from the system and provide information to the user. User tasks represent internal cognitive or physical activities performed by the user without a direct system interaction, such as selecting a strategy to solve a problem. Abstract tasks are used for complex actions which need sub-tasks of different categories and thus cannot be clearly assigned to just one of the three categories [13]. Service designers may use a graphical user interface tool, namely the ConcurTaskTrees Environment (CTTE), to design and test task models for their services [14].

[3] http://homer.aaloa.org/
[4] http://www.universaal.org/

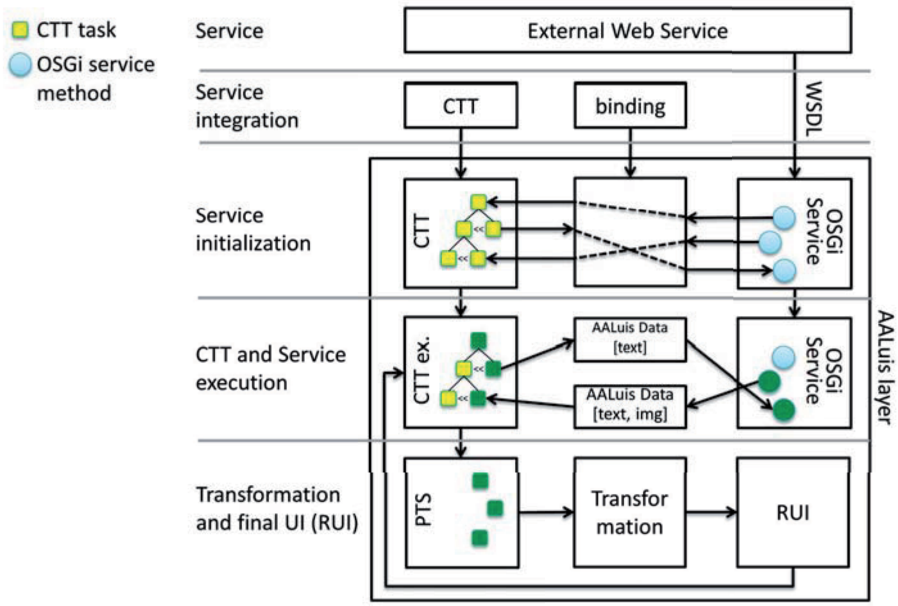


Figure 1. AALuis layer in three different phases. The service initialization phase, the CTT and service execution phase and the transformation phase which produces the final user interface.

3.2. Data Exchange

As already mentioned, system tasks are executed by the AALuis layer. The main purpose of system tasks is the data exchange between the user and the system. Therefore system tasks need to be bound to concrete service methods via the binding file. AALuis uses a simple XML file which specifies each system task, its service method and the corresponding in- and output parameters. The binding is applied during the service initialization phase of the AALuis layer (figure 1). AALuis uses a generalized data format, namely AALuisData, to exchange information between CTT tasks and services. The AALuisData generalization facilitates the delivery of equivalent information in different modalities as in- and output paramaters. The modalities may be used in the subsequent transformation process.

3.3. Transformation Process

As the CTT describes all interaction steps between a user and the AAL service, it also includes all possible UIs that may occur during the service interaction. The set of visible UI artifacts, like a control or an edit element, in a user interface depends on the active CTT interaction tasks set. This set of active interaction tasks is called Presentation Task Set (PTS) and is re-evaluated after every single task execution [15].

The current PTS and the AALuisData from the service method invocation are the entry point for the transformation process. AALuis generates the concrete user interface by applying a transformation process using the Model based lAnguage foR Interactive

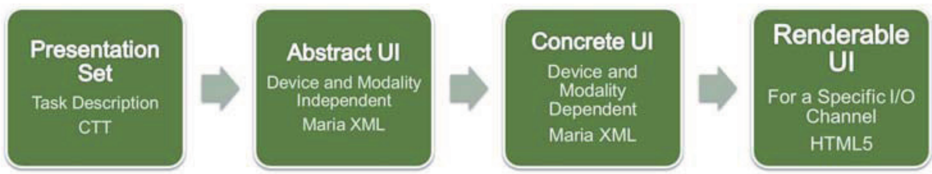


Figure 2. The AALuis transformation process.

Applications (MARIA)[16] in three phases (figure 2). In the first phase, the abstract user interface (AUI) is created based on the PTS and the particular device capabilities or user preferences are not taken into account [15]. In the second phase, the concrete user interface (CUI) is generated based on the abstract user interface. The generation process uses various device capabilities, such as the screen resolution or interaction possibilities. Thus the CUI is device and modality specific. In the final phase, the renderable user interface (RUI) is generated and user preferences, such as preferred font size or device, as well as other context information are incorporated. Context information might cover for example environmental settings like the current light illumination or the user's position. By applying this transformation process AALuis dynamically creates an adapted user interface for a concrete user.

3.4. Device Integration

Since AALuis aims to support multimodal user interfaces on multiple devices, device capabilities are taken into account during the UI transformation process. Therefore the knowledge about available devices is needed in real-time when the service is running. This is realized by the local network discovery for AALuis enabled devices via the UPnP [17] protocol. The approach allows embedding of appearing devices in and removal of disappearing devices from the AALuis layer in an easy and automatic way.

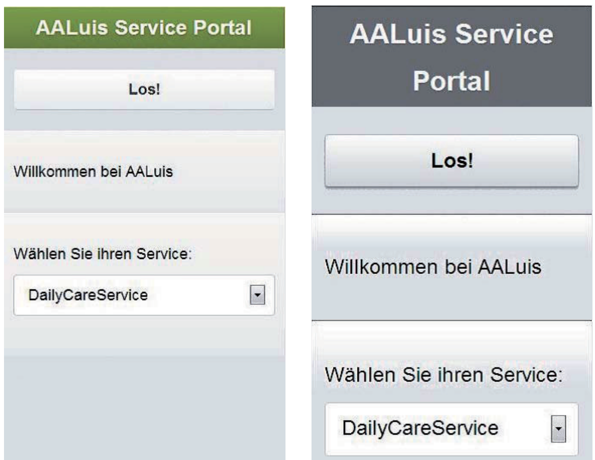
Beside the multidevice interaction, the UPnP approach provides also basic principles for multimodal functionality. It offers the AALuis layer the ability to keep track of currently available input and output channels. This information allows to switch to another input and/or output channel when the current used modality is not sufficient or applicable any more. As an example one can think about changing from a vocal based output to a text based output in a noisy surrounding. In combination with the user preferences and the environment context information this automatic setting reconfiguration enables the interaction with the AAL service in a very dynamic and flexible way.

3.5. Dialog Manager

The dynamic setting change with multiple devices and multiple modalities demands the exact knowledge about the current system state and the conversation flow. This is the responsibility area of the implemented dialog manager within the AALuis layer. In addition to on-the-fly modality and device switching the dialog manager is also responsible for interactions between multiple services. Depending on the service priority a service may interrupt a current ongoing service interaction. After the higher priority service interaction is finished the dialog manager restores the interrupted service to ensure that the user may continue with the previous interaction.

4. Results

The first project prototype includes the OSGi based layer and two external AAL services, the MPoint and the DailyCare service as well an internal service, namely the PortalService. The former two services are based on needs by user organizations and all three act as proof-of-concepts for the whole adaptation process. The prototype covers the whole UI generation chain from the service integration, task model definition, the user interface transformation till multimodal interaction on multiple devices [18] and first results are presented in [3]. Figure 3 illustrates the final UI displayed on mobile device with two different user preferences.



(a) Normal contrast and normal font (b) Higher contrast and larger font

Figure 3. Two RUI displayed on mobile device with two different user preferences.

5. Conclusion

The generated user interfaces for the two implemented external services illustrate the power of the AALuis layer. However the results also show that an automatic UI generation from a task model with the current semantic information does not lead to high sophisticated UIs. An extension of the task model and thus the CTT concerning additional semantic information is planned as an improvement in the second development cycle. It will be a big step towards an automatic generation of usable UIs.

The upcoming lab and user trials will help to identify weaknesses in the UI generation process as well as in the interaction with the implemented AAL services. The insights of the lab and user trials and already planned further enhancements, e.g. the semantic extensions in the task model, will help to improve the second prototype and thus to increase the usability of the UIs especially for older adults.

Acknowledgements

The project AALuis is co-funded by the AAL Joint Programme (AAL-2010-3-070) and the following National Authorities and R&D programs in Austria, Germany and The Netherlands: bmvit, program benefit, FFG (AT), BMBF (DE) and ZonMw (NL).

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1304

Design Issues in Accessible User Interface Generation for Ubiquitous Services through Egoki

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Abstract. This paper presents a number of design issues raised in the development of Egoki, a system to automatically generate accessible user interfaces to interact with services provided through ubiquitous computing. Egoki dynamically creates model-based user interfaces for each service from its specification in a User Interface Description Language (UIDL), taking into account the specific requirements of diverse user stereotypes. These user interfaces are finally adapted to each user by means of a user model. Among other issues, in this paper we discuss the need to select an appropriate UIDL and to obtain suitable multimedia interaction resources from the service designer.

Keywords. User Interface Description Language, Automatic creation of user interfaces; Adaptive interactive systems; Accessible ubiquitous computing.

Introduction

The impressive recent advances in mobile technologies and wireless networks allow the creation of effective ubiquitous computing environments that provide context-aware services to support mobile users. This technology may be extremely useful in helping people with disabilities to interact with their environment. For instance, wireless access to information kiosks or vending machines can be provided to people who are not able to use them directly because of physical, sensory or cognitive disabilities. Other location-dependent services, such as guiding services for people with orientation problems or tutoring for people with mild cognitive restrictions can also be provided by means of ubiquitous computing [1].

A typical ubiquitous supportive scenario is a public building where a mobile device carried by a person entering the building is detected and integrated into the network by a middleware layer. After being accepted into the network, the existing services are announced to the user. If she selects one of them (for instance buying a ticket), the system downloads a user interface (UI) to the user device that allows her to access the service. These UIs are usually generic and therefore are not adapted to the specific needs of the diverse users.

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Supportive ubiquitous computing-based intelligent environments have to provide accessible UIs in order to be valid for people with disabilities. One option is to create a basic UI for each ubiquitous service and to adapt it to the needs of each user. This approach is similar to the *transcoding* technique, used to tailor and enhance web accessibility [2], but this approach is not always possible because the system does not have enough interaction resources to provide accessible alternatives. Conversely, we propose to create a new UI from scratch, starting from a formal specification of the UI and the available interaction resources [3]. The UI is specified by means of a User Interface Description Language (UIDL) [4] such as User Interface Markup Language (UIML). This level of abstraction allows flexibility in the process of creating final UIs. This option is well suited for ubiquitous computing environments where most interactions are sporadic: the user accepts a service that is available, uses it, and forgets it.

The principal aim of this paper is to describe and discuss the main issues raised in designing the Egoki system. The rest of the paper is organized as follows: first other works in this area are cited; then, an overview of the INREDIS project and the Egoki system is provided to set the background; subsequently, the design constraints we faced are elucidated; afterwards a number of key design issues are discussed; and finally, some conclusions are presented.

1. Related Work

There are some European projects that consider a similar approach to provide adapted UIs. These projects are mainly focused on elderly people modelled by means of user profiles. In general they generate personalized UIs, usually taking into account the users' characteristics and the context. In addition, they mostly use a middleware layer to access the different services provided in a network, which makes them similar to our ubiquitous computing approach. However, there are differences in the user adaptation process and in the way they include different modalities.

GUIDE (Gentle User Interfaces for Elderly people) allows applications and services to automatically adapt their UIs to the specific impairments and preferences of elderly users. The resultant UIs are rendered in set-top boxes and interactive televisions [5]. In regard to the adaptation, the GUIDE project uses a technique called "multimodal fission" to select the most suitable modality for the output, based on the user profiles and the available output channels. Analogously to Egoki, GUIDE selected UIML [6] due to its flexibility to define new properties on demand. However, in contrast to Egoki, it considers more input techniques such as gesture and speech recognition. On the other hand the output is to TVs and, consequently, it can't be used for out-of-home ubiquitous services.

MyUI (Mainstreaming Accessibility through Synergistic User Modelling and Adaptability) [7] defines the "multimodal design patterns", a kind of model-based approach. Compositions of single patterns about the devices, personalization, interaction or adaptations are combined to provide a description of the User Interface. Instead of a UIDL, an extension of the UML State Machine Diagram called Abstract Application Interaction Model (AAIM) is used. The main difference with Egoki is the use of patterns instead of composing the UI directly from the information from the user profile and the UIML description.

AALuis (Ambient Assisted Living user interfaces) [8] uses a model-based approach to adapt the UI. Firstly, Concur Task Trees (CTT) [9] is used to provide abstract task definition and interaction. Then, the abstract UI is described using MariaXML [10]. After that, the modality of the UI is chosen using the context models and fuzzy logic. Finally, an HTML5 UI is generated. However, Egoki relies only on UIML [6] for the User Interface description and uses rules for the modality selection.

In contrast with the above-mentioned systems, after generating a UI for a specific service, Egoki allows the user to interact with the service directly through the middleware layer, avoiding any subsequent exchange of information with the adaptation system. The main drawback of this approach is the impossibility of dynamic variations of the UI when the context changes. However, dynamic adaptation is not always recommended because it can be negative in some cases; for instance, people with cognitive impairments could be confused due to changes in the UI or blind people can experience problems due to screen reader's flaws.

2. INREDIS and Egoki

INREDIS (INterfaces for RElations between Environment and people with DISabilities) is a project funded by the Spanish government's INGENIO 2010 initiative, developed from 2007 to 2010. Its objective was to develop basic technologies to allow the communication and interaction between people with some kind of special need and their environment by means of accessible and interoperable technologies. A multidisciplinary consortium composed of thirteen large companies and eighteen research institutions developed the INREDIS Project.

One of its specific objectives was to create Ubiquitous Computing-based intelligent environments to provide accessible services to people with disabilities. The hypothesis was that ATMs, information kiosks, vending machines, etc. could be made accessible if they are used by means of mobile devices, well suited to the characteristics of the users, if they are provided with well adapted UIs. Our contribution to INREDIS was a UI generator devoted to building tailored accessible UIs.

After the conclusion of INREDIS an advanced version of this UI generator, called the Egoki adaptive system, was designed using the experience obtained in the project. The Egoki system is part of a ubiquitous environment that provides the mechanisms necessary for the discovery of services and the communication and interoperation between the diverse devices and the wired and wireless networks. The aim of Egoki is to provide adapted and accessible UIs that are able to interact with the available services through this ubiquitous environment.

Schematically, the architecture of the Egoki system consists of three modules: Knowledge Base (KB), Resource Selector (RS) and Adaptation Engine (AE). In addition, the system requires two inputs to generate the final adapted UI: the abstract description of the service and the available interaction resources. The KB module uses an ontology that models information about user abilities, access device features and UI adaptations. The ontology stores, updates, and maintains the models and, in addition, it provides the necessary rules for reasoning and extracting new information. The RS module implements the mechanisms for selecting the most appropriate resources for the users. It requires an abstract service description as input and the available alternative resources. The AE module is devoted to the final rendering of the interaction resources and the generation of the adapted UI.

3. Design Constraints

Our approach to the automatic generation of UIs for interacting with ubiquitous services requires: (1) a formal specification of the UI; and (2) the specific interaction elements that can be used for each action.

3.1. User Interface Description Language

The formal specification of the UI entails the use of a User Interface Description Language (UIDL) [4] because the description of the service functionality does not provide the semantic information necessary to automatically build the UI. The minimum semantic information needed is: 1) a structure of the elements of the UI; 2) a description of the multimodal interaction resources of the UI; 3) a mapping scheme of the elements of the UI to the resources; 4) a description the behaviour of the UI; and 5) a communication mechanism between the UI and the underlying ubiquitous service.

Figure 1. Automatically generated user interface for a user with cognitive restrictions.

Initially, UIDLs based on the Cameleon framework [11], such as UsiXML [12] and MariaXML [10], were studied. These UIDLs seemed to adequately fulfill the Egoki requirements. However, UIML [6] was eventually selected as the underlying UILD because it was less complex than the others. Moreover, one of its main features was the provision of different resource types for each element of the UI, which was the main requirement for Egoki. This feature allows service designers to match a specific element of the UI to a text, image, video and audio resource. Egoki selects the most suitable type of resource from this set of resources, taking into account the user's capabilities.

In future versions of Egoki, UsiXML and MariaXML will be studied in depth since their development processes and their semantic information can be beneficial for new functionalities.

3.2. Multimodal Interaction Resources

As previously mentioned, a key feature of Egoki is to make an appropriate selection of the resources used to interact with each service. This selection is adapted to the user based on the information contained in diverse models. Nevertheless, if the service provider does not supply suitable interaction resources Egoki cannot create them. Therefore, the ability to produce adequate interfaces depends on the quality and the quantity of multimodal redundant interaction resources provided by the designer of the ubiquitous service. Therefore, service providers are required to provide multimodal interaction resources (alternative text, video, image, audio, etc.) for each function.

4. Discussion

The diverse tests conducted with real users showed that the UIs automatically generated by Egoki are fully functional and accessible [13]. This means that the automatically generated UIs allow the user to use all the functions provided by the application. In addition, users do not find any significant accessibility barriers to interaction with the service. For instance, figure 3 shows an interface automatically generated for a user with cognitive restrictions.

Nevertheless, the usability of the automatically created UI is not optimal. Evidently, UIs specifically designed for each application by experienced designers are more usable and accessible. However, the Egoki approach is still a valid approach because most ubiquitous applications do not provide this kind of high quality, user-adapted, accessible interfaces.

Another important issue is how to decide the layout of the final UI. The position on the screen of visual interaction elements or the sequence of audible elements very much affects the usability of the UI. Since Egoki does not have any knowledge about the semantic content of the interaction elements, their spatial and temporal distribution is based on previously created templates and style sheets. Our experience in marking sections of websites in order to apply *transcoding* techniques suggests a possible solution; to semantically tag the diverse areas of the UI, following a similar approach to WAI-ARIA [14] marking system. This would allow the generator to decide the appropriate arrangement for each type of user.

5. Conclusions

The different issues raised in the design of Egoki can be illustrative to other researchers trying to develop automatic UI creators. Firstly, it is highly recommended to describe service functionalities in terms of UI by means of a UIDL in order to deal with the lack of semantic information provided by service descriptions. In this way, the main elements of a UI can be automatically built satisfying a minimum degree of quality, instead of building a poor UI based only on the input and output data types of the service functionality. In addition, the provision of the different types of interaction resources by the service designer is a key issue. If these resources are not available, it doesn't matter how good the adaptive system is at selecting the most adequate type of resources for a user with disabilities. Finally, manually created UIs provide better usability than automatically built UIs. However, this approach is not always viable, due to the high number of possible variations of the UI when considering different users and devices. Thus, the automatic generation of UIs as appears to be a suitable alternative.

Acknowledgements

This research has been partly funded by the Spanish Ministry of Science and Innovation (ModelAccess project, grant TIN2010-15549). EGOKITUZ is funded by the Department of Education, Universities and Research of the Basque Government (grant IT395-10) and belongs to the Basque Advanced Informatics Laboratory (BAILab) supported by the University of the Basque Country UPV/EHU (grant UFI11/45). Raúl Miñón and Borja Gamecho hold PhD scholarships from the Research Staff Training Programme of the Basque Government.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1310

A Comparison of User Description Languages Concerning Adaptability based on User Preferences

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Abstract. The user interface is the most important feature of interaction between users and (AAL) services. Explicitly defined user interfaces are bound to a specific toolkit and programming language or markup language. Thus a separate user interface definition has to be created manually for different classes of I/O devices to be supported. Compared to manual user interface creation, the automatic or semi-automatic generation of user interfaces based on interaction descriptions considerably reduces the manual effort necessary for integrating a large number of devices and therefore automatically increases the number of supported devices. The main goal of this paper is to provide an overview of selected existing solutions for the definition of generic user interactions and the generation of user interfaces. The comparison shows that the aspect of adaptability is partly covered by the presented User Interaction Description Languages. Nevertheless it is important to analyze them with respect to additional criteria, like accessibility, context- and use-case awareness, to receive a meaningful overview of advantages and drawbacks of the different approaches leading to a good basis for choosing one of the presented approaches.

Keywords. Ambient Assisted Living, Human-Computer Interaction, User Description Languages, Comparison, Adaptability, User Preferences

1. Introduction

The user interface (UI) is the most important feature of interaction between users and (AAL) services. It can be critical to the success or failure of an ICT product or service[2]. In the course of aging the abilities and special needs of older adults change. Many services older people could benefit from lack of accessibility, adoptability, and usability of the user interface and interaction.

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[2]http://www.etsi.org/website/Technologies/UserInterfaces.aspx [Accessed: 04/2013]

Explicitly defined user interfaces are bound to a specific toolkit and programming or markup language. Thus a separate UI definition has to be created manually for different classes of I/O devices to be supported. Compared to manual user interface creation, the automatic or semi-automatic generation of user interfaces based on interaction descriptions considerably reduces the manual effort necessary for integrating a large number of devices and therefore automatically increases the number of supported devices. The major challenge of using such an approach of automatic or semi-automatic user interface generation is the quality of the rendered UIs. Especially when developing services and UIs for older adults who might not be experienced in the use of electronic devices and are likely limited to certain input and output modalities, it is important to provide products that ensure maximum accessibility and usability.

The main goal of this paper is to provide an overview of selected existing solutions for the definition of generic user interactions and the generation of user interfaces – subsumed as User Interaction Description Languages (UIDL). It is inspired by the theoretical survey presented in [1]. The UIDLs are examined and compared to each other, whereas the focus is on adaptability based on the environmental settings. Other important criteria, such as level of abstraction, openness, organizational background, status, number of implementations, and number of supported target platforms, are of importance as well, but neglected in the presented work. The paper is structured in the following way: The introduction and objectives are followed by a description of the methodology in terms of a comparison approach and an overview of UIDLs. Thereafter the results of the comparison are presented, followed by some final conclusions.

2. Methodology: Comparison Approach

We have established a comparison study to analyze UIDLs based on various criteria, whereas adaptability is of uttermost importance to identify their applicability to Ambient Assisted Living environments. The criterion *adaptability* concerns the possibility to adapt user interfaces automatically based on different environmental settings. For AAL environments, the following three characteristics concerning adaptability are important:

- **Accessibility:** The UI should automatically adapt to user preferences based on the user's abilities and disabilities.
- **Use-case awareness:** In different use cases, different I/O devices are used. For example, for activating and deactivating a service, a mobile phone is mostly used because the user can carry it with him or her, while changing the basic setup of a service is carried out using a PC due to the more sophisticated input mechanisms. UIDLs should know about the capabilities of UI devices and automatically adapt UIs to provide different functionalities on different I/O devices as well as to present the UI in the way that is supported best by each type of device.
- **Context-awareness:** Finally, it is desirable to automatically adapt the presentation of a user interface based on environmental influences, for example physical conditions such as the intensity of light around the I/O device.

3. Overview User Interface Description Languages

This section presents 15 existing User Interaction Description Languages. For each of these, some high-level information are given based on available literature and tools as well as a short analysis of their adaptability.

The *Alternate Abstract Interface Markup Language (AAIML)* is part of the first Universal Remote Console (URC) specification [2]. It is a markup language used for defining UI descriptions in an abstract way, based on XML. In practice, an AAIML document contains an AAIML model that describes the UI of exactly one target service that can be controlled from a remote console device. As part of the abstract user interaction description language, classes may be defined that restrict certain interactions to special devices and therefore to certain use-cases.

Presentation Template (PreT) Markup Language is part of the ISO/IEC 24752 standard [3], which is the direct successor of the ANSI/INCITS 389 through 393 standards family. It defines the latest specification of Universal Remote Console (URC). The concrete UI is rendered individually for the UI device's platform at run-time, based on the capabilities of the available services. Thus it supports in theory an unlimited number of I/O devices. It lets the user choose the device as remote console, which is an important step towards accessibility.

The *Extensible Interface Markup Language (XIML)* is a framework for defining abstract UIs and transforming them to concrete ones. In addition, it offers several methods for the automatic adaptation of UIs, based on different criteria. Its main focus is the use case of a generic UI, defined once for an application, which can be executed on a variety of devices, using different platforms [4]. User profiles and preferences can be specified. Personalization is integrated using automatic exchange of UI widgets. The mechanism of automatically generating rules for mapping intermediate presentation elements to concrete UI widgets provides a flexible way to react to contextual settings, device capabilities, use-cases, user preferences, etc.

The *Extensible Interaction Scenario Language (XISL)* was designed with regard to changing Internet usage behavior. It is a language for describing online multi-modal interaction systems, using an XML based syntax. It describes interaction scenarios rather than concrete UIs, thus being applicable to many different interaction modalities. XISL is based on existing open standards such as VoiceXML [5] and SMIL [6], but advances their concepts in a modality-independent approach. It does not provide any framework for automatic adaptation, but extensions can be customized for rendering the UI and adapting it to users' needs or environmental settings.

The *Web Services Description Language (WSDL)* specifies an XML-based language to describe web services based on their functionality [7]. It is used to define the functionality a web service offers and the interactions to access a certain functionality. Although WSDL is often used in combination with SOAP in practice, the language is protocol-independent. It does neither define nor generate an UI.

The *Web Service eXperience Language (WSXL)* was developed to reduce development effort while building web applications for different distribution channels by re-use. Service-based web applications specified using WSXL can easily be adapted to different presentation scenarios. This means that one web application can be accessed in different ways without the need of redevelopment. The adaptability description framework was designed for adaptation to different distribution channels inside the usage context of web services. No built-in support for the automatic adaptation is provided, but it could easily be added by external toolkits.

The *USer Interface eXtensible Markup Language (UsiXML)* is an XML-based markup language that can be used to define UIs in an abstract way, modality independent [8]. Its main goal is to reduce the effort necessary for generating UIs to be used in multiple contexts of use. It addresses mainly designers, in contrast to traditional UI toolkits that are often integrated into programming frameworks aiming at developers. So, full adaptability of UI is supported.

User Interface Markup Language (UIML) is a meta-language, not specifying concrete UI elements on its own, but providing a framework for the definition of custom vocabularies that can then be used to create generic UI descriptions. The development of UIML was inspired by the generic concept of HTML, which provided one markup language that could be rendered on several platforms [9]. Based on this, UIML's main goal is helping UI developers in creating UIs that are sufficiently generic to be used on different platforms, thus significantly reducing the effort in developing multi-platform UIs. UIs defined using UIML are either automatically transformed to different target languages, or interpreted and rendered on target devices in real-time.

The *Dialog and Interface Specification Language (DISL)* [10] is an extended subset of the UIML language specification. It provides a modeling language for specifying dialog models in an abstract way that can be used to generate UIs for multiple modalities and platforms. The language is designed to support switching between end devices on the fly. Adaptability is a built-in core component.

Model-based lAnguage foR Interactive Applications XML (MARIA XML) [11] mainly focuses on the definition of UIs used to access web service functionalities. The language follows a semi-automatic approach for generation of UIs: Basic final UIs are generated automatically from abstract UI descriptions, but developers are given the possibility to refine these concrete interfaces. This concept allows human intervention, but reduces manual effort. The mechanism of migratory UI implements an automatic adaptation based on contexts of use.

The *eXtensible Application Markup Language (XAML)*[3] is a declarative markup language based on XML developed by Microsoft. While XAML was created as general markup language for the initialization of structured objects, its main use is the specification of UIs as part of the Windows Presentation Foundation (WPF) and the definition of UIs for web applications that build upon the Microsoft Silverlight framework. It does not provide mechanisms to store users' preferences and to react to environmental factors.

The *XML User interface Language (XUL)* is based on XML and not compiled but interpreted at run-time by a special rendering engine. Its main use is the definition of UIs for applications developed by the Mozilla community, although also some additional projects make use of it. Adaptation could be integrated using the flexible CSS styling system. XUL UI automatically adapt to different hardware capabilities such as screen resolution, but limited to simple dynamic resizing and positioning of widgets.

The *Macromedia eXtensible Markup Language (MXML)* is a declarative markup language based on XML originally developed by Macromedia, now used by Adobe as part of the Flash product series. The main use of MXML is the specification of UIs of Adobe Flex applications. The compiled applications (SWF) can be run as web applets

[3]http://msdn.microsoft.com/en-us/library/ms747122.aspx [Accessed: 04/2013]

embedded in any web page, or as standalone applications. Through the use of layout managers, MXML UI automatically adapt to different screen resolutions by re-positioning UI elements. The display of different UI on different devices however is not supported.

VoiceXML is an XML-based markup language used to specify user interaction with speech-based systems. It was designed with a similar goal as HTML: HTML is used to specify visual web pages, while VoiceXML allows the specification of audible web content, featuring both one-way presentations and interactions. No support for adaptability is provided since the language focuses on speech-based interfaces that are presented in the course of one telephone call using exactly one device.

The *HyperText Markup Language (HTML)* is the markup language used for the specification of web pages. Version 4 [12] is the first version that separates semantics and appearance. The analysis also applies to the *eXtensible Hypertext Markup Language (XHTML)* [13]. HTML is based on the Standard Generalized Markup Language (SGML), while XHTML is based on XML. XML actually is a subset of SGML that adds additional restrictions to the base language [14]. No automatic adaptation support is provided, whereas CSS supports multiple media types by enabling styling the control elements differently for different devices or hiding of some elements for certain devices.

Table 1. Comparison of all analyzed User Interaction Description Languages regarding adaptability.

	Accessibility	Context-awareness	Use-case awareness
AAIML	unknown	unknown	yes
PreT	medium	no	no
XIML	yes	yes	yes
XISL	no	no	no
WSDL	N/A	N/A	N/A
WSXL	no	no	no
UsiXML	yes	yes	yes
UIML	prepared	prepared	prepared
DISL	no	yes	yes
MARIA XML	prepared	through migrational UI approach	prepared
XAML	no	no	N/A
XUL	no	partly	no
MXML	no	no	no
VoiceXML	no	no	N/A
HTML/XHTML	through browser	no	through CSS

4. Results

In Table 1 the results of the comparison regarding adaptability of all analyzed UIDLs are presented. As shown the characteristics are in a wide range and just some UIDLs are covering these important aspects (XIML, UsiXML). DISL lacks on accessibility support, but provided context- and use case-awareness. The solutions studied differ strongly concerning their field of application. To form a complete user interface generation system for AAL environments, several of these solutions need to be combined since all operate on a different degree of abstraction.

5. Conclusion

The comparison and the results presented in Section 4 show that the aspect of adaptability is partly covered by the UIDLs. Nevertheless it is important to analyze them with respect to additional criteria, like accessibility, context- and use-case awareness, to receive a meaningful overview of advantages and drawbacks of the different approaches. These characteristics are chosen due to their importance and relevance in the design of user interfaces and interaction for users with special needs to access (AAL) services. The project AALuis[4] uses for example Maria XML.

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[4]The project AALuis (www.aaluis.eu) is co-funded by the AAL Joint Programme (AAL-2010-3-070) and the following National Authorities and R&D programs in Austria, Germany and The Netherlands: bmvit, program benefit, FFG (AT), BMBF (DE) and ZonMw (NL).

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Special Session on Standardization within the Assistive Technology Field

Special Session on Standardization within the Assistive Technology Field

This Special Session will comprise contributions covering several aspects about the present development within standardization in the area of Assistive Technology. It will include the emerging grey zone in between traditional assistive products and consumer technology, new areas like cognition and accessible design, consumer participation in standardization, regional cooperation in Asia and special aspects related to Low and Middle Income countries and transfer of technologies. The European Standardization package will be described, as well as the motives and the purposes.

A report on disability from WHO (*World report on disability, WHO 2011*) states that more than one billion people in the world live with some form of disability, of whom nearly 200 million experience considerable difficulties in functioning. Assistive products can mean a difference to all these people.

There is a wide variety of assistive products/systems, many of which are technically advanced and of significant economic value. Some of the larger product categories in the market are wheelchairs, beds, assistive products for walking, hoists and aids for incontinence and ostomy. Growth sectors are primarily products based on information and communication technologies such as computer accessories, telecommunications equipment, special software and products for controlling and signaling.

New areas are being added recently such as cognitive aspects in existing standards and there is a growing concern that also assistive products with the aim to compensate for cognitive disabilities should be covered. Other areas which are included are products for personal hygiene and accessible design.

Consumers/users of assistive products are usually persons with a disability and/or older persons.

The major benefits expected of the standards developed are:

- criteria for manufacturers against which to design products;
- decreased production costs for assistive products;
- safe, reliable and functional products produced for purchasers and users;
- increased quality of life for users;
- improved cost effectiveness for purchasers, both private and public;
- enhanced compatibility between products;
- standards in new emerging areas such as accessibility and cognitive devices;
- common testing methods leading to comparable, reliable test results, such as the methods developed and standardized for testing electrical and manual wheelchairs.

Considering the trend toward independent living and the increase in the proportion of elderly people in the population the market of assistive products is expected to increase.

The market for assistive products is global. The technology used is often identical or similar – at least in the industrialized parts of the world. The need for standardization often coincides, and the competence/experts needed for standardization work can be found throughout the world. A close co-operation is established between the European and the International standardization bodies in the field of assistive products for persons with disability.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1321

Consumer Participation in Standardisation: A Case Study of Involvement in the Development of ISO 23599: 2012 'Assistive Products for Blind and Vision-Impaired Persons – Tactile Walking Surface Indicators'

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Abstract. Consumer participation in standardisation A case study of involvement in the development of ISO 23599: 2012 'Assistive products for blind and vision-impaired persons – Tactile walking surface indicators' The author, Carol Thomas, Director of Access Design Solutions UK, represented ANEC on ISO TC 173 Assistive products for Disabled People Working Group 8 to develop ISO 23559: 2012 Tactile Walking Surface Indicators. ANEC, the European consumer voice in standardisation, defends consumer interests in the process of standardisation and certification. This means we represent the European consumer interest in the creation of technical standards, especially those developed to support the implementation of European laws and public policies. ANEC also gets involved in the development of International Standards. Although the consumer lead in ISO (International Office on Standardisation) is taken by Consumers International (CI), ANEC provides expertise to CI through a Memorandum of Understanding as well as participating directly in some ISO and IEC technical bodies where CI is not active. The Challenge for ANEC: Despite its importance in representing the consumer interest, ANEC is not permitted a central role in the European Standardisation System. ANEC has observer status on CEN and CENELEC; and on International Standards. Nonetheless, ANEC has had considerable success in influencing European and International Standards attributed to the knowledge and commitment of its experts, the professionalism of its Secretariat, and the quality of its arguments. This paper will consider how ANEC influenced the development of ISO 23599 and the factors which contributed to achieving influence on behalf of consumers. The Challenges for development of ISO 23599: This International Standard took over 10 years to be completed. Around 1990, the first working group (WG 6) on the standardization of TWSIs was established under ISO/TC 173. However, the work was cancelled and restarted twice because consensus could not be reached within the ISO time limit. In 2010 a new Working Group was set up and ANEC joined as an observer. In March 2012, ISO 23599 was finally completed by ISO/TC 173, working group WG 8, Tactile walking surface indicators, under the chairmanship of Dr. Shigeru Yamauchi of Japan, with a secretariat of Dr. Seiji Mitani and Hidekatsu Aoki, also of Japan. The paper will consider why this standard took so long to be developed; what enabled completion by the Working Group set up from 2010 to 2012; and the contribution made by ANEC. Conclusion: The paper will conclude with a summary of the contribution ANEC can, and should, make on behalf of consumers; how ANEC maximises influence on the development of standards despite the

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challenge of only having observer status; and what developments would enable ANEC to play a clearer role in representing the interests of consumers in standardisation.

Keywords. Accessibility, consumer participation, design for all, disabled people, ISO 23599, standards, tactile walking surface indicators, TWSI, vision impaired persons.

Introduction

The World Health Organization has reported that the world now has 285 million people with visual impairments, 39 million of whom are totally blind, and 246 million of whom have low vision. [2] The International Standard ISO 23599:2012, *Assistive products for blind and vision-impaired persons – Tactile walking surface indicators*, will contribute to high quality and consistency in the use of tactile walking surface indicators which provide wayfinding and safety information for visually impaired people.

This International Standard took over ten years to be completed. The author of this paper, Carol Thomas, Director of Access Design Solutions UK, represented ANEC, the European Consumer Voice in Standardisation, as an observer on the final Working Group which completed this Standard in 2012. What were the challenges that had to be overcome to complete this Standard after ten years, and what were the challenges for ANEC to participate in the development of this Standard?

1. The Challenge for ANEC

Despite its important role in representing the European consumer interest in the creation of technical standards, especially those developed to support the implementation of European laws and public policies, ANEC does not have a central role in the European or International Standardisation System.

The three European Standards Organisations - CEN, the European Committee for Standardisation; CENELEC, the European Committee for Electrotechnical Standardisation; and ETSI, the European Telecommunications Standards Institute are mandated by the European Commission to develop the standards that provide the technical requirements needed by manufacturers to meet the law. ANEC has observer status on CEN and CENELEC, and although a full member of ETSI, ANEC is not considered to have the same influence in ETSI as a multinational company.

The standards development process in CEN & CENELEC is founded on delegations from national members, so ANEC strategy is to work closely with the national delegations particularly through their consumer bodies. ANEC also gets involved in the development of International Standards. Although the consumer lead in ISO (International Office on Standardisation) is taken by Consumers International (CI), ANEC provides expertise to CI through a Memorandum of Understanding as well as participating directly in some ISO technical bodies where CI is not active, as was the case in the development of ISO 23599. The challenge for ANEC is therefore participating, and influencing the development on behalf of consumers, while an observer alongside member delegations with a vote.

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[2] World Health Organization: *Visual impairment and blindness* Fact Sheet N°282 June 2012

2. The Challenges for the Development of ISO23599

Around 1990, the first working group (WG 6) on the standardization of Tactile Walking Surface Indicators (TWSIs) was established under ISO/TC 173. However, the work was cancelled and restarted twice because consensus could not be reached within the ISO time limit. In 2010 a new Working Group was set up and ANEC joined as an observer. In March 2012, ISO 23599 was finally completed by ISO/TC 173, working group WG 8, under the chairmanship of Dr. Shigeru Yamauchi of Japan, with a secretariat of Dr. Seiji Mitani and Hidekatsu Aoki, also of Japan.

The lengthy development period for this Standard occurred largely because, both before and during the Standard's development, the use of TWSIs was becoming increasingly widespread and varied, research was taking place in many countries, and divergent national standards were being developed. While a universal standard on tactile walking surface indicators would be of immense benefit to people who are blind or have low vision, enabling confidence in the provision, use and meaning when travelling to areas around the world, obtaining a consensus view on the precise detailed content of such a standard proved impossible.

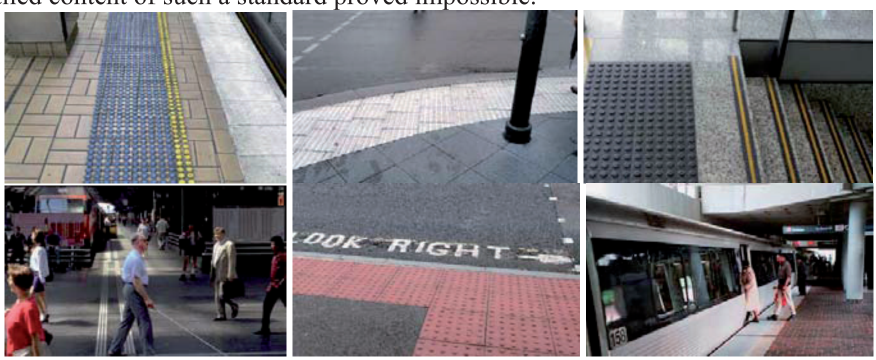

Figure 1. Examples of TWSIs: From top (L-R) Australia, Germany, Hong Kong, Switzerland, UK, U.S.A.

The images above are taken from an article in ISO Focus[3] which was prepared by Dr. Seiji Mitani and Hidekatsu Aoki, Secretariat of ISO technical committee ISO/TC 173, WG8, with the assistance of Working Group Members. They illustrate the range and varied nature of TWSIs in different countries where there is established practice and understanding of those surfaces amongst users. Agreement on one detailed standard which would reflect these and other examples could not be reached.

The installation of TWSIs is relatively expensive, and development of a standard that required the retrofit of TWSIs became an impractical goal. If visually impaired pedestrians have become used to particular types of installations in an area or country where they live, changing them would lead to confusion and loss of confidence in the tactile surfaces system.

Nonetheless, development of a standard based on the consolidated findings of science, technology and experience remained desirable to encourage consistency in new installations of TWSIs, particularly in areas that do not have TWSIs or do not yet

[1] [3] ISO *Focus*+ **Volume 3, No. 7** (2012), 28- 31.

have widespread installations of TWSIs, and to increase quality of the products. The World Health Organisation says that about 90% of the world's visually impaired people live in developing countries. It was therefore important to provide a standard that promotes good practice when tactile surfaces are implemented in developing countries.

3. Reaching a Consensus on ISO23599

In order to reach a consensus it was decided to acknowledge that we were not starting with a clean slate so a Standard would need to enable countries where the use of TWSIs is already established to retain their current systems.

The scope of the Standard says that "it is not intended to replace requirements and recommendations contained in…national standards, regulations and guidelines" based on the findings of science, technology and experience. However, "national design standards should provide for high-quality products and consistent TWSI systems within a country."

The Standard evolved into one based on underlying principles. These include:

- TWSIs should not be a substitute for poor design.
- The design and installation of TWSIs shall take into consideration the needs of people with mobility impairments. (This is important because, while of immense benefit for the mobility of visually impaired people, tactile surfaces can cause difficulties for people with mobility impairments so need to be correctly implemented)

- TWSIs shall:
  - be easily detectable from the surrounding or adjacent surface by raised tactile profiles (detectable through the soles of shoes and by a long white cane) and visual contrast;
  - maintain detectability throughout their lives;
  - be used in a logical and sequential manner;
  - be of sufficient depth in the direction of travel to provide adequate detectability and appropriate response by the users, such as stopping and turning.

Technical standards include the shape, dimensions, arrangements and spacing of texture elements for TWSIs that have been demonstrated to promote accurate detection and identification both under foot and by the use of the long white cane. There is also a technical standard for luminance contrast, assuring that TWSIs will be maximally visible to people with low vision. There remains choice within the technical standards to give flexibility considering different national circumstances. However, it is strongly recommended that any choices adopted by a country be applied consistently throughout that country.

Compromises include the listing of minimum requirements (below that accepted in some countries) and noted justification for higher requirements. We all know that minimum soon becomes the norm, but need to remember that the lower requirements are linked to the different way tactile surfaces are used in some countries. For example the minimum width of 250mm for a guidance surface was pushed for by Japan where continuous guidance is provided on most footways, even narrow ones where a greater width would not fit. In countries such as the UK where guidance paths are more likely to be provided in wider expanses of the public realm so need to be located and followed by visually impaired people this width would not be considered sufficient. Thus it is vital that minimum requirements are not plucked from this International Standard in isolation.

An Informative Annex provides detailed examples of TWSIs in different situations, as used in some countries, including at pedestrian crossings, at-grade kerbs, railway platforms, stairs, ramps, escalators, lifts (elevators) and revolving doors. There are some examples here which do not sit comfortably for some ANEC members such as the use of tactile surface at ramps - used in very few countries so a compromise with those that do, with a note of the concerns about the impact on people with mobility impairments using the ramp; and the example showing TWSI at the very edge of a rail platform, not acceptable in most countries but used in some. However these are examples not requirements.

4. The Role of ANEC

ANEC joined WG8 in 2010 at a time when WG members, some of whom had been involved in previous attempts to develop this Standard, had reached the view that compromises needed to be made if a Standard was to be agreed. ANEC was able to contribute to this. As ANEC membership includes representatives from many countries across Europe we were able to seek and input to the WG a range of views from consumer, disability and standards organizations within and outside Europe. I was one of two representatives of ANEC on the WG, both from the UK with experience on the UK tactile surface position at disability and access organisation, British Standards Institute, and government levels. We set this UK perspective aside in putting forward ANEC agreed positions. We were also able to communicate with consumer bodies involved in and able to influence their national standards bodies when compiling detailed comments on drafts and voting.

5. Conclusion

ISO 23599 has not been adopted as a European Standard and is unlikely to be adopted in countries where there is already extensive use and experience of tactile surfaces. However it is intended to ensure that best practice is followed by countries that do not have TWSIs or do not yet have widespread installations of TWSIs. Travellers who are visually impaired can then have reasonable confidence in the consistent presence, type and meaning of TWSIs as they travel from one country to another.

Based on the consolidated findings of science, technology and experience in various countries, ISO 23599 aims to specify the most detectable and recognizable shapes, dimensions and luminance of TWSIs. It also aims to specify best practice in installation to assure wayfinding and safety of users who are blind or who have low vision. In addition the comfort and safety of people with mobility impairments are considered.

ANEC is pleased to have contributed to the development of ISO 23599 and hope that this Standard will contribute to the consistent use of tactile walking surface indicators and, in so doing, enable the safe and secure travel of people with visual impairments around the world. With only observer status, participation in some European and International Standards Development does not go as well as this. Improved recognition of the role of ANEC and the value of ANEC participation to champion the interests of consumers would, we believe, be of wide benefit for the development and use of standards.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1327

Japanese Activities on International Standardization of Assistive Products

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Abstract. This paper describes Japanese activities on international standardization of assistive products. Accessible design and Asian cooperation are the main focus. These two activities represent Japanese strategy of assistive technology space; universal design products and orphan products. It is implied that the accessible design standardization activities promote the market size of universal design products in Japan. Asian cooperation activities might improve potential Asian market of orphan products.

Keywords. Accessible design, Asian cooperation, ISO

Introduction

Japanese population aging rate is 23.7% (April 1st, 2012) and the highest in the world. In addition, 11.8% of the population is over 75 years old. So, many people have difficulties in functioning of daily lives and usage of consumer products. It means that the Japanese society has a lot of needs for building more accessible environments and products for older persons and persons with disabilities. The United Nations General Assembly adopted "Convention on the Rights of Persons with Disabilities" on December 13th, 2006. Japan has already signed, but not ratified. Japanese government is preparing for ratification of this convention; e.g. revision of the Basic Act for Persons with Disabilities, publication of guideline according to the Barrier-free New Law and other activities. The Ministry of Economy, Trade and Industry recognizes importance of standardization of assistive products in order to propose solutions for these problems.

On the other hand, assistive products have been still expanding. Information communication technologies and robotic technologies, that are making rapid progress, are getting more important to assist lives of persons with disabilities. Scope of assistive products is also changing from specific products to general consumer products based on the concepts of universal design / design for all. It also caused expansion in the range of assistive products.

Definition of assistive products already includes universal design / design for all product[1)] as follows,

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- Any product (including devices, equipment, instruments and software), especially produced or generally available, used by or for persons with disability
  - for participation;
  - to protect, support, train, measure or substitute for body functions/structures and activities; or
  - to prevent impairments, activity limitations or participation restrictions

  (ISO 9999:2011 Assistive products for persons with disability – Classification and terminology)

Therefore, we need to take into account these concepts into standardization on assistive products.

In this paper, we describe Japanese contribution to the international standardization of assistive products. Japanese activities currently focus on two kinds of strategies. One is accessible design that defined in ISO/IEC Guide 71. Second one is Asian regional cooperation among China, Korea and Japan. These two strategies show a solution of complicated assistive product space.

1. Accessible Design

ISO and IEC published Guide71 "Guidelines for developers to address the needs of older persons and persons with disability" in 2001. This guide was discussed at the adhoc JTAG (Joint Technical Advisory Group) in ISO/COPOLCO (ISO's Committee on Consumer Policy) . Makoto Kikuchi of Japan was a convener of this JTAG and Japan was a secretary of this JTAG. "Accessible design" is defined in the Guide 71 as "Design focused on principles of extending standard design to people with some type of performance limitation to maximize the number of potential customers who can readily use a product, building or service."[2)]

After publication of the Guide71, Japan took lead to develop international standards related to accessible design in conjunction with China and Korea. These three countries submitted 5 proposals to TC159 (Ergonomics) and TC122 (Packaging) in 2007 and all were adopted. According to it, two working groups were established as follows,

TC159/SC4/WG10 "Accessible design for consumer products"
TC159/SC5/WG5 "Physical environments for people with special requirements"
TC122/WG9 "Accessible Design for Packaging"

5 international standards were so far published from these three working groups as follows,

ISO 24503:2010 Guidelines for all people including elderly and people with disabilities – Tactile dots and bars on consumer products
ISO 24500:2010 Ergonomics – Accessible design – Auditory signals for consumer products
ISO 24501:2010 Ergonomics – Accessible design – Sound pressure levels of auditory signals for consumer products
ISO 11156:2011 Packaging – Accessible design – General requirements

ISO 24502:2010 Ergonomics – Accessible design – Specification of age-related luminance contrast for coloured light

Furthermore, there are 4 more on-going works as follows,

ISO/DIS 24504 Ergonomics – Accessible design – Sound pressure levels of spoken announcements for products and public address systems
ISO/CD 17630 Ergonomics – Accessible design – Colour combination for younger and older people
ISO/NP 18088 Guidelines for designing tactile symbols and letters
ISO/NP 18087 Ergonomics – Accessible Design – Minimum legible font size for people at any age

In addition to them, "Advisory group for accessible design" was also established under the TC159 in 2007 based on Japanese proposal. The following four core tasks are assigned to this group.

1. Coordination in TC159
2. Collaboration and harmonization with TCs in ISO
3. Liaison with Disability Organizations (IDA) and the elderly organizations
4. Strategy development for AD-related standards

These strategic approaches promote dissemination of accessible design concept to the world and improve activity and participation of persons with disabilities.

In 2011, two working groups under the TC173/SC7(Assistive products for persons with disability/Accessible design) were established based on Japanese proposals as follows,

TC173/SC7/WG1 "Accessible design for tactile information"
TC173/SC7/WG2 "Accessible meeting"

In addition to them, there are 4 more projects planning in Japan.

In 2010, ISO/TMB decided establishment of a working group for revision of Guide 71. Chair of this working group is Masahiro Miyazaki of Japan. Japan is also contributing to revision of Guide 71.

2. Asian Cooperation

Asian countries including Japan have been discussing deference of body weight and height between western people and Asian people when we think about international standards of assistive products. Based on its back ground, China, Korea and Japan established "China-Japan-Korea Standardization Meeting for Assistive Products (CJK-SMAP)" according to discussions at the 10th Northeast Asia Standards Cooperation Forum in 2010. Chair of this meeting is Hyun Kyoon Lim of Korea. Each country registered a representative and a secretariat. The objective of this meeting is to promote making new item proposals for ISO with taking into account Asian specific situation, e.g. body weight, body height, life-style and so on.

The CJK-SMAP currently has four working groups as follows,
WG1: Reclining and tilting wheelchairs (Principal member body: Japan)
WG2: Postural change devices (Principal member body: Korea)

WG3: Handrails and grab bars (Principal member body: China)
WG4: Walking trolleys (Principal member body: Japan)

Each WG is developing working draft for new work item proposals (NWIP) to ISO and also trying to harmonize the draft with the national standard of each country.

Reclining and tilting wheelchairs are widely used in Korea, China and Japan. However, there is no ISO standard of this kind of wheelchair. Most of the current draft is modification from the ISO standard about wheelchairs but the tilting and reclining position for each test, test dummy and test cycle and load have been discussed.

Postural change devices are covered by Japanese long term care insurance. However, there is no working group in ISO/TC173. CJK-SMAP defined the term "Postural change devices" and methods of some mechanical tests.

Handrails and grab bars are also covered by the Japanese long term care insurance but there is no ISO standard about them other than handrails in bath room that are being discussed in ISO/TC173/WG9 "Assistive products for personal hygiene". CJK-SMAP is working on three drafts focusing on "Removable grab rails and handgrips", " Fixed grab bars and handgrips" and " Hinged rails and supports".

Walking trolleys are widely used in Korea and Japan. They have less body weight support function than rollators and have storage for shopping. CJK-SMAP defined the term "Walking trolleys" and is discussing definition and scope.

Table 1 shows past meetings from 2010 to 2013.

3. Discussions

In this paper, Japanese main two activities of contributions to international standardization are described. These two activities indicate Japanese strategy about assistive products. Key words are universal design products and orphan products. These two kinds of products are opposite concept each other and consist whole concept of assistive products.

Figure 1 shows the market size of universal design products (Kyoyohin) in Japan[3]. The market size was increasing from 1995 to 2000, and few change from 2000 to 2002. After 2003, it was increasing, again. Based on comparison between Figure 1 and standardization process of accessible design, it was implied that the standardization strategy improve new market of the universal design products.

Table 1: Past meeting of CJK-SMAP.

No.	Term	Place
1st meeting	November 2010	Busan, Korea
2nd meeting	March 2011	Seoul, Korea
3rd meeting	August 2011	Kobe, Japan
4th meeting	February 2012	Beijing, China
5th meeting	September 2012	Seoul, Korea
6th meeting	January 2013	Kobe, Japan

This consideration suggested good relationship between standardization and market.

Figure 2 shows the market size of the narrowly-defined assistive products (orphan products) in Japan. It remains mostly level from 2000. This trend means saturation of the market. CJK cooperation might solve these situation because there will be possibility to expand the market to Asian country. And, since Asian population is very large, Asian country should make more contribution to the international standardization for developing suitable products on Asian people.

The “reasonable accommodation” proclaimed in UN Convention on the Rights of Persons with Disabilities is effecting on Japanese society and also all over the world. Accessible design concepts fit on it, and must be expanding. In order to do it, international standardization plays important roles.

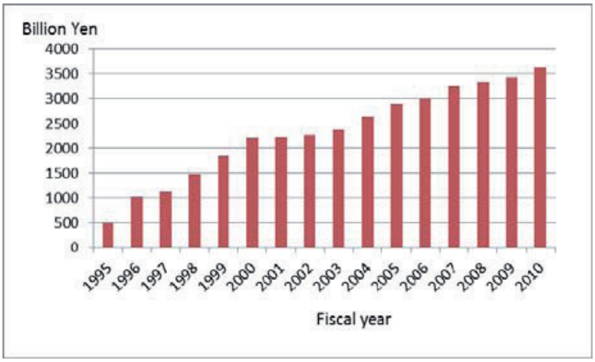

Figure 1: Market size of universal design products in Japan.

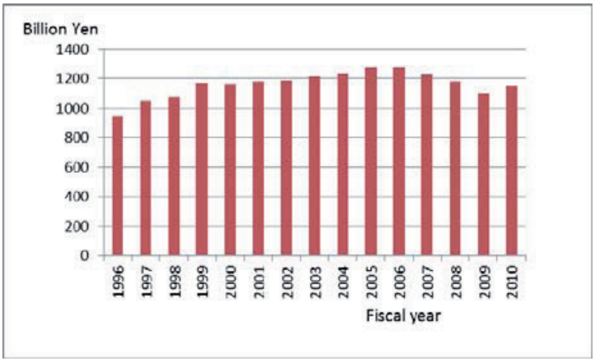

Figure 2: Market size of narrowly-defined assistive products in Japan.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1332

The Relationship between Cognitive Impairment and Assistive Technology: Implications for Effective Aid Use

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Abstract: Assistive technology for cognition (ATC) can compensate for cognitive impairments, thereby having a large potential to improve independence, daily-life/work participation and overall quality of life. The aim of this paper is to incorporate research findings, experiences from clinical work, and findings from ATC-projects, and to give an account of factors that predict effective use of compensatory technological aids in cognitively impaired individuals. The implications of these factors for future standardization initiatives in the field of ATC are discussed, and suggestions on how to develop assessment and implementation guidelines are proposed.

Keywords: Assistive technology for cognition, ATC, Cognitive impairment, Neuropsychological assessment, Standardization.

Introduction

There is an increasing number of technological aids available that may improve the ability to plan, organize and keep track of work-related and daily activities. A search for “organizer” in Apple app store yields almost 5000 hits, demonstrating the vast amount of potentially helpful aids commercially available. Most people use technological aids in their daily activities, such as keeping notes or creating reminders on their mobile phones. These simple aids, together with more sophisticated assistive technology for cognition (ATC), may be of particular help to individuals with cognitive impairments such as deficits in the ability to concentrate, think, comprehend, remember, plan and evaluate actions [1]. Advances in health care increases life expectancy and survival-rate after brain injury, subsequently leading to an increased overall prevalence of cognitive impairment. For instance, a national program for rapid identification and treatment of stroke has reduced Norwegian mortality rates [2], hence increasing the number of survivors with cognitive disability after brain injury. The rapid advances in technology and increasing call for ATC, points to a need for product-specific standardization and standardized guidelines on how to assess impairment and functional needs, how to merge person and technology (i.e. what works for whom), how to introduce and teach appropriate aid-use, and how to manage requirements for

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follow-up and support. The aim of this paper is to highlight factors that predict effective aid use and that should be addressed in future standardization initiatives.

1. The Implications of Cognitive Dysfunction in the Assessment, Selection and Use of Assistive Technology

1.1 Assessment

Cognitive impairment is a result of injury or disease that damages and/or alters the function of the brain, and is therefore a common feature of several patient populations, including acquired and congenital brain injury. Each year more than 15 000 Norwegians are hospitalized as a consequence of stroke [3], and one out of every 500 inhabitants are hospitalized annually due to traumatic brain injury [4,5,6]. Approximately 3-5 % of the population have attention deficit hyperactivity disorder (ADHD) [7]. These are only some of the illnesses and conditions that are associated with cognitive impairment, e.g. impairments of memory, time management, planning and lack of self-initiation. Assistive technology for cognition (ATC) can help individuals compensate for cognitive impairment, thereby having a large potential to improve daily-life and work participation, independence and overall quality of life. Empirical research and theoretical conceptualizations suggest a number of factors that predict the effective use of compensatory technological aids.

Evans [8] emphasizes the importance of age, severity of impairment and previous use of compensatory aids. Young people seem better able to compensate for cognitive deficits, whereas individuals with major deficits compensate less well. Moreover, previous familiarity with compensatory aids predicts more efficient use following brain injury. Wilson [1] suggests additional variables that are likely to influence aid use, namely insight and motivation, support from family members/work colleagues and absence/presence of sensory, motor and/or psychiatric disability. These findings illustrate the need for an exhaustive understanding of the ATC user and his or her prerequisites, if effective aid use is to be obtained. This information may be gathered through medical journals, from spouses, family and caregivers, and by systematic clinical assessment.

Experience from clinical work with persons with cognitive impairments underlines the importance of systematic assessment. At the Department of Vocational Rehabilitation – Brain Injury, Norwegian Labor and Welfare Administration, five separate procedures lead to the assessment of an individual’s cognitive impairment. First, medical journals are reviewed by a multidisciplinary team consisting of psychologists, occupational therapists and educational therapists. A comprehensive neuropsychological examination is then carried out. Neuropsychological assessment offers a means of acquiring detailed knowledge about the aid users’ cognitive profile, including preserved cognitive abilities and impairment severity across cognitive domains such as sensory-motor processing, attention, memory, language, visual-spatial processing and executive functions. A psychiatric evaluation is completed as part of the assessment, along with an estimation of the level of insight. Having established the cognitive profile, occupational or educational therapists then evaluate the individual’s performance in a simulated work environment in order to gain ecologically valid information about level of functioning. The information gathered trough the previous steps are then synthesized, and if needed, additional information is obtained. Finally, a comprehensive report is written, consisting of a thorough description of preserved cognitive abilities, cognitive impairments, feasible compensatory strategies, environmental adaption requirements, and suggestions with regard to ATC that could prove helpful to the individual. Perhaps most importantly, in light of the purpose of this paper, a description of how the cognitive profile may influence ATC skill acquisition is specified and possible pitfalls which may hamper effective aid use is addressed. In our experience, those who need ATC the most may have the greatest difficulty learning how to use them and therefore require extensive training and follow-up to be able to utilize the aid. For instance, an individual who is easily distracted due to attention difficulties may benefit from time management aids. However, learning how to use these aids may be hampered by the inherent attention difficulties, thereby requiring additional pedagogical interventions such as frequent repetitions and prompting, learning one aspect of ATC-use at a time and "overlearning" beyond the point of initial mastery so that skills become automatized. Moreover, in addition to aid use, environmental adaptations, such as elimination of possible distractors (e.g. noise, providing seating away from windows), could prove equally important for overall level of functioning.

A standardization of ATC implementation must take into account the complex interaction between cognitive impairment, potential for aid use, how the impairment affects aid skill-acquisition and required compensatory measures other than technological aids. One way of ensuring that this complexity is addressed in ATC provision is by developing guidelines emphasizing the importance of a comprehensive methodical assessment, and providing suggestions of questionnaires, structured interviews, checklists, observational procedures and assessment techniques that can prove informative. This way the integral needs of the individual can be fully comprehended.

1.2 ATC Implementation and Skill Acquisition

Studies have illustrated the importance of a systematic and structured training programme in ATC implementation [1]. Sohlberg [9] has conceptualized distinct phases of ATC implementation with explicit key objectives in each phase:

- Acquisition phase: establishing motivation ("How can ATC be of help to me?" "Do I see myself using it?") and mastery of basic ATC skills ("How is the aid used?")
- Mastery and generalization phase: Strengthen skills, increase user independence and expand aid use in various contexts. Evaluate and overcome difficulties.
- Maintenance phase: Scheduling follow-ups on a regular basis. Revise aid use and adapt to changing circumstances if needed.

Each ATC implementation phase requires training plans, support and follow-up carefully tailored to the user's individual cognitive profile and needs. For example, skill acquisition may be hampered due to memory impairments, which may imply a prolonged acquisition phase. In contrast, difficulties with self-initiation may disrupt the ability to execute independent aid use (mastery and generalization phase), even though mastery of basic skills has been achieved in the acquisition phase [9].

Findings from projects at the Department of Vocational Rehabilitation involving ATC utilization trials, e.g. "Smart phones as facilitators of vocational mastery" [10] and "Mobile phones as cognitive aids in ADHD or Asperger Syndrome" [11], are in accordance with the above suggestions, highlighting the importance of adequate and appropriate individualized training to ensure that the cognitive aid is used in a purposeful and effective manner. In the most recent project, eight students with ADHD or Asperger Syndrome were followed over a two-year period. They were provided with an ordinary smart phone that would function as a "cognitive assistant" in their daily lives. As part of the aid acquisition and mastery phase, each student took part in monthly two and a half-hour workshops together with three fellow students and two supervisors. Only two of the students were using personal organizers/daily planners at project startup, and all of them were reporting significant daily stress in relation to remembering appointments and prioritizing activities. At the end of the study, all students were using smart phones as daily organizers. One of the project's aims was to assess whether using a smart phone as a cognitive aid could reduce daily stress-related issues (e.g. loss of control, missing appointments or social difficulties). All of the students reported that the smart phone significantly reduced feelings of stress and increased feelings of control. Each student experienced that their smart phone had become an important part of their daily routine. However, perhaps the most important lesson learned from the project, was that it took a considerable amount of time, practice and extensive follow up before the students developed these routines. Paradoxically, some of the students reported increased feelings of stress and frustration associated with smart phone use in the second semester, as a consequence of being insecure about learning new technology, managing software updates, synchronizing their smart phone and computer and so on. To be able to employ the aid efficiently, it proved necessary to radically change daily habits, which required a considerable amount of time, effort and practice.

The findings from this project are in line with research underscoring the importance of systematic and extensive training to change current behavioral patterns and to generalize aid use to various contexts [1]. The project also illustrates the need to understand how motivational issues influence aid use. Models of health behavior change, such as the Transtheoretical model [12], can provide a framework for understanding how self-efficacy and motivation will influence ATC skill acquisition and mastery over time when assessing an individual's readiness to act on new behaviors.

2. The Need for Standardization of ATC Assessment and Implementation Procedures

Development of standardized guidelines will facilitate a systematic approach to the issues outlined above, increasing the likelihood of successful and functional aid use, which in turn may increase vocational participation, psychosocial functioning and overall quality of life. The challenge of developing a standard for the implementation of ATC is that the implementation process nevertheless must be tailored to individual factors (i.e. cognitive profile, motivation, expectations, level of insight, and previous experience with aids). Guidelines must be well-defined, but flexible enough to accommodate heterogeneity and individual variation. Thus, the goal of standardization work should be to develop a set of guidelines that ensure adequate assessment of the individual, that the appropriate aid is provided, and that the person is introduced to the aid in such a way as to maximize the possibility of effective use over time and across contexts.

2.1 Suggestions on How Current Theoretical Conceptualizations Can Inform Future Standardization Initiatives

Development of standardized guidelines for ATC assessment and implementation should be considered within a biopsychosocial framework, taking into account physical, psychological and social domains of functioning and how factors related to these domains might influence aid use. As highlighted above, effective aid use is contingent on environmental and social factors such as social support and alteration of the physical environment. Scherer and colleagues have incorporated these aspects into a framework for predicting assistive technology device outcomes [13]. The framework describes factors relevant to short-term and long-term outcomes, while taking into account the influence of moderating factors such as concurrent interventions, comorbidity and person-context interaction. This outcome-oriented model, together with classification methodologies (e.g. International Classification of Functioning, Disability and Health [14]) and system modeling methods (e.g. Human Activity Assistive Technology [15]) could serve as starting points for developing standardized and practically applicable guidelines for assessment and implementation of ATC. Moreover, guidelines should be evidence-based, i.e. research on aid effectiveness and empirically supported training programs should be taken into account. Cicerone [16] has reviewed cognitive rehabilitation methods and suggested empirically validated interventions for specific classes of cognitive impairments. An example can illustrate how findings from these lines of research can be informative in the context of ATC-implementation: In individuals with severe memory impairments, errorless learning is empirically validated as effective when learning novel tasks. This finding demonstrates how a specific aid should be introduced to individuals with substantial difficulties remembering, i.e. by principles of errorless learning rather than being taught aid use by trial and error. In our opinion, it is essential that a standardization of assessment and ATC implementation procedures incorporate such findings to ensure that practice recommendations are evidence-based and appropriate. Thus, standardized ATC guidelines should include descriptions and examples of various cognitive impairments and adaptational requirements, such as need for structure, repetition, multimodal learning, prolonged comprehension time, and so on.

3. Conclusions

Research findings, clinical experience and knowledge gained through ATC project trials converge on the importance of thorough assessment, along with systematic and structured training adapted to the individual’s needs, if ATC use is to be effective. From the authors’ point of view, an in-depth understanding of the cognitive profile of the individual is paramount when selecting and implementing a technological aid. The complex and multifactorial nature of cognitive impairment, along with rapid technological advancement, demonstrates the need for developing standardized guidelines. From our perspective, such guidelines are necessary in order to help professionals working in the field of ATC and to ensure effective use of technological aids in cognitively impaired individuals.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1338

Standardization within the Assistive Technology Field – A Review

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Abstract. This paper describes the background, the achievements and the challenges ahead of standardization within the field of assistive technology based on the work coordinated and done in ISO and CEN Technical Committees "Assistive products for persons with disability".

Keywords. Standardization, assistive products, ISO, CEN.

Introduction

International standardization in the field of assistive products has been intense in the last 40 years or so. This paper gives an overview of international standardization work on assistive products and the present environment which provides some conditions for future work.

1. Background

1.1. ISO

The international standardization activities on assistive products were coordinated in 1978 with the establishment in ISO of the technical committee "Technical aids for disabled or handicapped people", ISO/TC 173. Prior to this standardization for wheelchairs had already started in ISO/TC 136 "Furniture". In 1979 technical committees were established for prosthetics and orthotics, ISO/TC 168, and for optics, ISO/TC 172.

Already at an early stage it was much discussed whether focus should be put on standardization of traditional assistive products or if TC 173 rather should focus on promoting the idea of taking in consideration the special needs of disabled people in other standardization works.

Eventually the work programme of TC 173 was defined and most work projects were allocated to the different subcommittees set up under TC 173:

SC 1 *Wheelchairs*

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SC 2 *Classification and terminology*
SC 3 *Aids for ostomy and incontinence*
SC 4 *Aids and adaptions for communication* (dissolved in 1995)
SC 5 *Systems and equipment for integration at home and in society* (dissolved in 1985)
SC 6 *Hoists for the transfer of persons* (established in 1985)
SC 7 *Accessible design* (established in 2010)

Besides this some working groups were established directly under TC 173 for specific tasks:
WG 1 *Assistive products for walking*
WG 2 *Braille – Tactile reading and writing* (dissolved in 2002)
WG 6 *Acoustic and tactile signals that indicate status of traffic lights* (merged into WG 7 in 2000)
WG 7 *Provisions and means of visually impaired persons in pedestrian areas* (dissolved in 2008)
WG 8 *Tactile walking surface indicators* (dissolved in 2012)
WG 9 *Assistive products for personal hygiene* (established in 2011)

1.2. CEN

With the creation of a common market in Europe it became necessary in the 1990´s to prepare common European standards to meet the requirements set out by the European Medical Devices Directives. In April 1992 the inaugural meeting of CEN/TC 293 was held and it was agreed that the title of the TC would be "Technical aids for disabled people". This was the start of an intensive period with many new European standardization projects launched.

2. Achivements

2.1. Traditional Focus

In 2004 the title of ISO/TC 173 was changed to "Assistive products for persons with disability". Up to 2013 a total of 69 international standards have been published within ISO/TC 173 and its subcommittees. Many of these standards concerns significant product groups such as wheelchairs (27 published standards) and aids for ostomy and incontinence (26 standards).

Other important work is the preparation of a classification and terminology standard for assistive products, the latest edition being ISO 9999:2011, *Assistive products for persons with disability – Classification and terminology*. This standard has been revised and expanded by ISO/TC 173/SC 2 several times and efforts are made to harmonize the classification system of ISO and WHO/**ICF** (International Classification of Functioning, Disability and Health).

The major benefits expected of the standards are:

- criteria for manufacturers against which to design products;
- decreased production costs for assistive products;
- safe, reliable and functional products produced for purchasers and users;
- increased quality of life for users;

- improved cost effectiveness for purchasers, both private and public;
- enhanced compatibility between products;
- standards in new emerging areas such as accessibility and cognitive devices;
- common testing methods leading to comparable, reliable test results, such as the methods developed and standardized for testing electrical and manual wheelchairs.

2.2. ISO-CEN Co-operation

The market for assistive products is global. The technology used is often identical or similar - at least in the industrialized parts of the world. The need for standardization often coincides, and the competence/experts needed for standardization work can be found throughout the world.

From start a close co-operation was established between the European and the International standardization bodies in the field of assistive products for persons with disability. Parallel projects were established and working groups and TC-meetings were coordinated.

European standards on assistive product often refer to test methods defined in International Standards.

2.3. ISO-IEC Co-operation

International Standards developed by IEC (International Electrotechnical Commission) for electrical, electronic and related technologies has a great significance since these technologies are often applied in assistive products.

ISO and IEC also establish joint working groups to develop International Standards. An example of this is the IEC/ISO Joint Working Group created between ISO/TC 173 and IEC/SC 62D in order to elaborate a standard for all medical beds, including adjustable beds for disabled. The standard, published in 2009, is also adopted as a European Standard.

2.4. ISO Internal and External Liaisons

ISO/TC 173 and its subcommittees have established liaisons with other ISO Technical Committees as well as external organizations.

Internal liaisons exist with technical committees such as ISO/TC 59 *Buildings and civil engineering works*; ISO/TC 159 *Ergonomics*; ISO/TC 210 *Quality management and corresponding general aspects for medical devices*, and in particular with subcommittees and working groups established to address matters concerning people with special requirements.

Of great importance are also liaisons established with external international organizations representing user interests or the industry, such as ANEC, Rehabilitation International (RI) and EDANA, the international association for the nonwovens and related industries. Some other organizations in liaison with ISO/TC 173 are WHO and the International Committee of the Red Cross.

3. Present Situation

The past decade has shown reduced commitment in some countries with regard to active participation in the work of ISO/TC 173 and CEN/TC 293. This may be due to the fact that the initial challenge of creating international standards for traditional assistive products has been met, but also because of financial restraints. However, new ground is currently broken by the ongoing work on a first international standard for assistive product for personal hygiene.

It is also very important to review those standards already created and, when necessary, revise these with regard to the technical development and the introduction of new products. This important job to provide new editions of standards to correspond to the "state of the art" is carried out in the various subcommittees and working groups.

4. Challenges ahead

Assistive products and assistive technologies will continue to play important roles. The challenges ahead are to ensure participation in standardization work of stakeholders previously not much represented and to expand the work into new areas of assistive products and services.

Users and their organisations represent a unique competence, and it is vitally important to engage them in standardization work. This is underlined by the fact that the design of the products/systems often affects their safety and possibility to an independent life in a very personal way. The participation of consumer representation in standardization is essential but sometimes obstructed due to lack of financing.

There is a demographic change going on in many countries all over the world. It is expected that the population over 65 years will increase in these countries. This very much is a result of a successful health and social policy, including housing policy. It is fairly clear that the market for assistive products should increase in response to the trend toward independent living and the increase in the proportion of older people in the population. A large number of these persons need assistive products in their daily life. Thus the market for assistive products is expected to increase.

The rapid advance of technology and techniques also means that some standards have to be revised or amended soon after publication.

New areas need to be addressed such as assistive products with the aim to compensate for cognitive disabilities. Products designed to support persons with cognitive disabilities are beginning to represent significant economic values. Cognitive aspects should also be considered in existing standards.

Other areas of current concern within ISO and CEN standardization are products for personal hygiene and accessible design. With regard to the fact that an increasing number of older persons will live in an ordinary resident with the support of relatives it is also desirable in standards to address how to include self-evident and easily understood information addressing nonprofessionals on how to safely use assistive products in the ordinary home.

Information and Communications Technology or (ICT), is an integrated part in an increasing number of assistive products already available. To some extent physical products are being replaced by software available via Internet. This is a trend that is foreseen to be continued. For example mobile phones have become Smartphones. Mobiles in combination with apps have been found very useful especially for people with cognitive impairment and people with visual impairment through the use of audio menus, etc.

Assistive products are prescribed in many countries all over the world but an increased user influence on the choice of product is generally expected. At the same time the private market is growing fast.

There is also an emerging grey zone in between the traditional assistive products and products available on the ordinary consumer market. A product designed so that it can be readily usable by most people without modification is expected to gain market shares. The concepts of "Universal Design" and "Design for All" will be widely applicable. In this way, one can recall some thoughts on priorities that existed already when standardization in this field started in the 70s.

The ISO/IEC Guide 71:2001 *Guidelines for standards developers to address the needs of older persons and persons with disabilities* is a document to provide guidance to writers of relevant International Standards. The guide is currently under revision by an ISO/IEC Joint Technical Advisory Group. ISO/TC 173 is represented in this work.

5. Conclusion

Since the international standardization activities on assistive products were coordinated in 1978 the initial focus on ensuring safe assistive products through International Standards has been broadened to include a wide range of standardization initiatives aiming for increased accessibility and inclusion for people with special needs. It is hopeful to find that the major international standardization organizations are involved to meet the challenges ahead.

Special Session on Using the Cloud to Enhance AT

Special Session on usingthe Cloud to Enhance AT

This Special Session wants to share knowledge on cloud and ATs and the experiences of Cloud4all/GPII. The way to create an infrastructure to enable users to declare requirements in functional terms (whether or not they fill into traditional disability categories) and new systems that will allow users to access and use solutions not just on a single computer, but on all of the different ICT that they must use.
The goal of the session is to show how to take advantage of the cloud for the challenge of handling user settings across devices, applications, platforms and ATs. By substantially improving accessibility, over the next ten years these technologies will open up access to, and improve the use of, ICT products and services in general (whether eCommerce, eGovernment, eHealth, eCulture, or Internet banking) and make opportunities available for older people and for people with disabilities (i.e. to make online job applications, use job-matching platforms or eLearning applications).
The special session will let researches discuss the importance of knowledge engineering, context modeling, user-centred design methodologies, database federation, machine learning and ruled-based systems to ensure a better access to health and public services, improve employability and productivity or increase embeddedness for people in social relations and networks.

This Special Session should describe a framework to provide accessibility for anyone, at anytime, anywhere and at any device. It should answer questions like:

- How to create a highly loosely coupled architecture to integrate and launch AT
- How to allow most architecture components to be present locally and in the Cloud, even simultaneously.
- How to find suitable settings for equivalent ATs in different platforms, OS or devices
- What happens if the connection is down? Can lite versions of different modules may be present locally in order to perform simpler, common-use transformations?

Papers in this Special Session address the general overview of such an architecture, the description of the components and the main challenges to overcome.

Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1345

Federating Databases of ICT-based Assistive Technology Products

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Abstract. The importance of providing accessible and accurate information on Assistive Technology (AT) products to all the stakeholders needing it is widely acknowledged. In the past years, several AT information systems have been created in response to this need. Recently, information on AT products has also become important for building up the knowledge base of machine based expert systems. In 2005, some of the most important European AT information providers have joined together to create the European Assistive Technology Information Network (EASTIN), that represents an important source of information to create a *Unified Listing* of all available solutions to ICT access, i.e. a comprehensive database including information on AT products, and Accessibility Features built into mainstream products. This is in turn a key element to the creation of a *Global Public Inclusive Infrastructure*. This paper describes the methodology for federating the databases of the EASTIN network with the GPII Unified Listing.

Keywords. AT database, AT Information providers, Database Federation.

Introduction

Information on Assistive Technology (AT) products is of paramount importance for many stakeholders including people with disabilities and their families, health care professionals, AT suppliers and manufacturers, researchers and developers, and policy makers. The importance of ensuring the access to information on AT products has been repeatedly stressed by several EU studies [1] [2], and is acknowledged as a right by article 4 of the UN Convention on the Rights of Persons with Disabilities [3]. In response to this need, several information systems have been created in many countries around the world. Some of them have over 20-years history, such as the Italian SIVA [4], the UK DLF-Data [5], the German Rehadat [6] and the US Abledata [7].

Recently, the information on detailed features of AT products has also become essential to build up the knowledge base of machine based *expert systems* used, for example, to suggest appropriate AT solutions and/or to propose personalization on the basis of each individual needs. An example of such systems is the AskSara self assessment tool that guides the user in identifying appropriate assistive solutions for daily living activities [8].

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1 The Eastin Network

In 2005, some of the most important European AT information providers joined together to create the European Assistive Technology Information Network (EASTIN) [2]. The network stems from a project founded by the European Commission in 2004-2005 within the eTEN programme, and today includes the organisations responsible for the major European AT information systems in Denmark, United Kingdom, The Netherlands, Germany, Italy, France and Belgium. The network is currently operated by the EASTIN Association, a legal entity based in Italy supported by its partners through their annual membership fees.

The core of the EASTIN network is the web-site www.eastin.eu, that provides – in all the official EU languages – information on almost 70.000 products and some 20.000 companies (manufacturers/suppliers, retailers); it also includes related material such as fact sheets and case studies. EASTIN aggregates the contents of 7 independent national DBs and includes a search engine able to perform AT product searches across all these DBs. The EASTIN partners have worked together to harmonise their databases according to common requirements. The result of this work is the harmonized data structure used to present the product information in the EASTIN website.

Within a European funded project called ETNA (European Thematic Network on Assistive Information Technologies) [9], the EASTIN network is currently expanding, by including new resources and new information providers, and is improving the quality of information, by defining a more detailed dataset and taxonomy for the description of products.

2 The Global Public Inclusive Infrastructure

A coalition of academic, industry and non-governmental organizations and individuals have recently come together to promote the creation of a *Global Public Inclusive Infrastructure* (GPII), i.e. a global infrastructure that can deliver accessibility to every individual, instantly and automatically, where they need it, when they need it, on any device they encounter, and in a way that matches their unique requirements [10].

The GPII concept is based on three “pillar functions” [10]: 1) Providing a way for people to determine what would help them - and then to store that information safely for future use; 2) Providing a way to use their stored preferences to invoke the access features, technologies and services they need - anywhere on any device they need to use 3) Providing tools and infrastructure to allow diverse developers and vendors to create new solutions and easily and cost effectively move them to market and availability to users who need them. The CLOUD4all project [11], funded by the European Commission, aims at advancing the concept of the GPII by augmenting adaptation of individual products and services with automatic personalization of any mainstream product or service a user encounters, using cloud technologies to activate any built-in or installed access features the product or service has, or recommending the appropriate third-party solutions, based on the user's needs and preferences.

2.1 The GPII Unified Listing

One of the key components to achieve the first of the three pillars of the GPII is the existence of a comprehensive database of all available solutions to ICT access, including Assistive Technology products, and Accessibility Features and programs built into commercial products. The creation of such *Unified Listing* (UL) will be based upon a federation of resources, meaning that information included in the listing will be drawn from many different sources each credited on a per entry basis. This will allow the creation of a collaboration on the formation and maintenance of the listings related to assistive technologies and to mainstream accessibility features relating to ICT access, thus improving the long term sustainability. The UL will represent the knowledge base used both by humans (e.g. AT professionals, end-users, etc.) and by machines (e.g. tools for automatic personalization of products and services) to build up the most appropriate AT solution.

3 Federating the EASTIN Network with the GPII Unified Listing

The databases of the EASTIN network represent a unique source of information on the Assistive Technology products available on the European market and worldwide. Those databases, together with the EASTIN search engine, will represent the basis for building up the Federated Listing of assistive products that in turn will be one of the main sources of information on ICT related assistive technologies for the UL.

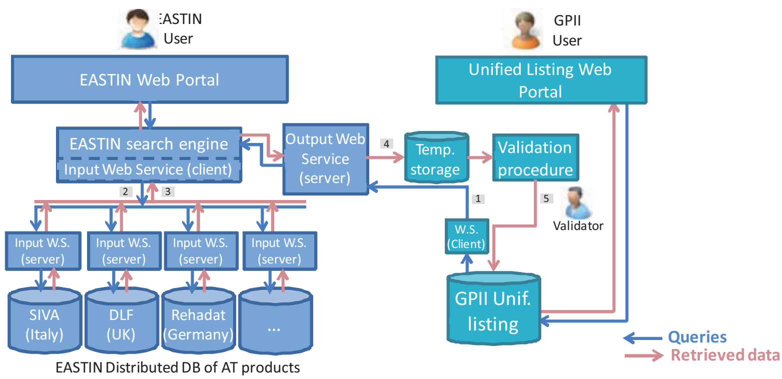

Figure 1 Scheme of the GPII-EASTIN connection.

A bidirectional connection between EASTIN network and UL will be established in such a way that the users of the GPII Unified Listing web portal can access information coming from the EASTIN databases, and users of the EASTIN Web Portal can access information coming from the UL. The connection between the EASTIN search engine and the UL is based on Web Service technologies (Figure 1).

The process of getting the information from the EASTIN databases, in order to store it in the UL, requires the following steps:

- A Web Service Client sends a query to the EASTIN Web Service Server.
- The EASTIN search engine in turn sends the request to all the information providers.

- The information providers answer the request with the list of products.
- The search engine sends the list back to the Output Web Service Client and the product details are saved to a Temporary Storage.
- Retrieved information is validated and stored in the Unified Listing Database.

3.1 Validation Procedure

The scope of the EASTIN portal and the GPII Unified Listing are different. The EASTIN information system includes assistive devices for people with disability in general (e.g. assistive devices for personal mobility, assistive devices for personal care, and more) whereas the GPII Unified Listing only includes products for ICT access. On the other side, EASTIN only includes assistive technology products, while the GPII Unified Listing will also include accessibility features in mainstream ICT products and assistive services. Moreover, differently from what happens in the EASTIN portal, where multiple records describing the same product may be retrieved in a search (because they are present in different databases), the aim of the UL is having a single record for each product with multiple layers representing the "original product descriptions" and other information that differs between databases. For those reasons, before entering the product records retrieved from EASTIN into the UL database, a *Validation Procedure* is required. The validation consists in the following steps:

- Decide what products are of interest for GPII unified listing (i.e. the subset of EASTIN records that deal with access to ICT).
- Cluster "duplicated" records from different databases that deal with a single product into a single record, and assign a "universal product ID" to allow automatic grouping of future versions of the records.
- Complete the product information by adding specific settings and other information needed by the GPII.

The validation will initially be a *semi-automatic* procedure (i.e. it will be performed by a human aided by automatic functions) with automatic processing later for updating the information of products already stored in the UL. A filter, based on the ISO 9999 classification codes [12], has been implemented to retrieve only products related to ICT and access. In order to help the validator in clustering the duplicated records, a special tool has been created including an algorithm to evaluate the *product similarity,* i.e. the probability that two records A and B describe in fact the same product.

Figure 2 represents the functional scheme of the *product similarity* tool: a record stored in the Temporary Database is loaded and details are shown; the similarity level of the record loaded with all the other records already stored in the UL database is evaluated. Based on the evaluated similarities the validator will then decide whether to store the current product into a new UL record or to add it to an existing UL record. In the UL the provenance of the record (database name and ID) is captured and stored to preserve the identity of the source of the record, and to allow for automatic update of UL records when data are updated in the original source database.

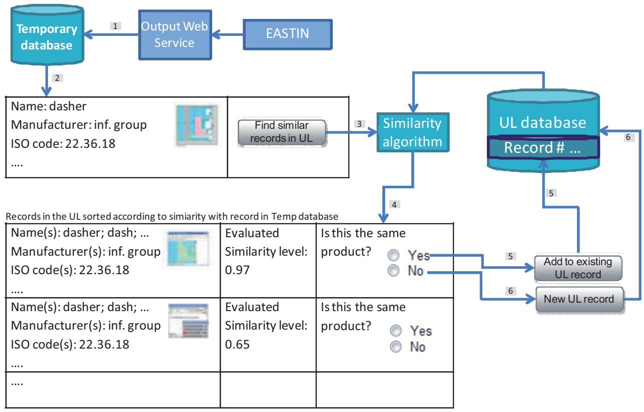

Figure 2. Functional scheme of the product similarity tool.

3.2 *Bi-Directional Federation*

A mechanism will also be implemented to propagate modification made in the UL to the other databases that federate with it. When a product record in the UL is modified (e.g. an error is corrected, a new feature is added, a new version becomes available, ...) a feedback notice is provided to the "original sources" (i.e. the DBs where the data have been drawn from) and any other federated databases (Figure 3).

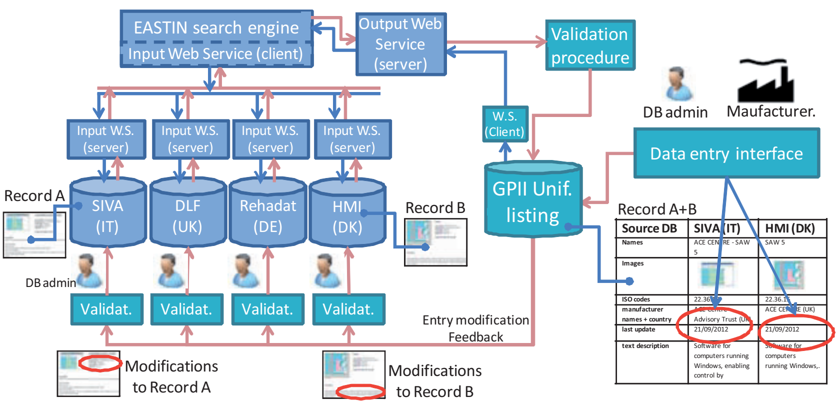

Figure 3. Bi-directional federation scheme.

This will make it easier for manufacturers and suppliers to keep the information updated and will help improving the quality of data in the different databases. For manufacturers and suppliers the ability to go to one location and correct entries for their products and have it propagate to all of the other databases that are the original source of the information is of great interest.

3.3 *Crediting Information Sources for Long Term Sustainability*

One of the key issues for the long-term sustainability of the federation mechanism is related to preserving the provenance of the information by giving appropriate credit to each source. The power of federated databases is the fact that the efforts to maintain the data can be spread across many teams who then share the results. However, if the databases are anonymously federated, it can begin to look like some of the databases are redundant, and this can cause some or most to lose their funding.

The UL web portal will be designed so to represent an additional entry point to the data included in the federated databases. A strategy for that is including information relevant at "transnational level" in the UL web portal while for the information relevant at "national" or "local" level (such as national prescription codes, local distributors / resellers, national legislations,...) the user will be redirected to the original information sources. In addition UL will also include a mechanism to count the number of visit to each record and communicate it to the original sources of information, so that the information providers can consider this as "indirect visits" to their databases. Basically, the UL will represent an additional entry point for the information included in the different sources rather than an alternative to those.

4 Conclusions

The Unified Listing will represent a single entry point where all the stakeholders, and also machine based systems, will find information not only on ICT related access products but also on accessibility features of mainstream ICT products. Key innovations of the federation of AT database include: a) sharing of the efforts needed to maintain the data while attributing credit back to the source, b) providing companies with a more convenient mechanism to update their data across databases, c) feeding of queries back to individual databases for extended local information, d) inclusion of information on access features of mainstream products intermixed with special ICT access features, and e) the coupling of all of this with the “auto-personalization-from-preferences” features of the GPII that will allow users (and professionals) to automatically have searches done that will present lists of just those products and features that meet a particular user’s needs and preferences – without them having to have any search skills.

Acknowledgments

The research leading to the results described in this paper has received funding from the European Union's Seventh Framework Programme (FP7/2007-2013) under grant agreement #289016 (CLOUD4All project), as well as the NIDRR, US Dept of Education (Grant H133E080022). The opinions herein are those of the authors and not necessarily those of the funding agencies.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1352

A Cloud-based Semantic Matching Framework for Ensuring a Universal Access

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Keywords. Semantic Representation, personalization, Ontologies, Cloud, Matchmaker, accessibility, functional limitations.

1. Introduction

In our modern society, access to personalised solutions and services is important to the public, including also people at risk of exclusion - notably persons with disabilities, with low levels of digital literacy/skills, and older persons by addressing their unique sensory, physical and cognitive needs. Thus, services and solutions designed for the 'general' user may not be suitable for all users and this calls for the provisioning of personalised innovative services and interfaces, according to the preferences and needs of a unique service user. However, the accessibility technologies that we have up-to- - date are meeting the needs of only some, at a very high cost and, as a consequence, accessible information and communication (ICT) for all people remains still a major research and development goal.

Personalization and adaptation of ICT solutions and services based on dedicated design, implementation and deployment of software and hardware is not feasible because of the cost and time involved for doing so. Motivated by this, we propose to introduce a Cloud-based Semantic Matching framework, which exploits innovative semantically-enhanced matchmaker techniques in order to create and offer real-time dynamic personalized services to individuals. The main aim of this framework is to provide a high-level modelling of context-related information of available solutions and services, in order to support and provide appropriate input to the Cloud4all/GPI public inclusive infrastructure [1,2,3].

Our framework will be built on top of profiling- user experience mining techniques; innovative semantically enhanced matchmaking methods for interface adaptation and personalisation; and an ontological model for the representation of available solutions/applications and their application unique settings. In addition, the proposed framework will have to handle dynamic and continuous changes, for instance, in the user profile experience, interaction mechanisms (e.g. iTV, Mobile devices), provisioning of services, availability of solutions, connectivity of inclusive solutions in everyday life applications and so forth. Thus, it can handle the user experience and the provided solutions and services, increasingly exposed in smart daily environments to real-time monitor the user needs so as to better support personalization in a seamless and unobtrusive way.

Based on the profile of the user and all the information which is automatically gathered and inferred from the user communities on the cloud infrastructure (clustered profiles), the framework can be used in order to recommend new personalized solutions and services, dynamically adapted to the current context and device of the user.

2. The State of the Art in this Area

Personalisation and adaptation of the user interfaces of specific ICT solutions is not a new topic. There are several utilities that specifically address personal accessibility requirements for a given product or platform. Most applications also offer user preferences that persist from session to session. However, there are no semantic ontological matching initiatives that enable personalized preference portability across different applications, platforms, devices and contexts (e.g., automatic configuration of user interfaces of workstations in libraries, online booking systems, kiosks, ticket machines, and computerized appliances). DReggie [4] is a dynamic service discovery infrastructure targeted at mobile commerce applications that exploits semantic matching using the XML-based DAML (DARPA Agent Markup Language) to describe services.

On the ontologies side, work has already explored accessibility concerns. Thus, there are several efforts towards the direction of defining ontological concepts and architectures for the semantic representation of ICT solutions, devices and platforms within the area of e-Inclusion. These efforts try to cover adequately the personal requirements of the end users, under an ICT artifact specific perspective. For example, besides user modelling, the ontologies developed in ACCESSIBLE [5] and AEGIS [6] incorporate the semantic description of solutions, applications and user interaction terms targeting users with functional limitations. Also the INREDIS Knowledge Base, stores all the ontologies that collect formal descriptions of the elements in the INREDIS domain (e.g. users, AS, devices, software requirements, etc.) [7].

In the current work, our main purpose is to provide a high-level modelling of context-related information of ICT solutions, platforms and devices by extending and integrating the previous ontological implementations. This framework will be able to support and provide appropriate input to the matchmaking tools that will be implemented in the Cloud4all project. In this respect, an appropriate semantic representation mechanism will be created in order to encourage and enable all potential stakeholders to use the same terms when describing the same things (the same concept and value range) with regard to the offered ICT applications and their application-unique settings that will be hosted in the cloud.

3. The introduced Framework

We have created a Semantic matching ontological Framework, in order to explicitly support the rule-based matchmaking processes that are typically present on the GPII/Cloud4all personalization procedure. The main goal of this framework lays in the separation between generalised user needs and preferences that are stored in user profiles and the application-unique settings details of the supported Cloud4all available applications. Thus, the ontological framework (Semantic Framework of Content and Solutions") aims at formalising conceptual information about: (1) Solutions/applications, and the relationship between them in the context of its application unique settings as well as the platforms and the devices that can be executed and run (2) platforms, devices and vendors that they are offering the available applications/solutions. As depicted to the following figure 2, the semantic framework will be used in the Cloud4all in order to provide a concrete ontological framework for coupling different application characteristics and their application-unique settings that will be the basis (engine) for supporting the overall GPII/Cloud4all process.

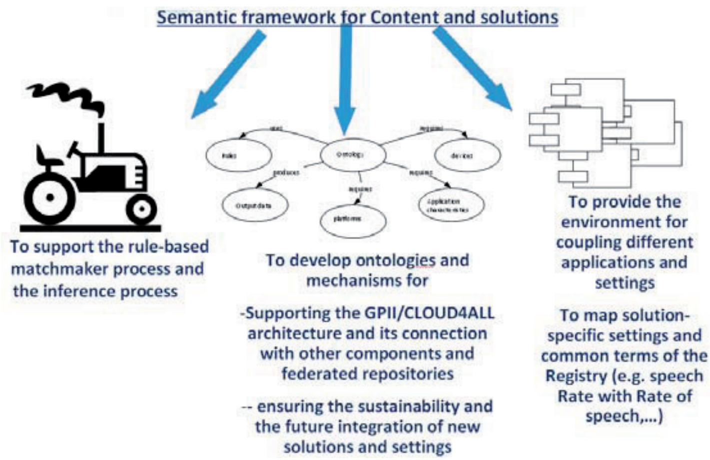

Figure 1: The Semantic Framework for Content and Solutions, a conceptual diagram.

4. Communication of the Framework with the GPII/Cloud4all components

The Cloud semantic infrastructure which consists of the Semantic Framework of Content and Solutions and the tools for generating and maintain metadata, is strongly communicating with other components of the GPII/Cloud4All system architecture namely: the Needs and Preferences (N&Ps) Ontological Model, the Registry of common terms that stores generic (i.e. solution-, platform-, device- independent settings), the matchmaker as well as and other components like the transformer, etc. The linkage of the semantic infrastructure and the GPII/ Cloud4All architecture components is being depicted to the following figure 1. Thus, the framework is being used in the context of Cloud4all for: (a) Translating generic N&P terms that are stored in the Registry of Common Terms to solution-, device or platform-specific settings; (b) selecting the best solution for the user among semantically similar solutions; (c) providing a framework for the matchmaker in order to perform suggestions for customizable settings that are not explicitly stated in a user's N&P set based on the semantic categorization of settings, and (d) providing a framework for the matchmaker in order to suggest to the user new solutions, not yet installed by the user, that meet his/her personal N&P.

More specifically, the Rule-based Matchmaker which is the basic decision support module of the Cloud4all architecture aims to match a user's N&P set to the application unique settings of the ICT solutions that are available in a given device. As depicted in figure 14, the matchmaker receives input as regards: (a) the N&P set of the user (step 1); (b) who reports which solutions are available on a local device through the Local Solutions Reporter (step 2), and (c) the specific settings with respect to the available ICT artifacts as reported by the Local Solutions Reporter (step 3). Having all this information, the Matchmaker infers a set of settings that should be customized according to the user's N&P set (step 4).

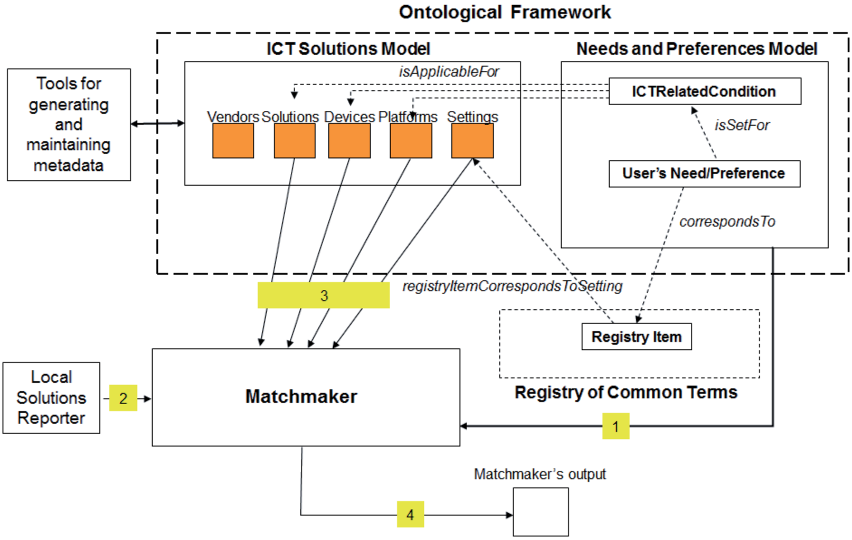

Figure 2: The overall Cloud semantic infrastructure and the interaction with the Cloud4All system.

5. Conclusion and planned Activities

Cloud4All is the first big international project aimed specifically at advancing the concept of a global public inclusive infrastructure, building the knowledge base needed, and evaluating the ability of the concept to work across differential platforms, technologies and applications. This framework will support this overall idea and, if successful, it will help to move it forward toward a reality for a universal access of personalised ICT solutions and services. A prototype of this framework has been released while more improved versions are being planned for the future.

We are currently working on the communication of the semantic framework with all the other components of the GPII/Cloud4all architecture that were described in section 4. Another challenge is the automatic management of the unified listing content and its connection with the ontological layer. Other work areas involve the development and adaptation of application unique-settings within the ontological concept that are being supported by the Cloud4all.

Acknowledgements

The research leading to these results has received funding from the European Union's Seventh Framework Programme (FP7/2007-2013) under grant agreement 289016 [3].

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1357

Improving Accessibility by Matching User Needs and Preferences

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Abstract. We present the concept of mapping needs and preferences of users to customisation facilities of ICT solutions which aims to increase accessibility and decrease barriers to customisation. We describe the challenges associated with the objective of cross-platform personalisation by mapping between preferences of one platform to preferences of another platform. Our matchmaking approach considers 2 scenarios which (1) allow the user to access arbitrary ICT products by launching their tailored ATs and (2) deliver new preferences which may improve the individual workflow in a certain context of use.

Keywords. Cross-Platform Personalisation, User Interfaces, Accessibility, User Preferences, Matchmaking, Ontologies, Recommender Systems, Statistical Inference

Introduction

Today's software applications offer a large array of customisation options. Many settings allow users to tailor the appearance, behaviour or accessibility of applications to improve performance and access. Operating systems, for example, include various options to enable text input without a keyboard, to make elements appear bigger on the screen or to hear text spoken out loud. Early findings showed that there are triggers and barriers to customisation by end users [8]. The most common barriers Mackay found in her early study were that users know little about customisation options and that it takes too long to personalise the system. Time factors were researched in [9]. For recent research on the impact of factors on users' customisation behaviour such as awareness of alternative ways of performing a task, social influence to perform simply like other users and exposure of users to customize, see [3].

For people with disabilities customisation and personalisation are a necessity to use most software or other ICT products. The selection of software, assistive technology (AT) and settings on a computer must take into account the various tasks and needs of the individual. Many users with disabilities need assistance by experts to adapt their system according to their needs and preferences. Once sufficient adaptations have been made to allow a subjectively fluent workflow, the user usually does not care about further personalisation. Mackay found that users will rather try to satisfy their tasks than to optimise their workflow [8]. We conclude from this that there is a gap between the user's needs in a specific context of use and the customisation options offered by operating systems and other software. This gap can be surmounted by automated adaptation. For example, automated adaptation could improve a system's accessibility by launching AT with settings that fit a specific user's needs. Let us assume that Karl usually works on a Linux PC which has been individually customised to launch the GNOME Magnifier. This meets his need for larger text and UI components. Later on, he needs to use a Windows system, and the knowledge about his need for a magnifier can be used to launch a magnifier on the Windows system. Moreover, recommendations for new solutions[1] or new preferences may enhance Karl's workflow when he wants to achieve a specific task. For example, instead of launching the GNOME Magnifier, another solution for Linux may be proposed. This alternative proposal would be based on various knowledge bases (other users, experts, AT catalogues etc.), statistical analysis, etc. For example, eZoom[2], may be able to improve Karl's user experience because it is faster and produces no artefacts.

With these goals in mind, we present our contribution to the idea of the Global Public Inclusive Infrastructure (GPII) [13], which has the following goals: (1) to develop an infrastructure that simplifies accessibility, (2) to increase built-in accessibility, (3) to grow the market for assistive technologies and services, (4) to facilitate cross-sector collaboration and (5) to increase the number of AT solutions and products [20]. We present a concept of matching between a user's needs and preferences[3] on the one hand and customisation facilities of arbitrary ICT products on the other with the objective to provide tailored access to technologies and information. We describe the challenges involved in the cross-platform personalisation that is being developed for GPII [14]. We introduce the 2 basic scenarios, the matchmaking process as well as the matchmaking framework to meet these challenges.

Related Work

There are many approaches that aim to improve the accessibility of ICT products through personalisation, adaptation or both. Recently, the presence of personalisation and adaptation technologies in user interfaces has increased and has started to become prevalent in our daily lives. Every technology has its specific domain, design area, adaptation mechanism and targeted user groups. In many cases successful personalisation depends on the knowledge of end users' needs and preferences (N&Ps). Most of the related work addresses specific and limited use cases only. We found that none of them addresses the full range of design areas, user groups and domains, including personalisation of AT.

The personalisation approach in MyDocStore[4] and Multireader [11], focused on accessible documents and their readability. A MultiReader document is a view on a personalised transformation of the contents through tailoring contents (such as sign language video, audio description), adaptable views (font size, colour schemes and speed variations) of enriched contents, and navigation aids based on micro-formatted objects. Personalisation of public digital terminals (PDTs) and mobile environments

[1] "Solutions" is the general term we use for assistive technologies, application settings (including settings in operating systems and mainstream applications) and services that meet the needs of people with disabilities.

[2] http://wiki.compiz.org/Plugins/Ezoom

[3] GPII and Cloud4all treat "needs and preferences" as a single term; what is a need for one person may be a preference for someone else and vice versa.

[4] MyDocStore. Project website. http://www.mydocstore.org.uk.

has been addressed through SNAPI[5], Web-4-all[6], and APSIS4all[7]. Web-4-All provides a system for easy configuration of multi-user public access computer workstations. APSIS4all follows two approaches: a "direct interaction" approach where a complete personalisation process is carried out at the PDT, and an "indirect interaction" approach where the user defines a desired operation by using the preferred device. GUIDE [2] and MyUI [10] propose new frameworks for developing personalised user interfaces (UIs). GUIDE aims to develop personalised, adaptive multimodal interfaces for elderly users. The adaptation of multimodal interface components is based on the user model controlling the mapping between the user characteristics and the interface configuration [2]. In MyUI adaptation relies on a repository of UI design patterns that are selected and applied to an abstract user interface model, according to the current user profile [10]. The recent momentum in the area of mobile and handheld devices has also led to the emergence of several research topics and efforts that address ubiquitous and mobile UI designs [12]. The EGOKI adaptive system combines user interface adaptation and automatic generation of user interfaces (for ubiquitous services) by mapping user characteristics, especially information about the most suitable communication modalities, to appropriate media [1]. SUPPLE is a model-based user interface generation tool which addresses user needs for ubiquitous applications [5]. While mapping components and contents to users according to a user profile is a more straightforward approach for personalisation, constraint-based search algorithms, as used in SUPPLE, are more widely applicable in their attempt to match between an interface specification, a device model and a user model.

Currently, there are many matchmaking technologies and user-specified content delivery systems, statistics-based predictive approaches, descriptive approaches and recommender systems. Most of these matchmaking technologies can be classified into relevant categories according to their matchmaking approach and their algorithmic technique. Since most of the existing and envisaged personalisation approaches focus on a specific domain, user group, design area, matchmaking technique or technology platform, it becomes important to propose new hybrid and more sophisticated frameworks, e.g. by combining several approaches as discussed in the section about the matchmaker framework.

Cross-platform personalisation is not new. Various approaches exist on device-, operating system- or application level. Assistants to migrate settings from one computer to another are well-known for Mac OS, Windows, or Linux. Some systems also provide migration of settings between different operating systems. For example, Mac OS provides a Windows Migration Assistant to transfer some basic Windows settings such as desktop wallpapers and email account settings. Some assistive technologies provide similar functionality. The screen reader JAWS, for example, provides a settings packager that allows users to import or export individual configurations. Cloud computing can make such manual migrations obsolete. Windows 8, for example, provides roaming options to transfer preferences to any other Windows computer by storing them in the cloud[8]. You can easily choose which settings you wish to have available everywhere for an individual and consistent Windows experience. First and foremost, these examples work for products where the underlying platforms were developed by the same vendors, for example several versions of Microsoft

[5] SNAPI. Project website. http://www.snapi.org.uk/
[6] Scheuhammer, J. Web-4-All Architecture. http://web4all.ca/.
[7] APSIS4all. Project website. http://www.apsis4all.eu/.
[8] http://www.istartedsomething.com/20110427/windows-8s-user-account-roaming-feature-revealed/

Windows. Development of solutions for cross-vendor migration of settings is challenging because of the different types of user profiles used on each platform. Existing approaches to cross-vendor migration are limited due to technical barriers but also because of business reasons. In contrast to the described approaches, Cloud4all investigates techniques that allow users to switch from one platform to another or from one device or AT to another, while making sure that all required settings, which reflect the user's needs and preferences, are "translated" to the target system. The target systems in Cloud4all span a wide range: from traditional desktop PCs and mobile devices on one end to smart TVs and kiosks on the other.

Matchmaking and the GPII

Many challenging issues need to be solved to support the GPII's goal of cross-platform personalisation. A platform for personalisation will need to deal with storage and retrieval of user preferences and with all the ethical and security implications associated with handling such sensitive user data. New standards are required to represent common user needs and preferences, but also to formally express user preferences for a particular context[9]. Furthermore, semantic descriptions of applications, assistive technologies and their settings become necessary, as well as the coordination process of setting up and launching solutions. In between those ends lies the interesting problem of matching preferences to actual application settings; this comprises matchmaking functionality in the personalisation infrastructure developed in Cloud4all.

Matching user needs and preferences to application settings is not a trivial problem. A preference such as "I want black on white text display" seems to match easily to an application setting such as "background: white; foreground: black". The semantics of such a preference are much broader, however. Why did the user express the preference? Is it a general preference that the user would prefer in most situations or is it a preference that was expressed to compensate for specific lighting conditions? It is obvious that a user's preferences are not universal and constant but that they are always specific to a certain context. This context consists of all measurable or detectable aspects of the situation and environment in which the preference was expressed. Technical circumstances like the current operating system or the device's screen size have a strong effect on the realisation of settings, and therefore bias the expressed preferences. Font rendering, for example, is very different on a Windows desktop PC with a 19-inch display than on a much smaller Android tablet with a retina display. Some users might be able to deal with a much smaller font size on the retina display because the rendering is sharper. For other users, the actual sharpness of the font rendering might not be that important but the actual physical size of the letters (in millimetres). Those users would probably want a larger font size on the tablet in order to achieve the same physical size of text. With these examples in mind, it becomes obvious that we cannot define user-independent transformations from one context to another. From a technical perspective the current user is the dominant context field for almost all preference transformations. From a non-technical perspective the current user is the dominant context whose work experience with ICT products can be improved through successfully performed adaptation of preferences into application settings among various devices. However, possible mismatches can cause negative

[9] http://wiki.fluidproject.org/display/ISO24751/AccessForAll+Working+Group

consequences as well. In the worst case, users might not be able to perform or continue their tasks if, for example, the translated zoom level is very different from the needed value, application colours are applied incorrectly or if the inferred Braille grade is wrong. Furthermore, users might become irritated if adaptations are applied that deviate from their needs or preferences or that they are not familiar with. For instance, if a matchmaker proposes the use of a screen reader that the user is not familiar with, interacting with the system could become difficult. Nevertheless, if transformations are performed properly, a match will be made between system capabilities and user needs.

Matchmaking Scenarios

Cloud4all's matchmaking approach is based on two generic scenarios: (1) inferring a preference for a target context and (2) responding to user actions by recommending new preferences. The first scenario applies when the user is in a context for which the system has no explicit preferences. Let us assume that Anne bought a new smartphone and the preferences for this new context, for example foreground and background colour, are to be defined. Beyond the device specification of the new smartphone, any other information that may impact readability, such as ambient light, can define the user context, provided that sensors are available and Anne has allowed using them. Anne`s preference set already contains some values for foreground and background but for other contexts, for example for her desktop, her previous smartphone or her TV. The task of a matchmaker is to infer a preference set for Anne's new device based on her existing preferences.

Scenario (2) for the matchmaking system focuses on responses while a user is adjusting some setting. Depending on the matchmaking strategy being used, this task may be significantly different from inferring a preference for the target context because such modifications to settings lead to a change in the system's knowledge about the user's preferences. Let us assume Anne successfully managed to use her new smartphone with the preferences that have been configured according to scenario (1). Noise encourages her to increase the volume on her smartphone. But this preference should not become her default preference for all devices. Therefore, every preference stored in the preference set will also include the context in which a preference was confirmed. Yet, besides the preference set, the new preference also arrives at the matchmaker, as the matchmaker might be capable of recommending further changes to Anne. If the matchmaker comes up with the conclusion that the ambient noise is very high, it might ask Anne if she also wants to enable subtitles. Thereby, scenario 2 aims to increase awareness of new features and improve performance of the user work flow according to her interaction.

Matchmaking Process

The input of the matchmaker is a user preference set, which is essentially a list of preferences. In general, there is no restriction with regard to the format of a user preference set. Matchmakers may handle user preference sets in any format, but implementation in Cloud4all focuses on standardised formats, for instance such as defined by ISO/IEC 24751-2 [7]. We expect that matchmakers will receive a user preference set in a format that conforms to the new version of ISO/IEC 24751, for which the Access4All working group did preparatory work (under leadership of Cloud4all partners) [10]. This new structure fulfils the requirements of matching preferences to any solution and for any context, independent of a specific application domain. In the preparatory work for the revision of ISO/IEC 24751, Cloud4all proposed a user preference set that is a flat ordered list of user preferences, in which a user preference is defined by the following triple: a property, a value and a condition. A *property* is a unique identifier that is associated with either a common or an application-unique specification [11]. *Common properties* are defined as generalised properties to be used by different devices, platforms or applications. By contrast, an *application-unique property* is only valid and meaningful within the context of a specific application. The *condition* field describes the context in which the preference is valid. Table 1 illustrates examples for (1) a common user preference, (2) an application-unique preference and (3) a conditional preference.

Table 1. Examples of three kinds of preferences: (1) a common preference, (2) an application-unique preference and (3) a conditional preference. Preferences are represented in a triple <property, value, condition> formatted as comma-separated values. Placeholder [uri] means http://registry.gpii.org.

	User preference in plain text	**User preference in triple <property, value, condition>**
(1)	I need a magnifier and prefer that it is positioned as a lens.	<[uri]/common/magnifierPosition, Lens, ' '>
(2)	I prefer screen reader ORCA with a speech rate of 62 when I am using Linux	<[uri]/applications/org.gnome.orca.rate, 62, ' '>
(3)	My preferred language is English. When a TV programme is not in English, I wants English subtitles	<[uri]/common/show-subtitles, false, value('[uri]/common/program-lang') == 'en'> <[uri]/common/show-subtitles, true value('[uri]/common/program-lang') != 'en'>

Besides the preferences set and preference changes, matchmakers receive input about the user's current context, for example the device specification, the installed AT and environmental information. The specification of context and context awareness is being developed by a specific working group in Cloud4all [6].

After receiving input from the flow manager, which is a component of the overall Cloud4all personalisation infrastructure [4], the matchmaking process is triggered with the goal to deliver settings that best match the user needs and preferences with the target context. However, matchmaking can also cause conflicts, namely if a mismatch has been produced or if a user is overtaxed by adaptations that he/she is not familiar with. Therefore, the highest priority is to infer preferences that enable basic access to a target context. Returning to the example of Anne and her new smartphone, this means that the preferences "background" and "foreground" are already known when she uses her smartphone for the second time. Such a precise match between user preferences and available solutions is handled by the Flat Matchmaker. If no precise match can be found, one or more additional matchmakers may be invoked to infer new preferences as described in scenario (1). However, new settings or solutions should be proposed very carefully. Only if users signal a preference change for a target context by changing the configuration by themselves, matchmakers can use their full intelligence and propose

[10] http://wiki.fluidproject.org/display/ISO24751/AccessForAll+Working+Group

[11] Example for a property: "http://registry.gpii.org/common/magnifierPosition"

additional preferences as described in scenario (2). Figure 1 illustrates the matchmaking process described in this section.

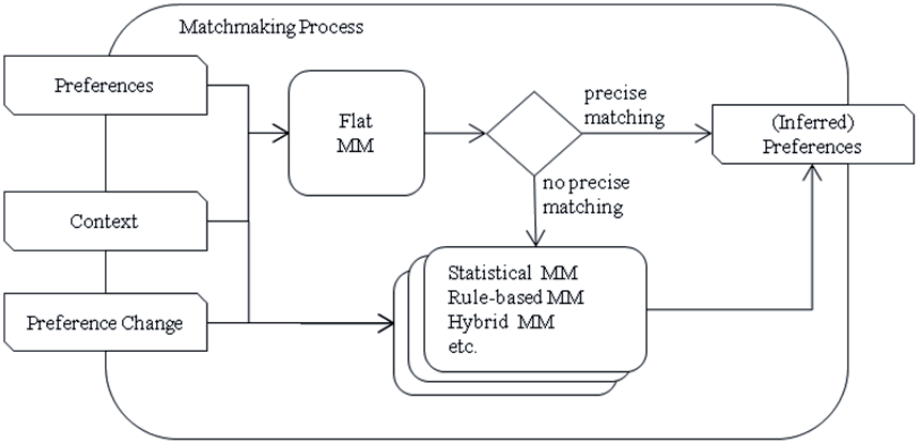

Figure 1. The matchmaking process simplified. Preferences and context information are used by matchmakers to infer preferences that best suits a user. (MM stands for matchmaker).

Successfully applied adaptation can incrementally improve the use of ICT products over a period of time. The user might learn more about his/her needs and preferences if new solutions or settings are proposed to him/her. The more a user is using the Cloud4all system, the more preferences related to a certain context are known for the matchmaking process.

Matchmaking Framework

In order to achieve the overall objectives explained in the previous sections, the matchmaking framework needs to be flexible and extensible. For example, the personalisation process may use more than one matchmaking strategy. Matchmakers can implement various approaches for similar matching problems; Cloud4all is working on statistical, rule-based and hybrid approaches. Matchmakers might also address particular matching problems, for instance matching the needs and preferences with shared applications. Handling dynamic context changes as well as locally available matchmakers in case of network problems are further examples of the diversity of matching issues. In general, we define a matchmaker as a software implementation that maps the user needs and preferences to solutions and application settings according to a certain context of use. Matchmakers can make use of further components provided by the Cloud4all personalisation framework. These components are summarised in Figure 2.

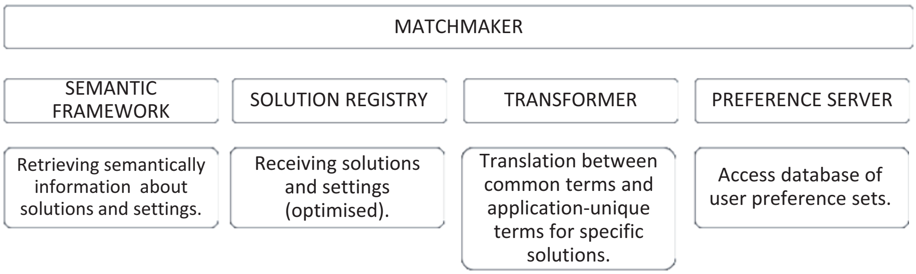

Figure 2. The matchmaker framework defines various components of the personalisation infrastructure which can be optionally used by various matchmakers.

Matchmakers may need access to information about mappings or translations between common terms and application-unique terms that have been contributed to GPII by vendors or developers. Such translations are executed by the Transformer [4]. Another component in the personalisation infrastructure is the Semantic Framework [15], which can be used by matchmakers to retrieve semantic information about solutions and settings. Furthermore, a matchmaker can retrieve solutions and settings from a performance-optimised database, namely the Solutions Registry [4]. Some types of matchmakers may need access to all the data in the Preferences Server, which stores preferences sets, for instance in order to perform statistical analysis [4]. A matchmaker is free to use the supportive components that provide additional information that can be used in the matchmaking process.

Conclusion and planned Activities

In general the personalisation approach explained in this paper aims to deliver tailored access to technologies and information, mainly to improve accessibility. The spectrum of related approaches indicates that personalisation and adaptation are promising in the field of accessibility. While existing approaches to adaptation in case of false proposals rely on the end user to detect and correct them, we have identified a new requirement, namely that automated adaptations must never result in inaccessible user interfaces.

Our approach to personalisation is a flexible and extensible matchmaking approach that is not limited to a particular domain, design area or user group. It is based on two general personalisation scenarios which follow two priorities: (1) give users access to any technologies based on their individual needs and preferences and (2) provide users with new features that may better suit their current context of use. The matchmaking process is designed to address these objectives by including different matchmaking strategies. A matchmaking strategy is independent of a certain technology and the modules defined by the matchmaking framework. The concept presented in this paper can reduce the effort of manual adaptation and configuration and increase the learnability and optimisation of ICT products. Personalisation developed for GPII capitalises on highly customizable applications and devices by mapping user needs and preferences to application settings, in an automated fashion and for a wide context of use.

Acknowledgements

Results presented in this paper have been researched within the Cloud4all project. Cloud4all is an R&D project that receives funding from the European Commission under the Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 289016.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
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doi:10.3233/978-1-61499-304-9-1366

A Cloud-Scale Architecture for Inclusion: Cloud4all and GPII

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Abstract. The Global Public Inclusive Infrastructure (GPII) is an international collaboration to create tools, infrastructure, and resources that can automatically adapt user interfaces to suit an individual's needs and preferences. With the GPII, users can store their preferences securely in the cloud, taking them with them as they move to different platforms and devices. As part of the Cloud4all Project, the authors have designed and developed an architecture and reference implementation to support the ambitious cross-platform technical and user experience requirements of the GPII. This architecture is intended to support the long-term growth, extensibility, and sustainability of the GPII's personalization system. In this paper we describe the architecture and organizing principles of the GPII/Cloud4All framework, its variety of expected deployment and interaction styles, and how it expects to meet future technical challenges and age gracefully.

Keywords. Inclusive design, accessibility, cloud, preferences, interface adaptation, personalization, REST, JavaScript, Inversion of Control

Introduction

The Global Public Inclusive Infrastructure (GPII) is an international collaboration to create tools, infrastructure, and resources that can automatically adapt user interfaces to suit an individual's needs and preferences. With the GPII, users can store their preferences securely in the cloud, taking them with them as they move to different platforms and devices.

The GPII takes a "one size fits one" approach to accessibility, recognizing that we all experience disability in different contexts and environments. In this model, disability is not viewed as a personal trait but as a mismatch between the individual's needs and the user interface available to them. An accessible system is one that can adapt to and accommodate the user's needs and preferences. The goal of the GPII is make this vision of a personalized user experience a reality across desktop, mobile and web environments.

From a functional perspective, the Cloud4all/GPII architecture is designed to enable users to describe their needs and preferences, store them securely in the cloud, and use them to automatically configure assistive technology, access features, and content. The system can adapt mobile, desktop, and web user interfaces, configuring them with the user's preferred applications (for example, a screen reader) and settings (e.g. their preferred voice speed).

1. Technical Challenges Faced by the GPII Architecture

The Cloud4all/GPII architecture addresses these critical technical challenges:

- Supporting a diverse array of platforms
- Enabling deployment in cloud-based environments as well as intranets and local/offline use
- Promoting long-term growth, scalability, and community contributions
- Minimizing the amount of code required to integrate third-party tools
- Ensuring that a user's preferences remain secure and private

Seeking to meet these challenges, especially those relating to the long-term technical and community trajectory of the system, have led us to a number of architectural and philosophical choices described in the next sections.

2. Technical and Philosophical Orientation

The system is composed of a set of REST-based[1] components that are responsible for doing the work of finding the user's preferences, matching them with the appropriate solutions, and setting up and launching the necessary assistive technologies and access features. These components are managed by an event-driven component called the Flow Manager, which weaves them together using declarative configuration instead of code. The system can be extended by adding new event listeners, components, and data sources to the JSON-based configuration files—no code typically needs to be modified.

The framework employs the Inversion of Control idiom, ensuring that each component is modular and can be extended without requiring brittle, hard-coded dependencies between components[2]. Additionally, this approach offers the flexibility to deploy each component in different ways, including locally and remotely. Developers and system administrators thus can "partition" the physical architecture according to their own unique performance and security requirements. The GPII/Cloud4all architecture is implemented using technologies that can work both in the Web and native environments, primarily JavaScript, HTML and Node.js.

3. Architectural Organisation

Figure 1 shows the overall structure of the deployed components comprising an installed instance of the GPII system - whether on the user's local device or in the cloud. A given installation may have multiple instances of each component, or none - in addition, these may be co-located or distributed. However, the core component at the diagram center, the Flow Manager, is present in each deployment.

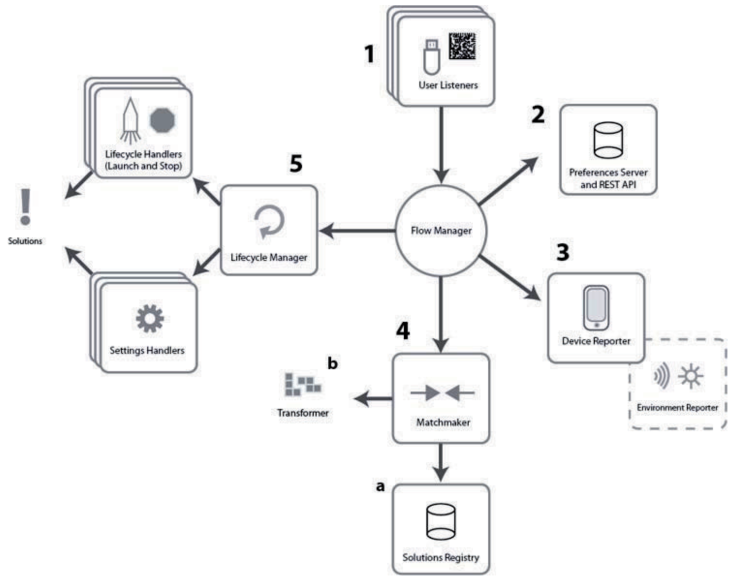

Figure 1: Component architecture of the GPII.

3.1. The Auto-Personalization Flow

The purpose of Cloud4all/GPII architecture is to enable the personalization of desktop, mobile, and web applications and content based on the user's needs and preferences. Here's how it works:

- The user starts the process by describing their needs and preferences to the system using an editor, wizard, or discovery tool.
- From there, the system is able to automatically configure a mobile device, computer, or web site with the user's preferred applications (for example, a screen reader) and settings (e.g. their preferred voice speed). Web content will be automatically adapted to suit the user's preferences as well.
- When the user approaches a GPII/Cloud4all-enabled device, such as a computer at a library or their new smartphone:
  1. The user offers a key (a unique, non-identifying string) to the device using a range of techniques such as:
     - a USB device (flash drive or special device)
     - an NFC ring or phone or other NFC Tag
     - typing in a special string on the keyboard
     - a continually changing key code
     - etc.
  2. The User Listener component, typically running on the local device, will detect this key and send it to the Flow Manager.
  3. The Flow Manager will orchestrate the process of configuring the device by bringing together:
     - The user's preferences (from the Preferences Server)
     - The range of applications and access features (Solutions) available to the user either on the local device, on the web, or in the cloud (from the Solutions Registry)

   - Information about the device's characteristics and the user's working environment (with their permission) (from the Device Characteristics Reporter)
4. The Matchmaker is the part of the system that makes decisions about how to meet the needs of the user. It is responsible for:
   - Matching the user's preferences with the available solutions
   - Resolving device, context, and environment-specific conditions for those settings
   - Assembling a list of the features and applications that need to be configured on the device
5. The list of solutions and their settings is then passed to the Lifecycle Manager, which manages the process of configuring settings
6. The Lifecycle Manager, in turn, invokes a set of Lifecycle Handlers and Settings Handlers that do the actual launching and setting of applications and access features.

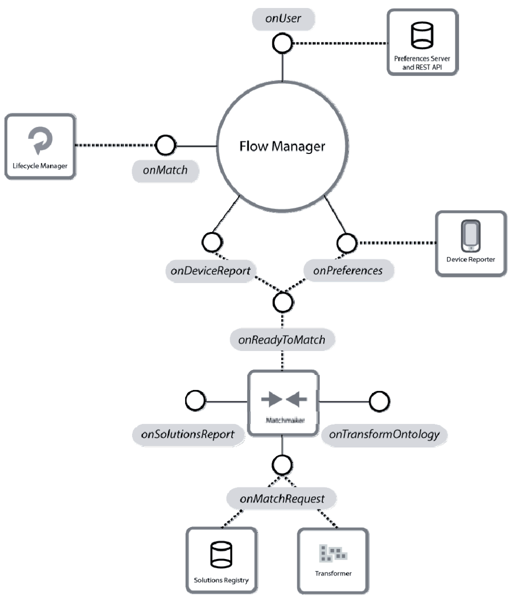

Figure 2: A simplified view of the GPII Flow Manager and Matchmaker's event-driven workflow.

3.2. The Flow Manager

The Flow Manager is the event-driven, asynchronous orchestrator of the personalization workflow. It is implemented as a very small server that runs on the local device, or may also be deployed in the cloud: it is responsible for bringing together the various components in the system and invoking them at the appropriate points in the process.

The key responsibility of the Flow Manager is to manage the workflow of the personalization process, providing the means to register components with the system and bind them to specific events and lifecycle points within this workflow. A depiction of this workflow in schematic is shown in Figure 2. The Flow Manager uses an

Inversion of Control approach (provided by Fluid Infusion[3]]) to instantiate and wire up dependencies between components. This means that components rarely have a direct coupling with other components in the Cloud4all system. New features and components can be added to the Flow Manager without requiring code changes to the other components or the Flow Manager itself.

4. Preferences Editors

Given Cloud4all's broad and diverse audience, it is clear that no single preferences editor user interface design will meet the needs of all users. There is an incredible diversity of experience levels, comfort with technology, ability, age, and other factors that influence the design of user interfaces for preference editing. We need to speak the language of our users, giving them an environment in which they feel comfortable discovering what they need and experimenting with new settings. The Cloud4all architecture needs to take into account this diversity, making it easier for designers and developer to create different user interfaces for different users.

The two main preferences editors that are part of the Cloud4all deliverables are the Preferences Management Tool (PMT) and the Personal Control Panel (PCP). Both will be developed with a common core framework (the UI Options Preferences Framework) and will share a consistent set of user interface controls and interaction idioms. They will, however, provide distinct user experiences that are optimized for different use cases. The PMT provides a more in-depth means to edit an entire preference set (including contexts and conditions where appropriate). The PCP, on the other hand, is optimized for quick, on-the-fly adjustment of frequently-used settings.

From an architectural perspective, both the PMT and PCP will be built using web technologies (HTML, CSS, and JavaScript) to ensure that they:

- can themselves be automatically personalized and transformed to suit a users preferences
- will be available across the myriad of platforms, operating systems, and devices we anticipate supporting in Cloud4all without costly rewrites
- will share a common design approach and technical foundation to many other aspects of the Cloud4all architecture, including the Flow Manager and the Preferences Server

The PMT will be accessed as a familiar in-browser web application, optimized for larger screens and longer time spans of usage. The PCP, on the other hand, will be always available on the particular device or system the user is interacting with. As a result, the PCP will be wrapped in a "native app" runtime so that, despite being cross-platform and built with web technologies, it will still work in offline contexts and idiomatically like any other app on the platform. This native wrapping will be accomplished on desktop using a Node.js-based runtime such as the Node-WebKit project and on mobile with Apache Cordova (also known as "PhoneGap").

5. Security and Privacy

A user's preferences may reveal personal information about their lives and needs, either directly or indirectly; privacy and security is thus of critical importance to the design of the Cloud4all architecture. While we are still in the process of designing the Cloud4all security and privacy, the intention is to use tools and standards that are broadly used on the web and in industry, such as the OAuth 2.0 framework[5]. OAuth will help ensure that the Security Gateway and core architecture will protect access to a user's preferences by third party applications such as the web sites, content delivery tools, and other appilcations. The use of OAuth will let users approve or deny access to their information on a per-site basis, ensuring they control who gets to see and act on their needs and preferences.

After the basic OAuth 2.0-based authentication infrastructure is established, an attribute release layer such as the Kantara Initiative's User Managed Access will be layered on top[6]. This will give users the further ability to specify that a site or application is able to see only portions of their preferences set, ensuring that the risk of "privacy leakage" is reduced by only sharing the minimum information required by a service to meet the user's needs[7].

The architecture's security and privacy infrastructure will be developed as a set of low-level libraries that can be integrated directly into the realtime framework's Node.js-based web services, ensuring that all components within the system can be protected appropriately and in a performance-optimized manner.

A key goal of this effort is to ensure that this architecture can support diverse privacy and security requirements internationally.

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Assistive Technology: From Research to Practice
P. Encarnação et al. (Eds.)
IOS Press, 2013

doi:10.3233/978-1-61499-304-9-1372

Managing Preferences in the Cloud – Requirements and UI Design

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Abstract. This paper describes the extraction of user requirements for cloud based preference set initialization and management and the development of a preference management tool for managing user needs and preferences for user interface adaptation in the cloud as part of the Cloud4all project.

Keywords. cloud computing, user interface adaptation, preference settings.

Introduction

Cloud computing will play an important role in the research area of accessible ICT in the next years. Cloud computing as a centralized provision and usage of ICT services over a network will be a big chance to enhance accessibility [1]. Assistive Technology does not necessarily have to be installed on the user's device. Users can use their preferred AT on every device, anywhere and anytime. Furthermore, adaptable and adaptive user interfaces can access data from the cloud to automatically adapt devices and user interfaces.

User Interface adaptation und device auto-configuration based on data in the cloud and providing accessibility services from the cloud is the main research topic of the European Commission FP7 grant Cloud4all. The Cloud4all project aims at establishing a new paradigm in accessibility by augmenting adaption of individual products and services with automatic personalization, using cloud technologies to activate and augment any natural (built-in) accessibility or installed access features a product or service has [1].

The augmented adaptation of the user interface and accessibility features is thereby based on preferences and needs of the cloud users. This approach is not deficit-based or diagnose-based. User interface adaptation will rely on personally defined preference settings only. Therefore, the user has to define an initial set of preferences and needs valid for general device auto-configuration or for a specific device and context. These preference settings will be stored in the cloud. A match making algorithm will use this data, to infer preferences for other devices, platforms and conditions and will automatically adapt devices and user interfaces with regard to the user's needs and preferences. As an example, a user defines an initial set of preferences for high contrast and readability. These preference sets will be stored in the cloud on preference server.

When accessing a ticket machine, the user will be identified via Near Field Communication, USB device or password; a device reporter will provide information about the device and the environment, which will be taken by the matchmaker to infer appropriate device settings for the ticket machine, based on the initially generated user preferences.

However, before an automatic adaptation can be processed an initial setting of user preferences and needs is mandatory. Furthermore, the user needs to be capable of changing his/ her settings anytime and anywhere regardless of the inferences from the matchmaker. On this account, within the Cloud4all project a Preference Management Tool will be developed for preference set initialisation and management. This tool will be complemented with an on-the-fly control panel of settings.

1. State-of-the-Art on user Profile Initialization and Management

There are different approaches for the personalisation of adaptive and adaptable user interfaces and profile management. The European project GUIDE (Gentle user interfaces for elderly people) employs a guided tour with questions, tasks, and interactive games, in order to diagnose user skills and preferences. A similar approach is taken by the European project MyUI (Mainstreaming Accessibility through Synergistic User Modelling and Adaptability). Both projects aim at providing accessible user interfaces by system-initiated adaptations. GUIDE relies mainly on augmentations of an existing user interface by additional elements to improve the accessibility [2]. In contrast, MyUI generates individualised user interfaces during run time from an abstract description of the interactive application [3]. A main difference to the Cloud4all approach is that both projects rely on a user profile, which describes user characteristics, i.e. capabilities and disabilities. Especially, GUIDE takes an approach to user profiling which has to be carried out within an explicit step of system initialization [4] and is very close to medical diagnosis. This categorization of users according to their limitations is for ethical reasons not desirable for Cloud4all. Besides defining the user profile based on information about the user and his limitations per se, the MyUI infrastructure also includes a “User Interface Profile” which maintains features of the user interface – without storing information about the user himself. Design patterns (so called “Individualization Patterns”) provide rules for transforming the user profile into the user interface profile, i.e. for deducing optimal user interface settings from the available knowledge about the user and his environment. The most important mechanism for the MyUI user and context profiling consists in hardware (e.g. eye tracking) and software sensors which detect relevant events during the interaction. Such events are, for example, repeated undo actions (the user apparently selects wrong options by accident), time-outs (the user doesn’t react to a prompt within a certain time slot), and detours.

A highly relevant project for preference set management is the Fluid Infusion Project [5]. The Fluid Infusion framework includes a toolkit of flexible, ready-to-use user interface components for setting preferences as well as the framework to build custom components. The Infusion User Interface Options component is part of a system that allows users to customize the presentation of user interfaces by providing controls for adjusting preferences. UI Option components can easily be integrated into the Cloud4all tools, because this toolkit offers a direct, minimalistic approach for setting UI options and because the components are flexible enough to be included into new interaction concepts. On this account, the UI Option approach is used to provide basic UI components for Cloud4all needs and preference management.

2. User Requirement Analysis and User Interface Development

Within the Cloud4all framework, a requirement analysis with different end-users was conducted to gather the main requirements regarding preference management and automatic personalization of devices and user interfaces. Two focus groups have been carried out with users that had different impairments (blind, low vision, deaf, hardness of hearing, learning difficulties and physical limitations) as well as elderly users with mixed mild limitations in seeing, hearing, and cognitive abilities. The following topics have been discussed with the users and requirements have been inferred:

- Requirements for device auto-configuration and user interface adaptation,
- Requirements for preference management and preference set initialization,
- Categorization and presentation of user interface variables.

Table 1. Main user requirements for preference set initialization and management.

Requirement
Users would use a personal device (e.g. personal computer, smartphone, tablet PC) for preference set initialization, that is already adjusted to the user needs and/ or already equipped with the needed AT. Device settings can then be saved as preferred settings.
Preference set initialization should be handled in a way comparable to an application store: different alternatives for preference settings are offered and can be accepted or rejected.
Users would prefer a step by step approach for preference set initialization (e.g. dialogue wizard), where user interface parameters can be adjusted to the user's needs by selecting an option out of an defined number of proposed options or by adjusting the value for an interface parameter (simple and advanced mode).
Users can imagine generating a first "rough" preference set, that is extendable, as well as to compile a detailed preference set in one session.
The WYSIWYG[1] principle should be applied – when changing a preference setting, a preview of the effect should be given.
Preferences should be clearly categorised within the preference management tool. A categorisation in sensory channels, e.g. "visual", can be ambiguous, because it is not clear, if the category contains preferences regarding visual elements or settings for people with visual impairments.
Users would like to manage preferences and to change preference settings of public devices remotely, using a personal device (e.g. preferences settings for a ticket machine are accessed via a persona smart phone using near-field-communication).

Based on the user requirements and the architectural requirements a first conceptual design of the preference management tool has been defined and implemented as a first prototype.

3. The Cloud4all Preference Management Tool

Within the Cloud4all approach, accessibility will be ensured by automatic interface adaptation based on the user's needs and preferences. The ideal case: the matchmaker adaptation would provide the most accessible interface/ device (in regard to the user) on every device in every possible context. However, to make this happen, the user needs to initially define preferences, which the matchmaker can use for adaption. On this account, Cloud4all applications for preference set initialization and management

[1] What You See Is What You Get: This is a design principle that is based on displaying the options available in the most direct manner.

that will be accessed before any adaptation has been processed have to be accessible to a wide range of users. This aim can be achieved by providing flexible user interfaces. This means that users and developers can customize the way to interact with the system, such as changing the screen-layout.

The Preference Management Tool will provide the mechanism for the initialisation of preference sets and the platform for managing preferences for different devices and contexts in a flexible way. The Cloud4all preference management tool will be a browser based application available on personal devices like PCs or smartphones and will be connected to the Cloud4all architecture. There are various ways to initialize a set. A wizard will provide a step-by-step approach for defining a set of main preferences, device settings can be mirrored to be stored as initial preference sets, and the user can use the preference editor for defining preferences for every user interface component available in Cloud4all. Furthermore, with the PMT (Preference Management Tool) the user can access preference sets stored on the Cloud4all Preference Server. For example, a user can change settings for an ATM machine using the PMT on a Desktop PC or mobile phone. The transaction messages between Preference Management Tool and the Cloud4all system will be in the JSON format. The Cloud4all Needs&Preference Ontology includes various user interaction related concepts and will be used to link user needs and preferences with User Interface Components. Furthermore, UI Option components of the Fluid Infusion Project are integrated for preference setting. The Infusion User Interface Options component is part of the PMT that allows users to customize the presentation of user interfaces by providing controls for adjusting preferences. User Interface Options (UIO) was designed to harness the flexibility of HTML and CSS to support user interface customization. It presents a user interface so that users are enabled to specify their preferences and it provides the engine that transforms the interface according to those preferences. The UIO framework underpins the entire interface customization capability of the Cloud4all technologies [5].

After registering to the Cloud4all system, the user chooses the preferred way of preference set initialisation. Conceptual design of the wizard is still under development, but it is foreseen to provide more than one wizard, so the user can even choose a most appropriate wizard (e.g. a wizard that deals more with icons and symbols or a wizard especially for assistive technology can be imaginable).

The initial preferences will encompass a predefined set of basic preferences that will build the basis for inferring device specific preferences. After creating a first set of preferences, the user can change the preference settings or define new preferences for specific devices by using the preference editor.

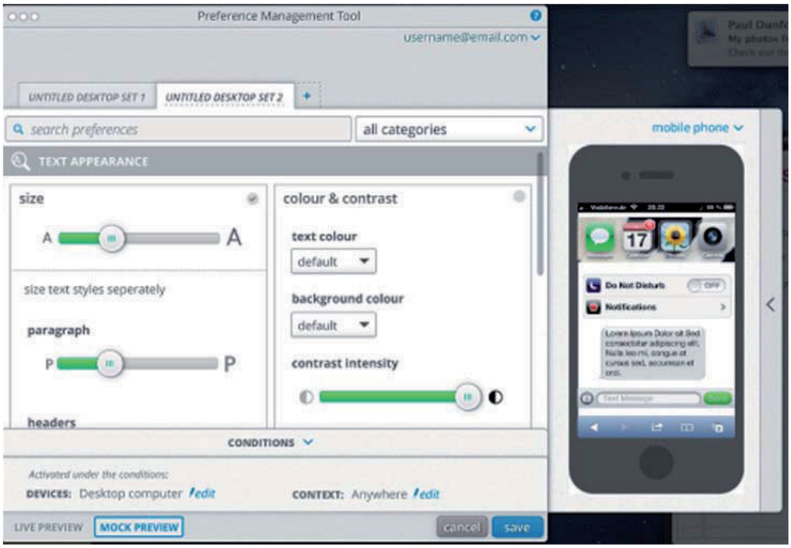

Figure 1. Cloud4all Preference Management Tool with setting preview.

The user can set preferences by searching for UI Option components or by selecting a UI Option category.

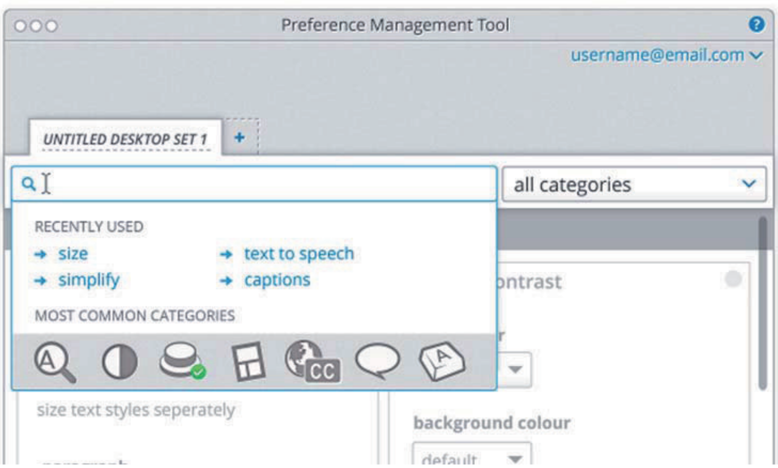

Figure 2. Cloud4all Preference Management Tool with search functionality.

A live or mock-up preview will show the (simulated) setting changes for the selected device. The user can also define conditions under which certain preference settings will be activated. Conditions, e.g. device or context of usage, can help define preferences and user needs in more detail. A preference set with defined conditions will only be used for auto-configuration if the conditions are fulfilled.

4. Conclusion and further Research Topics

Users differ a lot concerning their willingness to create preferences using a management tool. Some users want to define only a 'rough' initial preference set leaving in depth preference definition to the inferences of the Cloud4all matchmaker. Other users want to set their preferences in detail, considering conditions and devices for preference setting. Thus, special attention needs to be given to providing an interface that picks the users up wherever they start, either knowing exactly which UI Option they want to adapt (such as "line spacing"), or just having a vague idea of what their current problem is (I need something "better to see"). Furthermore, the interface has to cater for all types of users, whether they want to go deep into the system and do detailed preference settings, or if they just want to make a profile that ensures every interface they use is somehow accessible, as later they will do the detail changes on the devices themselves. On this account, the Preference Management Tool has to be designed in a way that the complexity of the Cloud4All approach is not visible to the user, even though some pro-users want full access to deep preference edition functions.

To assure that the tool for preference management developed within Cloud4all fulfills the user's requirements the prototype and the concept behind will be validated with users in the first Cloud4all pilot phase. Furthermore the tool will be complemented by advanced functionalities for privacy settings and user identification as well as for sharing preferences with other users.

Next to the Preference Management Tool the design and research teams of Cloud4all are working on a personal control panel as an on-the-fly solution for preference management. While the Preferences Management Tool is meant to set up and edit preference sets that are stored on the preference server, the personal control panel will be meant for immediate and non-permanent changes.

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