UbiComp Applications for Assisting Visually Impaired People Live an Independent Life: A Participatory Conceptualization Design Phase

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Abstract. This paper presents a classified set of proposals of Ubiquitous Computing Applications aimed for the wellbeing of the visually impaired, and the initial design analysis and conceptualization process that led to them. Domestic applications for the visually impaired have been conceptualized and evaluated, with insight from participatory design approaches. Thirty two total proposals resulted from brainstorm sessions between the designer and a focus group of blind end users. The proposals were then ranked by a broader focus group of visually impaired end users. Top ranked scenaria are further evaluated in order to identify strengths and weaknesses and make further improvements. Such classified scenarios can provide valuable input towards a ubiquitous computing system that is designed from its very conception based on the needs of the visually impaired.

Keywords: Scenario based design, Visually impaired, Ubicomp applications.

1 Introduction

Visually impaired people face daily great difficulties in living an independent life. The main reason for this is the almost exclusive use of visual information in our environments. Aiming to assist this group's independent living, a set of Ubiquitous Computing (UbiComp) application scenarios reported here were defined, evaluated, and prioritized, using Participatory Design methods.

The iterative process of user-centred design for the blind starts in the first design phases: analysis and preliminary concept phases. The setting assumed from the analysis is the domestic environment. Thirty two total proposals resulted from brainstorm sessions between the designer and a focus group of end users. Many of these scenarios addressed the replacement of printed information with other forms that can be reachable and usable from blind people within their domestic environment, aiming to their safe and independent living. The proposed ideas-scenarios were focusing on activities such as cooking, dressing, entertaining, washing, cleaning and also more specific needs such as security alerts, finding of things and obstacles, medicine information and many more. The proposals were then ranked by a broader focus group of visually impaired end users. "Talking Eyes", a top ranked scenario was further

N. Streitz and P. Markopoulos (Eds.): DAPI 2014, LNCS 8530, pp. 272–281, 2014.
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evaluated in order to identify its strengths and weaknesses and further improve it. This prioritized set of scenarios, presented here as a result of concept design research, can serve as valuable input towards a ubiquitous computing system that is designed from its very conception based on the needs of the visually impaired.

2 Related Work

The Chatty Environment [4-7], and iCARE [9], [11], were the two most notable research environments related to the research presented here. Both approaches are addressed to visually impaired users and are using augmented everyday objects, aiming to a better, safer and more independent living of the visually impaired. The approaches are similar to the design concept research approach presented in this paper. The Chatty Environment is an environment where the world uses an alternative audio channel, to reveal itself to the user. A prototype was built which consisted of several components: a large number of tagged entities in the environment, a world explorer in form of a portable device and a tag reader connected to the world explorer to pick up the tags. iCARE on the other hand proposes 5 different applications: iCARE Reader, iCARE Information Assistant, iCARE Interaction Assistant, iCARE Haptic Interface and iCARE Accessible Environment. Both of these projects used participatory design methods. Inspired by these projects and the work described in [12], research presented here, followed some methods of requirements analysis: interviews, focus groups and questionnaires- and cross checked the resulted requirements and feedback that the users gave to all these researches. Scenarios were used in all these projects as a testing method for the proposed ideas. A new approach in this research, compared to the existing projects, was the combined evaluation method of Cognitive Dimensions of Notations framework (CD) questionnaires [3] with Bellotti's questions [2]. Other differences are the large number of proposed scenarios and the absence of any assisting devices that users would have to carry in order to achieve their goals.

3 Towards a Taxonomy of Ubiquitous Application Scenarios

Participatory design methods (brainstorming, interviews, questionnaires, and observation) were adopted as a user centered design approach most suitable for defining a UbiComp application for the visually impaired. Scenario based design was used for the presentation of the application proposals; scenarios were described in the form of textual descriptions.

A primary team of five people was formed as a focus group; four of the participants were visually impaired and represented the future users of the system and one, the author, who was sighted and had the role of informing, inspiring and organising the whole process. The age of the team was ranging between 20-45 years old. Every member of the team had a high or higher education level and they were all active

members of the society. Two of the members are actively involved in the "Panhellenic Association of the Blind" which appeared very helpful through the process. The process was formed in three stages -Analysis, Idea, Evaluation- as they are defined in user centered design processes and according to ISO 3407 [1] . At this point we have to emphasize that this research is focused on the concept of a suitable ubicomp application and not the actualized or prototyped application and that's the reason why the stage of "design" is in fact the "idea generation".

4 Design Analysis Phase

At the stage of the Analysis, information was gathered about visually impaired users and their needs and requirements. In order to do so personal interviews were conducted, and visits on location / domiciles of visually impaired were realized. Observation was direct in their environments, but also via videotaped sessions of blind living at their homes. A live interview with the visually impaired was used, based on a questionnaire text script in order to facilitate understanding of the everyday living habits of blind people. A focus group was formed in order conduct a brainstorming and exchange ideas, problems, thoughts and probable solutions that would lead us to ideas that would meet the needs and requirements of more than one user.

The methods of user-analysis were based on [8],[15] and were similar to the ones used in related research such as «The Chatty Environment» [4-6]. Through the initial analysis the environment of the proposed applications was identified as the domestic environment, being of primary importance to the focus group; it is also more contained in terms of the technology involved, and thus more likely to be better suited for currently available Ubiquitous computing infrastructure. Within the augmented domestic environment the identified needs and requirements of the blind were addressed through participatory proposals. A user persona (fig.1) was described, in order to facilitate design research during the concept phase. The persona transfers abstract concepts to a human figure [13]. In this way, the requirements of different users will take the form of a specific future user.

Resulting from the initial analysis, the needs and requirements of the users were clarified, along with the users' environment. The primary wish of members of the group was to be able to have an independent life and not needing to depend on other people. More specifically, the proposed ideas would have to:

- replace the environment's visual information
- preferably focus in domestic environment
- allow the user to be independent
- not enforce their disability and make them stand out more than it already happens. That means that **blind people don't want to have any extra visible appliance that they would have to use or carry around.**

Two extra facts that appeared through the interviews were the memory factor and the vocal information. **Blind people have a strong memory and they don't want an application that would minimize the exercise of this sense** and also they are very familiar and open to speech, as their preferred output medium.

FEW WORDS	I am Marios. I am 24 years old, blind, master's student at Law School and member of the "Panhellenic Association for the blind" (P.A.B). I have a very good relation with my parents and my sister but the last few years I live by myself. I am very social, I have a lot of friends, I like going out, travel and reading. Generally I'm very optimistic despite all the difficulties that my disability could cause me. Through P.A.B. we examine problems and difficulties of visually impaired, we take part in researches and we believe in a better future.
MY DAY	I wake up early, I always take my breakfast and I leave for the university where I spend many hours of the day. At the afternoon I spend some time at the P.A.B., I go for a walk or a bit of exercise. At the evening I go back home for studying, relaxing and dinner.
TRANSPORT	Wherever I go, I use the white cane. It helps me move around in known & unknown places, indoors or outdoors. If I need to take a transportation, I use the subway or I take a taxi.
HEALTH	My health is in great condition. Blindness is something I was born with and I'm used to live with it. I believe it's easier for me than for some people who lose their site in a later age.
VALUES	I want to be independent and self-sufficient. I don't want to be treated differently.
PERSPECTIVES	I get informed about progress & evolution. I fight for my beliefs. I'm very optimistic that in the future, technology will be able to help me live a more independent life.

Fig. 1. The persona description

5 Ideas – Concepts

After the gathering of information, the identified requirements transform into ideas – proposals through scenario based design. Scenarios may come up from brainstorming and they can be very effective when users are involved for their creation [14]. Thirty-two (32) proposals were created and presented with a scenario based design process. As the length of this paper does not allow us to present the full scenarios, these are briefly outlined in Fig.2.

	NAME	Context	USER REQUIREMENT	GRADE
1	Talking Eyes	Domestic	Food Products' information	6 **(#1)**
	Smart Outfit	Domestic	Dressing up – Finding of requested clothes	31
3	Smart Mirror	Domestic	Dressing up – Affirmation of good result from another person	91
4	Smart Clothes	Domestic	Dressing up – Matching clothes	62
5	Let me Know	Domestic	Safety at home (Left appliances and lights in «on» mode)	70
6	AmbiFeel-ings	Domestic	«Watching» visual mediums (TV, Projections, etc)	81
7	Welcome	Domestic	Get informed when someone arrives home	105
8	Best Friend	Domestic	Taking care of a pet	101
9	EnLighten me	Domestic	Get informed for a burnt bulb	84
10	Weathy	Domestic	Weather information – Sunny or cloudy day	61
11	Stain Free	Domestic	Get informed about stains on the clothes	58
12	Reminder	Domestic	Get informed upon request for proposed home-works	103
13	Super Clean	Domestic	Cleaning – Information about forgotten spots	78
14	Home Deblock	Domestic	Avoiding blocks	71
15	Street Deblock	Outdoors	Avoiding blocks	85
16	Warning	Domestic	Informartion about damaged cooking utensils	55
17	Talking Eyes Med	Domestic	Medicine products information	38
18	Measure	Domestic	Measuring during cooking	57
19	Show me the way	Outdoors	Recognition of routes	47
20	Digit Read-er	Domestic	Vocal digit reader for bills	30 **(#3)**
21	Finder	Domestic	Finding of lost items	49
22	Map Read-er	Domestic	Map reading through haptic and vocal input and output	89
23	Make my day	Domestic	Boiling	97
24	Shopping List	Domestic	Information about ending consumable goods	61
25	New Data	Domestic	Information for updated research results	93
26	Compass	Domestic / Outdoors	Orientation help	67
27	Separate it	Domestic	Separating clothes for washing	71
28	Scan It	Domestic	Recognising visitors and people who ring bell	70
29	Spot It	Domestic	Finding of displaced items	65
30	Eat It	Domestic	Information about food denaturation	26 **(#2)**
31	Informer	Outdoors	Information about the exact amount of taxi bill	38
32	Dust Off	Domestic	Information about dust on clothes and fabrics	72

Fig. 2. All the 32 scenarios were created together with the focus group as a response to some of the problems that blind people meet in their everyday life. The grading shows the preferences of the users. The smaller the number, the more preferable the scenario, e.g. Talking Eyes was ranked as first priority from 3 users and as third priority from the fourth user (1+1+1+3=6).

6 Most Prominent Scenarios

The scenarios were discussed and re-structured to reach their final form, which was given to the users of the team for ranking at the stage of evaluation.

The ranking was made based on the following criteria: personal priority preference, degree of addressing the needs of each user, degree of facilitating his/her autonomy.

The most widely preferred application scenario, as it came up through ranking, was «Talking Eyes». It describes an application that informs the user about the identity of a food product, the expiry date and any other related information that might appear on the packaging. As the user grabs the product and removes it from the storage place, he/she can hear a voice that announces the identity of the product and the expiry date, e.g. Spaghetti Barilla, July 2011. At this stage the user doesn't have to do anything in order to be informed. The basic information of the identity and the expiry date are "given" to him/her without having asked for them. If the user needs some extra information about the specific product, he/she may ask the application for this information by saying for example: "Ingredients". Then the application announces again to the user the requested information. The specific application pre-assumes the existence of embodied RFID tags on food products that hold all the necessary data of a product as it appears on its packaging. The data stored in the RFID tags is recognized by an RFID reader that turns digital data into vocal and announces it to the user.

The next four top ranked scenarios were the following:

Ranked second in the Focus Group preference was «Eat it»: an application scenario, set in the domestic environment, that informs the user about denaturation of food. There are certain types of food products, such as cheese for example, where some level of denaturation may appear without making the food dangerous. «Eat it» uses a sensor that can spot the denaturation, a vocal device through which the user is informed and an augmented "smart" knife that can «guide» the user to cut off the denaturated piece of the product.

Third in preference was «Digit Reader»: an application scenario, set in the domestic environment, that informs the user about numeric information on documents such as bills, food delivery checkes, etc. As the user takes the document and places it on the augmented table, the table vocally informs him/her about the total amount he/she is supposed to pay. In that way, blind people may be sure that nobody is taking advantage of their disability by overcharging them.

Ranked forth was «Smart Outfit». This is a domestic application scenario, whereby blind people can choose the clothes they want to wear without the help of another person. The user opens the closet and asks for a specific garment, e.g. Gray suite. Tagged sensors on the clothes recognize the demanded cloth and the hanger of the specific cloth comes out of the closet. The user may continue in the same way asking for his whole outfit such as shirt, shoes, etc.

In the fifth place was «Talking Eyes Med». A scenario for a domestic application that informs the user about all the necessary information of the medicine he/she uses. The application works in exactly the same way as «Talking Eyes» through RFID tags and RFID reader.

7 Evaluation

After ranking the scenarios and selecting the preferred ones, the next process step was to explore those in more depth. Questionnaires were given to the users in order to evaluate «Talking Eyes», that was the widely preferred application scenario. At the initial conceptual stages of the system design, the aims of the evaluation were to test:

- the awareness of the users according to the purpose of the future system
- the understanding of the needs they may fulfill through it
- the expected necessity and frequency of its use
- the level of difficulty they expect to meet by its use
- the easiness of understanding its functionality.

Through open type questions we expected them to share with us their concerns – if there were any- about problems of the system, trust, privacy, benefit and their overall expected satisfaction. The questionnaire of the evaluation was based on the Cognitive Dimensions of Notations framework [3], a questionnaire optimized for users. The questionnaire was accompanied by the scenario of the application idea which we have tested by answering the five questions that Bellotti [2] suggests for designers and researchers, before giving it to the users for the final evaluation. For the evaluation an additional three new people were added to the initial focus group; these people were also visually impaired but had not participated into the previous concept creation stages.

8 Results of Evaluation for Talking Eyes Scenario

The outcome of the evaluation showed that the users believe that the proposed application (as part of an overall system) can meet their needs and requirements but also pointed out at the following new facts:

- All users understand the needs they can fulfil through this application.
- 6 out of 7 total users believe that the particular application would be quite to absolute necessary to them.
- Most of them mentioned that they could use it 1-3 times per week.
- All users believed that it would be quite easy for them to use the application (based on the description provided).
- All users believed that the functionality of the application was clear.
- 5 out of the 7 total users couldn't find any problems with the application described.
- All users stated that they would trust the application.
- 6 out of the 7 total users didn't have a privacy issue. (There are more benefits to them than privacy concerns).
- All users stated the importance of the health benefit that the particular application accomplishes.
- All users believe they would be quite satisfied by such application.

The existing team and the new team of evaluators differentiated on two key-points: the address and the action as they are defined by Bellotti [2]. Two out of the seven total users (28%) expressed doubts concerning those two areas. They specifically mentioned an "on-off" function of the system as well as the choice of not being informed of the type of the product as for some food products they can recognize them from their packaging.

According to Bellotti, and by keeping in mind the results of the evaluation, the following challenges arise: For addressing the system: a) How to disambiguate intended target system, b) How to not address the system. Regarding action towards the system: a) How to avoid unwanted selection. The aspects described by Bellotti are worth taking into account for the creation of future system application proposals, as well as for detailing the ones of this study.

Bellotti's framework was used in two different phases. First the proposed scenario was checked by designers, before giving it to the focus group for validation. This appeared very helpfull in order to test the parameters of the application and it's meeting to the stated users' needs and requirements. At the next step, we assessed the proposed idea according to the Bellotti framework. The framework of Bellotti presents five design challenges inspired by analysis of human-human communication that are mundanely addressed by traditional graphical user interface designs (GUIs) [2] . In conjunction with the questions from the Cognitive Dimensions framework [3], the Bellotti design framework appeared to be very helpful and accurate for leading the design process. The Cognitive Dimensions evaluation results pointed out the very specific areas of Bellotti's framework that needed to be re-examined: the areas of address and action. More details in process and results is reported in [10].

9 Conclusions

The design research in the initial concept phase advocates that visually impaired people wish and need to be autonomous, independent and safe. They don't want to be depended on others or behave differently than the sighted. UbiComp systems comprising of specific applications, that are evaluated and ranked from their conception phase through a design process as the one described in this paper, can help to meet this goal, so that the scenario-ideas that get realized into applications are suitable for this specific group's needs. Such Ubicomp applications should aim to enhance the capabilities of blind people, give them new prospects, and allow them to live an independent life and to take advantage of the same information as sighted people do. All the applications presented in section 2 were created according to the blind users' requirements and presented a solution to their specific problems. What is important in this approach is that, compared to similar projects such as "The Chatty Environment" [6],[5],[7],[4] that we mentioned earlier, the focus was on keeping the applications simple and without any extra required effort from the users. The use or carrying of any extra appliances was not adopted, which was an important point that the blind users themselves stated from the interviews during the analysis phase.

All the applications concepts generated in this design process (reported more extensively in [10]), after being improved and revised via focus group appraisal, can be used as use cases or initial requirements in a domestic UbiComp System that aims to facilitate the safe and independent living of blind people.

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