Requirements of Indoor Navigation System from Blind Users

Mei Miao, Martin Spindler, and Gerhard Weber

Department of Computer Science, University of Technology Dresden
Noethnitzer Str. 46, 01187 Dresden, Germany
{Mei.Miao,Martin.Spindler,Gerhard.Weber}@tu-dresden.de

Abstract. Most blind people navigate within buildings with help only from other people. One of the reasons is that there isn't enough information about the buildings available to them. To address this problem, we are working on a project named MOBILITY. One of the goals is that an application should be developed, which helps blind people navigating themselves in public buildings independently. This application is multimodal and can be installed on mobile phones. Auditory and tactile output can be used for the navigation in buildings. A thorough user requirements analysis of this application has been carried out with blind users. In this paper we report on the results of the user requirements analysis.

Keywords: Blind users, user requirements analysis, indoor navigation system.

1 Motivation

1.1 Mobility and Disability

Disabilities mostly lead to less mobility. Particularly, blind people and wheelchair users are at a disadvantage. There are sometimes digital plans for public buildings available. Information like path structure and space are offered on such plans. However, most of them are prepared just for sighted people, but not accessible for blind people. Therefore, it is especially difficult for blind people to get some information about an unknown building in advance. This makes the navigation in buildings for blind people more difficult. The most often used method to get information about an unknown building in advance is to ask friends.

Some blind people also use tactile maps, but there are very few tactile maps available. As tactile maps are usually produced by sighted people, they are often incomprehensible for blind people. Therefore, many blind people do not like working with tactile maps. Another disadvantage of tactile maps is that there are often obstacles for blind people such as billboards and they can't be mapped. Many blind people do not go to an unknown building without accompaniment. For the orientation in buildings, they usually have to stop passersby and ask for help.

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1.2 The Project MOBILITY

To address these problems, a project named MOBILITY has been started in 2011. One of the goals within this project is that a multimodal application should be developed, which will help people with disabilities, especially blind people. So they can orient and navigate in public buildings independently. A sighted person creates content and annotation into digital plans of public buildings like airports and train stations. This information of digital plans will be offered both for mobile phones and for the web. Furthermore, additional information for example how does a drinks machine work, will also be integrated. This information will be then converted automatically in an accessible format for the users.

1.3 User Centered Design

Since the 90s, the User-Centred Design (UCD) [1] has had increased attention, particularly in the area of human-computer interaction. UCD is applied to develop this application within this project. Within a UCD the needs and wants of future users guide the development. UCD is characterized by two main features: firstly, the users are actively involved from the start of the development. Secondly, the development process is iterative. User requirements analysis is the first milestone of UCD [2]. To identify the needs from blind users on this application, a thorough user requirements analysis has been carried out with blind users. We identified the requirements and classified them into two groups: the requirements of functionality and usability of the application and of route description. In this paper we report on the results from the user requirements analysis.

2 Related Work

Several navigation systems are developed based on GPS (Global Positioning System) for visually impaired people, like *Trekker*[1], *LoadStone*[2], and *Wayfinder Access*[3]. They talk to you about what is around you, your position, and the street name and so on. Therefore, blind people can move outdoors on their own with these assistive technologies.

However, navigation systems for indoors have not been developed as much as for the outdoors, because GPS is not available in buildings. It requires other location methods like WiFi access points, RFID tags and so on. The TANIA system[4] [4] aims to provide blind, visually impaired, and deaf-blind people to navigate on their own, both indoors and outdoors. For the indoor navigation they used a step-based tracking method, and for outdoors GPS signals. One problem with a step-based tracking method is the inaccuracy due to the varied step lengths or changing floors.

1 Trekker: http://www.atkratter.com/index.html

2 Loadstone: http://www.loadstone-gps.com/

3 Wayfinder Access: http://www.dvlop.nl/saveWayfinder/main/home.php

4 TANIA system: http://www.blindnavigationinternational.org/projects_en.htm

Most of the developments are just based on developers' Ideas. Users' real wants and needs will often not be thorough analyzed.

3 Procedure of the User Requirements Analysis

In this section, we briefly describe our procedure of the user requirements analysis which was based on [1-3]. The user requirements analysis consist of the following 6 steps: (1) Extensive literature research, (2) Creation of user profile, (3) Analysis of the environment, (4) Interview of mobility coach and mobility coaching, (5) Requirements gathering from blind users, (6) Confirmation of requirements derived from steps 1 to 4 with blind users.

(1) Extensive literature research
In the first step, we did an extensive literature research in respect of indoor/outdoor navigation, navigation systems, and route description for blind people. Some possible requirements are derived from this step.

(2) Creation of user profile
We designed a questionnaire to figure out blind users characteristics, like remaining visual acuity, experience with pedestrian navigation systems, mobile phone, and Internet, etc. 6 blind users (2 female and 4 male) were asked to fill in the Questionnaire. Half of them are congenitally blind and the other half are adventitiously blind. From the questionnaires we created a general user profile for blind users. After that, we derived possible requirements from the user profile.

(3) Analysis of the environment
In this step, we analyzed 2 typical public buildings. They were one airport and one train station. We also derived possible requirements which were depending on the environment of use.

(4) Interview of mobility coach and mobility coaching
We interviewed a mobility coach for blind people. We got useful advice concerning the orientation and perception of blind people. One of our developers was blindfolded and then navigated in a train station and an unknown building to get a sense of what the blind people experienced. Some possible requirements could be derived again.

(5) Requirements gathering from blind users
In this step, we conducted structured interviews [6] with the 6 blind users. We asked the blind users, which functionalities they want to have and how they want to have the functionalities.

(6) Confirmation of requirements derived from steps 1 to 4 with blind users
As mentioned, we derived requirements from 4 aspects: literature research (in step 1), user profile (in step 2), environment (in step 3), and interview of mobility coach (in step 4). In order to verify if these requirements are really important for blind users, they will be confirmed by the 6 blind users.

4 User Requirements of the Application

After conducting the 5 steps, we identified a set of requirements from blind users on the application. In this section we describe the main results. The total requirements are classified in two categories: *requirements of functionalities and usability* of the application and *requirements of route description*. Requirements of functionalities and usability mean which functionalities do blind users want to have and how do they want to have them. Route description is a very important part of a navigation system. It is essential that blind users understand the route descriptions so that they arrive at the destination effectively and efficiently. Helpful information for sighted people is not necessarily helpful for blind people. For example, “Turn to the right after a big plant.” this is almost meaningless for blind people, because they cannot see where the big plant is. Therefore, it is necessary to figure out which information helps them to orient in public buildings.

4.1 Requirements of Functionalities and Usability

According to the results of user profile in step 2, most of the blind users are not familiar with pedestrian navigation systems. This indicates a need for ease of learning. For example, the design of menu navigation and the key mapping should be learned and memorized as easy as possible.

Furthermore, the blind users have taken the following main functionalities for important of a pedestrian navigation system:

4.1.1 PC Version of the Application

As expected, blind users want to have the application on a mobile phone while on the move as well as on a computer at home. The PC version does not have to have the same functionalities like the mobile phone version. But the same functionalities of both versions should be represented in similar interfaces. Using PC version blind users can get more information about buildings and plan the routes in advance.

4.1.2 Input Destination/Stopover

This function is one of the main functions of navigation system. One new thing is that blind users would like to input their destination/stopover, both on mobile phones and on the computer. For planning a route, they can do it on a computer in advance. The Route should then be transmitted to the mobile phone. On mobile phones, most of the blind users prefer speech input, but only if the speech recognition works well.

They also want to use virtual keyboard, standard typewriter keyboard (QWERTY/QWERTZ keyboard) and standard mobile phone keyboard. All of the destination/interim destination inputted should be saved for the further use.

- *“Where am I” function*

Users can get Information about the current position.

– *"What is next to me" function*

The immediate Point of Interests (POI) will be announced along the route. They should be categorized and the user can select the categories which are interesting for them.

– *"What is around me" function*

With this function users will get information about what there are after they have defined a certain direction and a certain distance. How to define the directions should be investigated further.

– *Overview of the buildings*

Auditory information about the overview of buildings should be supported. This information comprises the structure, the primary and secondary goals of the buildings.

– *Feedback of input and actions*

Feedback of input and actions should be presented in tactile or speech form.

– *Warning of obstacles*

The Warning should occur early enough. Emergency stop should not be used too much.

– *Warning of poor signals*

Tactile and auditory information should be provided for poor signals, as well as when the signal is back again. The last route description should be repeated following the absence of the signal.

– *Warning of being off track*

Tactile and auditory information for a warning of being off track.

– *Pause, repeat and stop function for route descriptions*

Blind users should have control over the route descriptions.

– *Create and annotate POIs*

For the further use, blind users can add POIs which are interesting for them in the database.

– *Transfer of configuration to other mobile phones*

If users change their mobile phones, they do not need to configure it once more, but just transfer the configuration to a new one.

4.2 Requirements of Route Descriptions

A route description describes how you can move from your start point to your destination. As mentioned above in everyday life, blind people have to face many problems with route descriptions of sighted people. We begin this section with the general requirements of route description, followed by detailed requirements of the route description representation.

4.3 General Requirements of Route Description

– *Personalization of the route description*

Route descriptions should be personalized. Depending on how well bind users know the building, how they orient in a building and which information is interesting for them, they should have the possibility of adapting the route description to their own preference flexibly. For example, because of a guide dog, a blind user may prefer a lift instead of stairs. Another example is that a blind user can select the categories of the POIs which will be outputted.

– *A short but meaningful overview of the route*

Blind users considered that before starting, an overview of the route can be helpful. The overview begins with information about the current location, and then a summary about the total route. It should comprise information about the main areas and the floors on the route.

– *Description of functional waypoints*

Functional waypoints mean an object that the users have to use, such as doors, stairs/staircase, and lifts etc. It is very helpful for blind users to know how to use them. For example, for a lift it is important to know if there is a speech output and where the buttons are.

– *Integration of helpful environmental pattern*

Environmental pattern for blind people means tactile, auditory and olfactory information from the environment. As an example, "In front of the stairs there is a doormat."

4.4 Detailed Requirements of the Route Description Representation

– *Description of direction changes*

"left/right/forward/back" was accepted by all of the blind users and none of them want "north/south/west/east" for indoor. In contrast to our assumption, most of the blind users can not deal with the "clock hand" system (e.g.: 3 o'clock means turn right). The degree system excepting "90°/180°" was also rejected.

– *Description of Distance*

For describing distance the unit meter is suitable, but not for the number of steps. None of the blind users find the number of steps helpful.

– *Estimation of effort*

Most of the blind users find an estimation of effort with reference to time as unnecessary, but half of the blind users would like to get information about distance.

– *Information about the current position after changing of floor and area*

In order to help the blind users to build a correct mental map, it is necessary to tell them where they are after the changing of floor and area.

5 Conclusion and Future Work

To ensure a successful outcome, a thorough user requirements analysis is the first step. It is essential that the requirements should be gathered directly from future users, but not just from literature research, experiences or other ways. In our case, an interview with a mobility coach, who teaches orientation and perception of environmental cues to blind people, is a domain expert to get more information about the navigation of blind people.

We described in this paper the results of user requirements analysis with blind users on an indoor navigation application. In our project, the user requirements in respect of functionality, usability, and route description will guide the development of design concepts of the application. Subsequently the design concepts will be evaluated by blind users.

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