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

Specific I/O-devices for several handicapped and elderly

Zuerst erschienen in:
CD-ROM-Ausg.: Meeting diversity in ergonomics : proceedings IEA 2006 congress / ed. by R. N. Pikaar ... - Amsterdam [u.a.] : Elsevier. - 2006, insges. 6 S.

Specific I/O-devices for several handicapped and elderly

S. Lutherdt[a], P. Kurtz[b], U. Fröber[a], H. Witte[a]

[a] *Department of Biomechatronics, Ilmenau Technical University, PF 1000565 Ilmenau, GER*
[b] *Department of Working Science, Ilmenau Technical University, PF 1000565 Ilmenau, GER*

Abstract

To fulfil the requirements of several user groups with the need of assistance in tourist activities and regions an assistance system was developed. The user frontend is realised by a handheld device combined with additional features matched to the user specifics. The system assures a optimal presentation of the needed information by a easy to learn and easy to use new gesture-based GUI. This and the additional specific I/O-devices and components provide the IT-Biocompatibility. These add-ons are adaptors for wireless transfer to hearing aids, vibro-tactile belts or accumulators and sensors for measuring of vital parameters.

Keywords: I/O-devices, GUI, Assistance system, handicapped and elderly

1. Introduction

The German legislation was changed in the last few years towards an integration of all kind of people into societal activities. With this it followed the prevalent opinion of the WHO and its associations like is reflected in the new International Classification of Functioning, Disability and Health (ICF) [1].

By this point it was self-evident resulted to start a project to support people with handicaps also in vacational or tourist environments. These project called “TAS - Tourist Assistance System” is a cooperative project of different sectors of the Technische Universität Ilmenau, the Fraunhofer Gesellschaft and the small company systems engineering ilmenau (SEI) within the InnoRegio-initiative “Development of a barrier-free model region for integrative tourism in Thuringia” of the German federal ministry of education and research (bmb+f).

For this project a reduction of existing barriers means to reach positive changes in the field of information offered (implementation of the BITV[1]), 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). But giving a support to people who need it essentially for their autonomous move by this

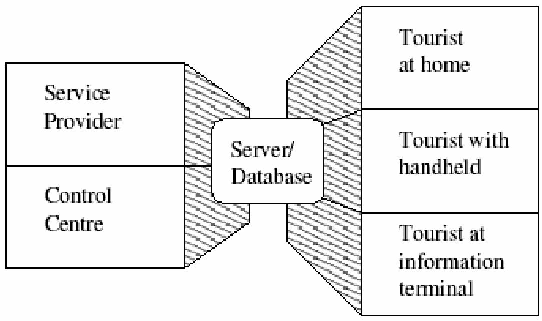

Figure 1: System components of TAS [2]

assistance system gets other potential users a great benefit too because getting them helpful or interesting information and details about their special interests.

The framework of TAS which is shown in Fig. 1 was created for users with handicaps which make them mobility impaired. It consists of stationary components like terminals, a communication and control centre with an internet presence as well as mobile components. These are mainly handhelds with specific add-ons resulting from the special needs of the users. The system is currently established in a small model region to demonstrate the functionality und various possibilities for the different user groups. But it can be very easily scaled and distributed to other regions and combined or added by new services.

At the bottom of the system are location based services which are the state of the art in tourist or other similar fields. To use these services the mobile devices are equipped with GPS-receivers of the latest generation. The unique selling point of this system esp. against other navigation services is the principle, that everyone who use this system get only but all the information he needs over a well-adapted interface.

The ergonomic design process to find these special interfaces, the results and the combining into a mobile assistance system is described in this paper.

2. The ergonomic design process of the assistance system for handicapped people and elderly

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 authorities, tourist service providers, communal and regional representation of interests of handicapped people, communal and regional service centers for tourist 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.[3]

Because of the multi-part development of this system beginning with the base components and add-ons for visual impaired followed by extensions for mobile and hearing impaired the design process does not proceed straight forward. But it also did not allow an iterative cycle like proposed by [4]. Therefore a special process was created which contains elements of both. [3]

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 (as well concerning each of the partial groups as for the whole system) has not a sufficient size. There would be the danger of falsification of the results because of overlapping samples from the user groups while testing.
– The limited development period and the available human and material resources demand a direct, unidirectional development process without important (cyclic) feedbacks.[3]

Resulting form the abovementioned conclusions the following steps were made:

1. generating user profiles
2. executing of task analysis
3. recognizing or deploying of general design principles
4. implementation into the system

For the generating of user profiles and the task analysis an intensive incorporation of the future potential users took place. Although basic system features have been given by the project goals, they should be completed by early insights in user specific requirements in terms of the best possible inclusion to the system design. [after 8].

The temporally shifted beginning of the several project parts had allowed to establish the design process in the first part (system components for blinds) and to test the process in the second part (components for hearing and mobile impaired). It has been shown that this 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.

3. Information presentation in assistance systems for handicapped users and elderly

3.1. Identification of obstacles for handicapped users

For the whole system and the underlying strategies

1 German decree of barrier-free internet technologies

three basal principles were defined to compensate the existing deficits of the users:

1. bypassing of obstacles (by a user adapted intelligent route planning and user conformable technical components)
2. aid to overcome the obstacles (by technical additives and needed information)
3. eliminating of obstacles (also by technical additives and needed information) [5]

Looking at these principles it will be apparently that obstacles for the users do not only exists physically in the surrounding but also by the use of technical equipment and information offers. The reasons for these obstacles resulting from somatic restrains (loss or restriction of perceptions, mobility of limbs or the whole body etc.) as well as from informational or experiential deficits. A great number of the potential users are elderly and have another access to technical equipment and experiential background. But they do want to use such “modern” technical aids because they increase the living quality for the users.

To determine these theses some interrogations around the potential users (with the aid of associations of handicapped people like BSVT or DSB[2]) were made together with a Thuringian company specialised in social and market research[3]. The outcome was that about 50% of the blind and visual impaired want to use the system additionally to their familiar equipment (e.g. white cane) and together with friends or accompanying persons. The dispersion of estimations around the people with hearing impairments was quite similar. The sample of the interviewed people was selected from members of the associations and clients of aid manufacturers. The sample number was 459 people with several visual impairments (38.4% male, 61.6% female). Most of them are elderly, the dispersal was 4.3% 18-35 years, 14.9 36-55 years, 9.4% 56-62 years and 71.4% >63 years. This is reflecting also the age pattern of these visual handicaps under the population in the highly industrialised countries with a more and more increasing number of elderly. The range of age under the people with hearing loss spread from 20 to over 60 years (sample number 30, 43% female and 57% male, 23% 20-40 years, 43% 40-60 years, 30% over 60 years). For the interrogation two different methods were executed. The visual impaired were interviewed by telephone, for the preparation and setting up of the questionnaire were held interviews of a focus group and of some experts (see fig. 2). The interrogation of the hearing impaired was made as a Delphi-interrogation of selected experts. This results from the awareness that during the preparation of this interrogation it came visible that the potential participants would be similarly answered like the visual impaired. Therefore the method and the scope of the interrogation were changed to get a new input for the further design process.

The main scope of interrogations was on the level of operating knowledge with IT-devices, experienced and known problems during vacations or in a tourist environment, common used aids for their special handicaps, needed and wanted information during hiking or vacation and the manner of information presentation.

Figure 2: Interrogation of experts about user habits and design deficits of electronic devices for blinds

To audit and complement the results of these interrogations some on-site inspections take place with potential users from the focused handicapped groups like is to be seen in fig. 3. At these inspection tours the feasible routes with the occurring obstacles were determined.

Figure 3: On-site inspection to determine the outdoor routes and classification of their obstacles

---

[2] BSVT: Association for visually impaired people in Thuringia (Germany)
DSB: German Association for hearing impaired people

[3] aproxima Agentur für Markt- und Sozialforschung Weimar

3.2. Concept of IT-Biocompatibility

To implement the discovered requirements into the system to reach a product with a high level of usability it is necessary to adapt the technical components as well as the offered information to any special user. This principle of individualisation is borrowed from medicine and biomedical engineering. In this fields where technical components have a direct contact to biological material in many ways it is very common (and mandatory) to examine and assure the biocompatibility of all devices and materials.

Starting from this the concept of IT-Biocompatibility was created. To reach the same standard it is required to adapt the IT-devices or there user related components including the interface, the I/O-strategies and the kind and amount of any information to the respective user. That means an adaptation to personal abilities, experiences, compensation of sensual or mobile deficits and lack of experiences in use of similar devices or user algorithms. Other research groups had found that for visual impaired the semantic understanding of display contents is broadly affected. Control actions of these users could not be executed without additional aids or assistance. [6] Therefore naturally sounding (female) voices are more accepted for trustworthiness. [7] Nevertheless the blind users preferring on computer workplaces synthetic voices for screenreaders (often with a male voice).

The realisation of these requirements means that the set-up of the assistance system will be rearranged for every new user every day. E.g. blind users get headsets and vibro-tactile devices additionally to the standard mobile device with a newly developed (graphic) user interface (GUI). But users with residual visual abilities can adjust the display and GUI to their special needs (font size, several colour schemes). Users with colour-blindness get a corrected colour scheme, and hearing loss users get the information as text, image or animated sign language (video clip).

Another requirement like abovementioned is to present all of the information in that manner like users expect and understand. It is helpful to use metaphors or analogies, but only borrowed from the experience base of the user. This is complicated because of the heterogeneity of the user groups. But the compromise is to use only standard vocabulary without technical specialised items or Anglicisms. It would be helpful to underlie critical information with small explicit images or pictograms.

3.3. Needed information for a helpful and riskless use of the system

It is trivial that the needed information depends on the kind and severeness of a handicap, but it also depends on the individual history. The interrogation had shown that it is more important when and how someone got handicapped then his current age.

Furthermore the wanted information of the users is wide-spread from typical tourist information like museums or theatres, opening hours, shopping facilities or restaurants and sport or wellness possibilities. But there are also asking about the next bus-stop, medical facilities, public lavatories, opticians or acousticians for immediate help in any case of problems with the technical additives.

The most mentioned requirements for a safe and riskless use of the system, esp. the mobile device, are summarised as follows without a ranking:

- actuality of all information esp. of the described obstacles and the routes to bypass them.
- description of tracks combined with a navigation system.
- short, clear but comprehending, the criteria is that after the desription the user should be able to explain the route to another tourist.

Some information especially demanded from visual impaired:

- indication of the position
- level of difficulty of the track
- advice to the next obstacle near to the user and the manner to overcome or bypass it

Other special requirements for hearing impaired users are:

- completeness of all statements (names of streets, public buildings, orientation points)
- visual or vibrational offer of any hazards in the surrounding

These different requirements result from diverse strategies for orientation or navigation.

It was astonishing that some kind of information does not played a role for the interviewed like weather data (only 1,8% responses) or point of the compass (12% responses).

The information should be given by a female voice, this is conformable to other researches [see 7][4]. It is also a tribute to the IT-biocompatibility that users with a hearing impairment get the auditive information in a range of frequency they are able to hear. [cp. 9] To

[4] Amongst others from automotive manufacturers in Germany.

realise a proper transfer to their hearing aid they get a adaptor (ELI™) for wireless transfer via Bluetooth® from the mobile device.

3.4. Identified obstacles by the use of IT-devices

The most named obstacles of the asked users were:

- too much functions on the devices
- incomprehensible I/O-strategies
- liability to interferences
- too small input and control elements
- small fonts or missing labelling
- incomprehensible handbooks or guides
- use of unknown or not common items
- missing help functions

4. Implementation into specific I/O-Devices

4.1. Presentation of the complete system

To realise all of the requirements and to assure a continuous process of user attendance and assistance the system generally consists of three parts: stationary components in the tourist region, mobile components for personal use and web-based components. These components build a user frontend to access to the system and an administration backend (see fig. 1). Access to the system is possible through an internet presence with facilities of planning a vacation, booking requests and orders of the personal devices of the system for the vacation. For this a personal account on the server with detailed personal needs will be generated.

The personal user device consists of a handheld (PDA, Palm) which can be lend by the users added by special I/O-components. Additional stationary terminals are established at interesting and well-accessible points in the region which are user conformable and accessible too.

All services, user data and route planning operations will be handled by two redundant servers in a control and service centre. This system backbone consists of an application server, the data base and a web server. For the whole functionality and the implemented routines see [2].

4.2. Selection of I/O-device combinations

As mentioned earlier the user generate an own user profile (at home or during the vacation) to log in into the system. Within this profile all needed information for personal adjustment of display and other output devices are stored. This data also will be used for individual route planning. But if a user has more than one handicap that may require some conflicts for adjustment and route planning. These conflicts are solved with Fuzzy algorithms. The table 1 shows possible combinations for the users I/O-devices which result from the algorithm.

Table 1: Possible commbinations resulting from detected user requirements

	Hardware components							Amount of min. addressed sensual modalities
User group	**PDA**	**Head Set**	**Vibro-belt / V.-accumulator**	**ECG-recorder**	**ELI**	**FF-Joystick**	**Step counter**	
visually impaired	X	X	X	X[1]			X[1]	3 (2)
blind persons	X	X	X	X[1]			X[1]	2
Hearing impaired	X	X[2]	X	X[1]	X[2]			3 (2)
deaf persons	X		X	X[1]				2
wheelchair-bound persons	X[3]	X[1]		X[1]		X[4]		2
walking impaired / seniors	X	X[1,2]	X	X[1]	X[1,2]			2 (3)
others (e.g. families, athletes)	X	X[1]	X	X[1]			X[1]	3

[1] optional, [2] possible at availability of hearing aid (no headset), [3] possible as laptop or subnotebook with carrier, [4] preparation of equipped vehicles possible

4.3. Development of a new graphic user interface for blinds and visual impaired

Because of the highest requirement level of the blind users to get access to the system by a “graphical” user interface the efforts were pointed to reach a solution for blinds and visual impaired. Other groups can use it easily and the GUI is lowly adaptable or expandable (e.g. with images or graphic elements).

Initial point of the development was that blinds use their hands to detect or get information (“read”). To control the handheld they should not have to learn new strategies and input actions like they normally do for telephony or other well-known devices. These actions were identified by the questionnaire. Also useful to create the GUI was that blind users are mostly able to recognize more steps in menu structures then others. The resulting GUI is shown in fig. 4. The input actions only effect by gestures on the screen. To provide from unintentional inputs or malfunctions a minimal amount of pixel have to be activated. The GUI only accepts 4 gestures, strike up and down as well as left and right. To determine a real input a maximal deviation in the angle and a minimal length of the movement h are given. [2] The input is always feasible by four simple gesture on any place of the screen without learning of gesture patterns like circles or spreading of fingers.

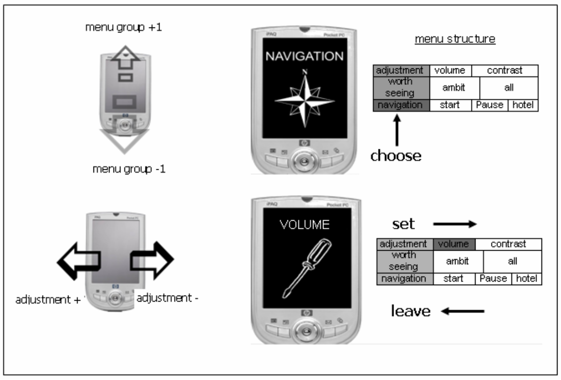

Fig. 4: Screenshots and description of the menu structure

4.4. Realisation of multimodality during I/O-actions

More than for other users multimodality in I/O-actions is necessary for sensual handicapped users. Because they have a restrained perception by a partial or total loss of one or more senses they try to compensate it with the remaining. To disburden the mostly used sense (e.g. auditive sense for blinds) from additional loads which are not highly prioritised (like orientation or communication) it is necessary to use other senses like tactile or haptic. These sensual channels are also useful for a danger notification to bypass or prevent an informational overload for a faster reaction of the users.

Like shown in table 1 all of the users get an output by min. 2 sensual modalities. For input actions currently exists only the described handheld device with a gesture based GUI. In the proposed environment and the prevalent conditions their speech-recognition systems will not be applicable.

5. Conclusions and further goals of the project

With the project TAS –Tourist Assistance System a well-accepted system for all people was developed. The greatest benefits obtain people with several handicaps which up to now not were able to participate in various tourist activities. Tests with potential users had shown that the system will meet the needs of the proposed users. It is scalable and therefore dispersible into other regions, and there exists a market and real demand on this system.

Some problems are not discussed in this paper like the lack of up-to-date available GPS-devices or the energy supply of the PDA's. Besides this the system has to be transferred into a commercial system.

The next steps to enhance the system are to broaden the number and kind of I/O-devices. This will be a tactile vibrobelt similar to ActiveBelt® [10] and an integration of a moveable seat and force feedback controls into wheel chairs. This moveable seat can realise a natural stimulation of muscles with lost moving patterns of walking (see [11]) but it also can present information about the actual state during the ride.

References

[1] Bundesarbeitsgemeinschaft für Rehabilitation (Ed.). Rehabilitation und Teilhabe. 3rd ed., 2005, Deutscher Ärzte Verlag Köln. ISBN 3-7691-0420-X

[2] Stiller C, Roß F, Witte H. A handheld/server based assistance system for tourists with special needs. Proc. of the Int. Conference on Advances in Computer Science and Technology (ACST 2006) Puerto Vallarta.

[3] Lutherdt S., Fröber U., Wernstedt J. et.al. Development of assistance systems for user groups with specific handicaps – a challenge for the ergonomic design process. Proc. of the XIX Annual Int. Occupational Ergonomics and Safety Conference 2005 (ISOES 2005) Las Vegas.

[4] Mayhew, D. The usability engineering lifecycle. Morgan Kaufmann Publishers, Inc. San Francisco1999.

[5] Lutherdt S., Kurtz P.: Nutzung verschiedener Sinnesmodalitäten für Ein-/Ausgabeschnittstellen in Assistenzsystemen für gehandicapte Nutzer. Proc. der Frühjahrskonferenz der GfA e.V. Stuttgart 2006

[6] Enge M. Language Assistance for Different User Groups When Using Machines VDI-Berichte Nr. 1678, 2002. VDI-Verlag Düsseldorf, p. 61-66

[7] Nass C., Lee KM. Does computer-generated speech manifest personality? Proc. of the SIGCHI Conference on Human factors in computing systems, p.329-336, April 01-06, 2000, The Hague, The Netherlands

[8] Nickerson R. Engineering psychology and ergonomics. In Hancock P. (Ed.) Human performance and ergonomics. Academic press London.2nd ed. 1999. pp. 1-37

[9] Levitt H. Communication Aids for People with Hearing Loss. in Hancock PA (Ed.): Human Performance and Ergonomics. Academic Press London. 2nd ed. 1999. pp 129-171

[10] Tsukada K. & Yasumura M. ActiveBelt: Belt-Type Wearable Tactile Display for Directional Navigation. Proc. of UbiComp2004: Ubiquitous Computing. 6th International Conference Nottingham (UK) 2004.

[11] Andrada E., Stadelbauer B:, Voges D. et. al. SpineMover: on the way towards a bionic transfer of human motion principles. Int. Symposium on Adaptive Mo tion in Animals and Machines (AMAM). Program abstracts. Verlag ISLE. Ilmenau 2005. pp. LM2-LM3.