Lutherdt, Stefan; Fröber, Ulrike; Wernstedt, Jürgen; Witte, Hartmut; Kurtz, Peter :

Development of assistance systems for user groups with specific handicaps – a challenge for the ergonomic design process

Publikation entstand im Rahmen der Veranstaltung:
XIX Annual International Occupational Ergonomics and Safety Conference, Las Vegas, Nevada, USA, 27 - 29 June 2005

Proceedings of the XIX Annual International
Occupational Ergonomics and Safety Conference
Las Vegas, Nevada, USA
27-29 June 2005

DEVELOPMENT OF ASSISTANCE SYSTEMS FOR USER GROUPS WITH SPECIFIC HANDICAPS – A CHALLENGE FOR THE ERGONOMIC DESIGN PROCESS

Stefan Lutherdt[1], Ulrike Fröber[1], Jürgen Wernstedt[2], Hartmut Witte[1], and Peter Kurtz[3]

[1]Department of Biomechatronics
Faculty of Mechanical Engineering
Technical University of Ilmenau
PF 10 05 65
98684 Ilmenau, Germany
Corresponding author's email: stefan.lutherdt@tu-ilmenau.de

[2]Department of Systems Analysis
Faculty of Informatics and Automation
Technical University of Ilmenau

[3]Department of Working Science
Faculty of Mechanical Engineering
Technical University of Ilmenau

Abstract: The goal to develop an assistance system for handicapped users with several impairments was successfully achieved. The design process as a whole lifecycle with iterative processes was shortened by several reasons. But this newly applied design process with underlying design rules given from mechatronic and biomedical products results into a usable system for the targeted groups as well as for other potential users. The main components of the design process were an intensive task analysis and determining of user profiles and user requirements.

1. INTRODUCTION

In the past years a rapid boom in the field of information and communication technologies took place. Especially by miniaturization manifold capabilities to support handicapped persons are given. Nevertheless these technologies are not widespread in terms of assistance products. An exception are cellular phones and personal computers. An survey on relevant persons (in this case members of the associations) and expert dialogues revealed deficits of technical devices in everyday life as well as deficits of aids that are developed especially for visually impaired people. Absence of user-friendliness has often been criticised for the existing devices.

Often these so called „marginal groups" (in addition elderly people too are addressed) are assessed not very attractive from a commercial point of view. Hence there are no special efforts to adequately fulfill the requirements of these persons. One more reason could be due to the heterogeneity of different groups of handicapped people and for this reason different requirements for devices and techniques.

Based on legal rules and laws in Germany it has become an obligation ("Behinderten-Gleichstellungsgesetz" and following decrees like BITV) to enable all persons, especially handicapped persons, for equal participation in public life. In accordance to the classification made by the WHO 1980 a reduction of existing (and unfortunately generally accepted) obstacles in touristic environments for impaired people effects a reduction of their handicap opposite to people without impairments.

For the project „Touristic Assistance System for barrier-free access to vacational , leisure-time and educational activities" (TAS) a reduction of existing barriers means to reach positive changes in the field of information offered (implementation of the BITV), to improve planning a preparation of vacation and to offer a support during typical vacation activities. This assistance allows a lot of persons for the first time to take part in leisure time activities autonomously (e.g. hiking, visiting restaurants, go swimming or access services).

ISBN: 0-9652558-2-4

2. INITIAL POINT

To establish such an assistance system in an user environment successfully, intensive explorations on the different requirements to an accordant system have to be made. The challenge in system design from the ergonomic point of view is the extreme inhomogeneous formation of the user groups. These potential future users are:

1. tourists with and without different handicaps as the directly targeted group for the assistance.
2. local authorithies, touristic service providers, communal and regional representation of interests of handicapped people, communal and regional service centers for touristic offers, system providers and administrators of the TAS, public short-distance traffic, regional emergency dispatch centers and work groups as well as gastronomical and hotel services.

Because wishes, requirements and the advantages resulting are very different between the diverse users, reaching a concordant solution is just possible by an intense analysis of all tasks and user relevant aspects of the divergent groups. The benefit of the assistance system for elderly handicapped people results in an increase of traveling qualitiy and therewith an improvement of quality of life. For commercial users the system gives the oportunitiy to enhance the atractiveness by the assistance system as an regional unique selling point with the according economic effects.

The usually chosen approach in usability engineering of an iteratively ongoing design lifecycle to identify and increase operator convenience could not be applied for this system for the following reasons:

- The target group has not a sufficient size and is mainly not available all the time to include tests of a reasonable amount iteratively in the development. There would be the danger of falsification of the results because of overlapping samples from the usergroups while testing.
- The limited development period and the available human and material resources demand a direct, unidirectional development process without important (cyclic) feedbacks. Especially the second headword is not enough accepted and established. But in most cases esp. in SME's[1] development processes there is not enough scope (financial as well as temporal) for a whole usability design lifecycle.

Although basic system features have been given, they should be completed by early insights in user specific requirements in terms of the best possible inclusion to the system design. [after Nickerson 1999] Even then the solution developed is an intersection of possible versions of single solutions for the different user groups. Therewith a satisfying usability for all people is just reachable with cutbacks. This fact was knowingly accepted as a compromise in terms of social tolerance and abdication of exclusions (by single solutions or privileging of majorities).

3. REQUIREMENT ANALYSIS

To avoid iterative development phases an extensive requirement analysis was made. A shortened usability design process was derived from the known lifecycle Thereby the following main points (as derived from Mayhew 1999) were in the focus of the analysis and therewith in the design process:

- Creation of user profiles
- Task analysis
- Common design principles for information and communication devices for mobile applications as well as for internet-based information offers
- Design and installation of specific user interfaces

Because of the fact that the system is to be developed and applied primarily for persons with specific handicaps, the requirements for these user groups have been acquired and faced to the generally known requirements of assistance systems and information technologies for users without impairments.

The development happened without an explicit processing of a style guide[2]. Although the results have been reviewed regarding to their applicability for other user groups. All elements defined have been constructed with an open structure, which is expandable. For this reason it was possible to add new information for a later following adaptation of the data base.

[1] SME: small and medium enterprises
[2] For designing the web-based information offers indeed were fallen back on existing style guides (e.g. from W3C, WAI).

3.1 User profiles

Initial point of all operations has been the challenge to establish an assistance system for blind and visually impaired people, that allows these persons an autonomous movement in nature within a defined region at selected routes. This group was selected by considerations, that this group has to overcome the most individual problems in the environment described.

In Germany there live approximately 6.7 million people with a severe disability. 500.000 of them are visually impaired, 155.000 are blind, 250.000 have speech disorders, defective hearing or disturbances of equilibrium. More than 100.000 are paraplegic and dependent to a wheelchair.[SBA 2004] All numbers are more or less estimations, because just those people who get national or private support payments statistically can be registered. About 16% of the blind persons have a good command of the Braille alphabet, only 23.000 are able to write and read Braille-shorthand. 1.600 blind persons live with a seeing-eye dog (~ 1%).

All persons of the targeted groups have in common, that they have a complicated access to electronic information and respectively the information carriers such as PC or information terminals because of either sensory or physical handicaps. [DBSV 2004]

For a better description of the user profiles for blind and visually impaired persons, a multi level interrogation was executed. Thereby a big number of samples (459) could be reached by involving the association of the blinds and visually impaired of Thuringia. The most important parameter of the interrogation had been the existence of certain technical devices in their homes, the experiences made whit them and the importance of the existence of different features of PCs and communication devices. A second spot was pointed to the experiences during their possibly made vacations in the past and the expectations of a region with attractive offers for blind and visual impaired people.

Figure 1: Interrogation of experts about user habits and design deficits of electronic devices for blinds

As a result of the analysis the following essential requirements could be determined for this user group. The results particularly diverge from the hypotheses established before:

- The manner and cruelty of the disease is little determining of possibilities to use a assistance system and the acceptance of such a system.
- More important is the individual history, esp. the entrance time of the visual impairment, but also personal experiences and the accoutrement of the private surroundings with IT-devices and computers.
- Because blind users of PC's and communication devices are often using other exploration strategies and other ways of perception, the blind and visual impaired have other expectations about these used devices and the jointed operational strategies as seeing people. (cp. Kahlisch 1998)

3.2 Task analysis

The main problem performing the task analysis was in that case, that the users could not be observed during the task execution, because there is nowhere a comparable system. Thus all the application flow and user related tasks were observed and analysed as imaginary processes.

The task focal points of the whole assistance system were defined to 3 parts:

- Availability of route planning for handicapped people from home (PC) or at specialised travel agencies. This web based information have to contain statements about special support and leisure-time activities during their potential stopover.
- Navigation and tracking with user adapted information relaying of user specific information contents during the residence in the area of the assistance system.
- Monitoring of critical vital parameters after a medical indication.
- Reconfiguration of the routes after temporal necessities.

Figure 2: On-site inspection to determine the outdoor routes and classification of their obstacles

After all the system has to be configured that way, that handicapped people could use the system as well as that interested not handicapped tourists could use the information for their benefit too.

To determine the routes and identify the existing obstacles multiple inspections with concerned people and experts were made (example see fig. 2). The results were filed in tables in a SQL data base. Also in this data base (at the main server) were filed additional information about the sensory and motor abilities of the particular user groups. These abilities got a weight for valuation of the ability to overcome several obstacles. Simultaneously to all of the user groups were assigned the variants of user interfaces. Some examples of potential obstacles (stationary, movably, constantly or temporally appearing) are shown in fig. 3 (without weighting). Thereby is to see that some obstacles are relevant for all of the user groups and some others only for one or few of them.

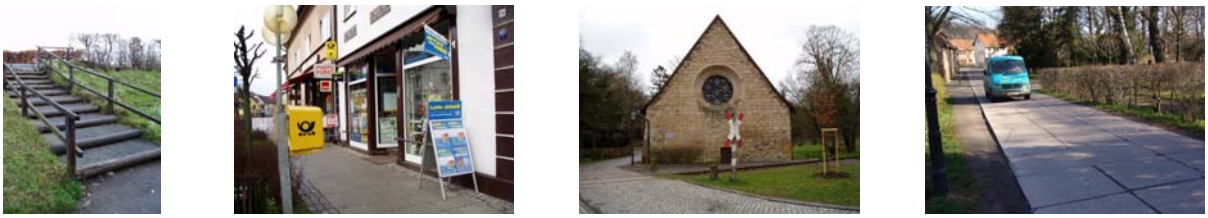

Figure 3: Several possible obstacles in the inspected surrounding (temporal a car, stationary like the stair, mailbox or lantern, imaginary like a possible arriving train at the crossing)

3.3 General design principles

At the starting point was defined that the system should be consist of available components based on the competences given from already successfully completed projects. It have to be included the technical standards of barrier-free buildings and web design as well as modules and components from defence, medical engineering and from robotics.

The existing rules and positive examples of barrier-free information offers (e.g. given from W3C, WAI), of constructional formation and good accessibility as well as of established aids have to be incorporated into the systems design. All of critical information have to send at least over 2 sensory channels. With it is to be seen that it is inevitable for blinds and deaf people to have a haptic interface (e.g. via vibration).

All design principles logically applying to all of the hardware components as well as to the software technical connection and the design of graphical user interfaces and dimensioning of informational aids.

4. IMPLEMENTATION

Because of the connection to the internet and the intended application in areas with specific health relevant requirements, special safety strategies have to be abided during the realisation of the systems requirements. This concerns the safeguarding by hard- and software against attacks and systems crashes as well as safeguarding against internal system failures. Therefore the general design rules of biomedical products were taken as a basis. The essential components of the system were laid out redundantly. The whole system works with two independent and mutual observing main servers with an identical hard- software configuration. Self-contained from these servers the information are provided by firewall-secure webservers. The common safety and encryption protocols for wireless and wire-bound communication were implemented. All

of the data packages are proofed of their meaningful content and get a time stamp. In case of missing communication or incorrect data necessary rescue activities are initiated. The concerning device will be ignored or blocked in the further communication.

At the main servers a GPS[3]-coupled route planning software based on a geographical information system (GIS) is installed. To important track points of the digital maps tabular context information are linked. The tables are filed into a SQL data base and can be arbitrarily expanded. These context information (e.g. obstacles, points of interest, aids etc.) are needed for an user specific route planning. By means of obstacle tables and likewise in the data base filed tables of the possibility to adapt the routes and devices to an individual use, an optimal stretch of way will be determined. For this some special algorithms of fuzzy logics are used. After this the user gets all the needed information as well as a notification about the severity code of this selected track. The information is given over the user-chosen interface. (see fig.4 and 5)

Figure 4: Variation of the communication interface for blind people with knowledge of Braille

Figure 5: Mobile user terminal(PDA) with installed route planning software and visual and tactile notifycation of an obstacle

The communication interface is done by a personal organizer (PDA), via a complying configuration like WLAN, Bluetooth[4], audio output or vibration. To meet the users requirements some additional components will be provided, e.g. headsets or braille displays like shown in fig.4 .

Furthermore the graphical user interface will be specially configured according to the needs of the several users (esp. with extra-large buttons, colour adaptation for people with defective colour vision or choice of a certain voice output). Therefore an own user profile will be filed on the server during the accommodation. This file contains the sensory and motor abilities of the user and with it a special user configuration can be generated and downloaded to the user terminal.

The localisation and navigation during the hiking happens on the base of GPS with a terrestric support from regional allocated barrier-free info-terminals (see fig. 6) These terminals also own a GPS-receiver, but their position is known exactly. The signal-depending inaccuracy of the current GPS-position can be corrected or enhanced at these reference points with the measured positions by statistic algorithms (after a delay of some days for data acquisition).

Figure 6: Barrier-free stationary info-terminals with a possibility of direct query at the terminal (see left fig.), the feasibility to connect with several back-ends over WLAN, Bluetooth or infrared

[3] GPS: global positioning system
[4] WLAN: wireless local area network; WLAN and Bluetooth are two standards for wireless communication

5. CONCLUSIONS AND OUTLOOK

It has been shown that a shortened design lifecycle with an extensive analysis of user potentials, tasks and system requirements yields usable results. A modular extensible data base of identified obstacles, general user qualifications, user experiences to use applied system components as well as usable and available aids was established. This data base enables a route planning system for commonly not compatible user groups by the use of fuzzy logic algorithms with weighting of data base parameters.
By the early inclusion of the concerned during the requirement analysis a high level of acceptation is to be awaited. This was affirmed by first tests and interrogations. In the further process of system proving these early results have to be confirmed by continuing usability tests.
To provide the actuality of the data is it necessary to integrate regular controls of these routes into the future operational concept. To ensure the consistency of all inputs with the existing data set and otherwise to make a quality assurance independent from different persons a data input software for mobile devices should be attached to the route planner. For this input software special forms have to be developed with constraint guiding and explicit necessary confirmations for a sequential execution of these tasks. Through the connection to the main servers over the route planner the form data will be balanced and optionally replaced. These data input software actually is in development process and have to demonstrate its usability by following tests. For development and testing some self-developed tools like "*EUKOS*"[5] and "*ODIS*"[6] will be applied.
Though commonly a PDA is not a usable device for real mobile applications (cp. Larni 2004) at the moment none better (and cheaper) devices are available. Otherwise all the potential problematic input functions are limited to a minimum, in essence during the control of routes and affiliation of data. The input actions of handicapped users always happens by hardware buttons and not necessarily during their motion. The data output on graphical display over the audio interface (by using a headset) is task conformable and adequate or superior to other devices.

6. REFERENCES

1. DBSV 2004: Deutscher Blinden- und Sehbehindertenverband e.V.: „Statistisches". Retrieved March 31, 2005, from Internet http://www.dbsv.org/infothek/Statistik.html#Leistung.

2. Kahlisch, T. 1998. Software-ergonomische Aspekte der Studierumgebung blinder Menschen. Dissertation, Hamburg Kovac 1998, ISBN 3-86064-797-0, retrieved March 31, 2005, from Internet http://www.kahlisch.de/phd/inhalt.htm.

3. Larni, J. 2004. Working with a PDA while walking, Proceedings of the WWCS2004 in Kuala Lumpur, 29 Jun – 2 Jul 2004.

4. Mayhew, D. 1999. The usability engineering lifecycle. A practitioner's handbook for user interface design. Morgan Kaufmann Publishers, Inc. San Francisco.

5. Matthesius et.al. 1995. ICIDH - Internationale Klassifikation der Schädigungen, Fähigkeitsstörungen und Beeinträchtigungen. Ullstein Mosby Verlag, Berlin/ Wiesbaden, 1995

6. Nickerson, R. 1999. Engineering psychology and ergonomics. In Hancock P. (Ed.) Human performance and ergonomics, AP academic press San Diego, London, New York, pp. 1-37

7. SBA 2004: Statistisches Bundesamt Deutschland: Schwerbehinderte Menschen am Jahresende. Retrieved March 31, 2005, from Internet http://www.destatis.de/basis/d/solei/soleiq27.php.

8. Sievers, G. 2002. Gestaltungshilfen im EU-konformen Softwareentwicklungsprozess (EUKOS) in: Ergonomie und moderne Bürokonzepte (Tagungsband). Herbstkonferenz der Gesellschaft für Arbeitswissenschaft e.V., Ilmenau 2002

[5] EUKOS: (German abbreviation) EU-konformer Software-Entwicklungsprozess (Sievers 2002)
[6] ODIS: (German abbreviation) Oberflächen-Dialog-Simulator, designed on insights of the „Seeheim-Conference User Interface Technique"by Nowack et.al. (Dep. of Working Science of the Technical University of Ilmenau 2004)

9. WEB for ALL 2005. BITV – Verordnung zur Schaffung barrierefreier Informationstechnik nach dem Behindertengleichstellungsgesetz (und Anlage 1 und 2), und Gesetz zur Gleichstellung behinderter Menschen und zur Änderung anderer Gesetze (Behinderten-Gleichstellungsgesetz), retrieved March 31, 2005, from Internet http://www.webforall-heidelberg.de/html/deutsch/bgg.php