Accessibility for People Who are Blind in Public Transportation Systems

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Abstract
In order to support access for people who are blind to modes of transportation in the city, it is necessary to design technological tools that allow them to carry out activities safely, autonomously, and functionally. In this context, three mobile orientation and mobility support systems were designed for people who are blind to aid in their effective navigation using various modes of transportation in the city of Santiago, Chile. This work presents the most significant implications of the use of these systems.

Author Keywords
Transportation in the city; mobility; accessibility; blind people.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction
The integration of people who are blind into daily societal activities requires accessibility to all modes of transportation available in the city in order to make independent travel to and from different points possible. In this way, it is feasible to develop and/or adapt technological tools that allow for the autonomous, safe and effective use of various means of

Figure 1. Using MBN. The software allows for a virtual tour through the stations of the metro system in Santiago, Chile, assisting real user's travels. In addition, the system provides relevant information about facilities and items within the metro stations and places near them. Users that interacted with mBN performed 3 travel routes. First, a travel to a known location, second, to an unknown place, and the third route was to use the system to solve unexpected problems during navigation. To evaluate route performance of the users, we used an O&M skills checklist instrument for pre and post testing that included the cognitive, psychomotor, social-emotional domains.

transportation by people who are blind, so that they do not have to rely on other people.

Many blind navigation systems and patents have been proposed that allow integration with public transportation systems [8, 9, 10]. Considering that a lack of sight makes driving a car and other modes of transportation impossible, public transportation becomes the only option that people who are blind have in order to move from one place to another and perform their daily activities. Social integration policies for people with disabilities seek that public transportation be more accessible in cities all over the world. One of the main tasks of such policies is the implementation of resources in order to educate and orient bus and metro train drivers as well as passengers both with and without disabilities, regarding the correct way of using urban modes of transportation, in addition to certain measures that aid in the use of transportation by people who are blind. In this way, certain debates and queries have been directed at certain institutions in support of people with disabilities to be able to access and utilize public transportation [1, 2], regarding measures that aim to better understand the transportation needs of these individuals and to work efficiently in order to provide them with adequate solutions. All of these actions seek to eliminate social discrimination, and to favor universal access and the full social inclusion of people with disabilities in public transportation, thus allowing for their effective and independent navigation throughout the city.

Designing Navigation Systems for Transportation

In this context, it is feasible that people who are blind would be able to access various modes of transportation using technological tools that allow them to carry out navigational activities safely, autonomously and functionally whenever necessary. Accordingly, a proposal based on audio feedback would allow for a tool that provides people who are blind with information, so that they are able to use the existing means of transportation in the city independently based on their prior orientation and mobility (O&M) skills. Many of the barriers that these users encounter regarding their ability to access and utilize public transportation, including structural issues, design problems and difficulties with accessing information, could be avoided if the initial design of the various modes of transportation included were designed to support systems based on mobile technology.

In order to support the planning of trips both for pedestrians and users of public transport, three mobile support systems for the orientation and mobility of visually impaired people were designed, to aid in their effective navigation using various means of transportation in the city of Santiago, Chile. These systems are: MBN (Mobile Blind Navigation) [3], AudioTransantiago [4], and ambientGPS [5]. MBN satisfies navigational needs through the use of the underground Metro train transportation system. Audiotransantiago provides contextual information for planning trips by using the urban bus transportation system. Finally, ambientGPS allows users to walk between different points throughout the city. MBN was tested with a sample of 5 blind users between 19 and 28 years old, AudioTransantiago was tested with a sample of 6 blind users between 27 and 50, and AmbientGPS was tested with a sample of 6 blind users aged between 19 and 35. The interaction sessions with mBN, AudioTransantiago, and aGPS software were

Figure 2. Using Audiotransantiago. The software stores the contextual information on each stop of the urban public bus system passenger transport in Santiago, Chile, routes. From this information the user chooses to plan his trips in advance. In turn, the software incorporates additional information on the nearby streets around them, as well as significant landmarks near to the bus stops. Users of AudioTransantiago participated in 4 work sessions. In 3 of them, they took over the system, planned trips, simulate the performance of these trips and finally carry out a real route. This route of 2.3 kilometers was performed in an average of 2.5 hours per user. To evaluate the performance of the user, at the end of the travel we proceeded to fill out a checklist with statements concerning abserved O&M skills.

implemented in up to 4 sessions of 60 minutes per user.

The means of physical access required by law and which must be integrated into the public transportation system, clearly respond to the need to provide timely information that supply people who are blind with the autonomy they need to move throughout the city, based on tools that facilitate their interaction with each of the different modes of transportation. It is for this reason that the previously mentioned systems were based on the use of mobile technology, due to the characteristics of their adaptability to geographic and temporal conditions [6]. In addition, these devices provide what is needed in order to manage and integrate useful information, generate collaboration, and encourage knowledge construction [7].

Discussion

In evaluating the three software systems implemented, it was possible to determine a high user acceptance of the applications and also of the use of Pocket PC devices, in the sense that the participants learned to use the device without any major difficulties, demonstrating a high level of skill in the use of the buttons on the pocketPC. Also, the use of the audio system, both the synthesized voice and the non-verbal sounds, was well accepted by the users in which the natural sound of the text to speech (TTS) and the clarity of the sounds in general were highlighted. Learners were very receptive to the solutions proposed and showed high motivation when using the system.

Usability and cognition results after interacting with mobile applications plus the high acceptance and ease of using these tools by users who are blind, place them as appropriate mobile applications for the assistance of blind users in their autonomous navigation in the city through different means of transport. In any case, more research is needed including quantitative measures that extend qualitative measures presented here.

These systems emerged to provide the possibility for people who are blind to compile information on their physical surroundings, and especially contextual information regarding bus/train stops and stations, transfer stations between different bus and metro train lines, and places of interest along the routes that are being navigated, such as museums, public services, or other places. In general, this information is typically captured by utilizing visual channels, as is other information such as the location of bus or train stops, transfer stations, public transportation service route maps and even the cost of transportation service fares. In this way, each system allowed the users to gain access to and manage information regarding buses, metro lines and routes between sectors that are easy to navigate by foot, as each of these systems provides tools that allow users to travel autonomously, understand the functionality of transportation systems, the value of fares, and in many cases orient themselves regarding the spatial configuration of public transportation routes. Accordingly, the architectural or design-based barriers to navigation between different points within the city were reduced, favoring the learning process for the use of these means of transportation, improving information processing and spatial-temporal orientation, as well as O&M skills. All of this was achieved while moving between one point to another, without the need for prior information.

Figure 3. Using AmbientGPS. The software translates and analyzes the data received from the GPS and compares it with the necessary information about the places where learners plan to go by walking. We developed 8 routes of interest to users using the software. All the intervention was performed in a total of 7 months and the performance of each route lasted between 1 to 2.5 hours, depending on the skills of each user. For performance evaluation, we applied an observation cognitive skills checklist, a standard route evaluation, and a self-assessment of the performance.

These tools have the advantage of providing users who are blind with autonomy both in terms of decision-making and in performing activities that require navigation between various points throughout the city. This happens because of the flow of information that is provided to the users through the audio tracks. This allow them to know key aspects to move autonomously, such as their actual position, current position, direction and distance to the destination, and a description of the important elements of the environment. Many people who use public transportation do not travel with a companion who can support their navigation, and who they can ask for help when planning a new trip in the city. For this reason, the autonomy that each of these technological tools provides is a fundamental pillar regarding equal access by users who are blind to the various kinds of public transportation available in the city. In the case of bus and metro train drivers, it is necessary to implement policies focused on education regarding the attention that can be provided to such users. In the same way, it is necessary for the urbanization processes of cities to include the use of touch or sound-based traffic lights that are perceptible to the visually impaired. In this way, they are provided with complete autonomy to move about in the city.

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