A University Indoors Audio-Tactile Mobility Aid for Individuals with Blindness

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Abstract. This article presents the development of an Audio-Tactile aid in order to facilitate and enhance the spatial knowledge as well as the independent and safe movement of individuals with blindness in the University of Macedonia indoors. Moreover the developed aid provides information that helps blind individuals to obtain a cognitive image of the university indoors, plan routes they wish to track and easily identify specific locations and services. The implementation procedure of the Audio-Tactile navigation system included the following steps: 1) development of digital maps that include specific spatial information for people with blindness, 2) production of tactile maps 3) research on the readability of the tactile maps by blind individuals and development of revised tactile maps, 4) development of Audio-Tactile maps and their connection with touchpad devices, and 5) a study to derive the most appropriate locations where 10 touchpads will be installed in the university indoors.

Keywords: Mobility, Visual Impairments, Audio-Tactile System.

1 Introduction

Students with visual impairments are less likely to complete their studies in comparison to their sighted colleagues [1]. There are several factors that inhibit the representation of individuals with disabilities in higher education [2]. Such factors include difficulties relating to physical access, low expectations and poor levels of awareness. Independent and safe mobility is vital for individuals with visual impairments, and inevitably the issue of mobility around the university campus has been stressed as a significant barrier for studying in higher education [1].

Individuals with blindness are facing significant difficulties during their orientation and mobility in space, as they do not have access to all spatial information that will enable them to move successfully and safely. The majority of the researchers that examined spatial performance of individuals with visual impairments and sighted individuals came to the conclusion that visual experience influences decisively spatial behavior [3,4]. Moreover, blindness has a negative impact on the development of blind people's spatial skills [5,6].

Individuals with blindness are unable to collect the external visual stimuli from the environment or to use conventional maps [7]. The difficulties are more acute when

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the movement takes place in new environments or in environments with complex structure. Beyond the fact that there is always the possibility of injury due to the existence of various obstacles in the path of motion, the identification of the location of specific information is particularly problematic, especially when referring to an environment with a great abundance of important locations. Such an environment is that of the indoors of University of Macedonia where several academic departments and administrative services are located in the same single building.

This article presents an application in which audio, tactile, and Audio-Tactile information will be available in combination in order to facilitate and enhance the cognitive maps as well as the independent and safe movement of individuals with visual impairments in the indoors of the University of Macedonia. Moreover, the goals of the project are the provision of information that helps blind individuals to obtain a cognitive image of the university indoors, to plan routes they wish to track and easily identify specific locations and services.

For individuals with visual impairments, the sense of touch is considered as a basic modality for acquiring and selecting spatial information [8]. The importance of the tactile aids as tools that provide spatial information is widely acknowledged [9]. Tactile maps can provide individuals with visual impairments with knowledge about immediate and distant places and also contribute to successful wayfinding [10].

The great benefits of tactile maps are also emphasized by the results of studies in which tactile maps have been found to be more helpful for cognitive mapping of spaces by individuals with visual impairments in comparison to direct experience [11]. The contribution of tactile maps in formatting new cognitive maps or in reforming the existing ones is very important. Tactile maps can also be an extremely effective tool for representing spatial information for the orientation and mobility (O&M) of individuals with visual impairments [12]. Individuals with visual impairments can obtain information about the spatial relationships between places and locations from a tactile map faster than they will by direct experience with the environment, if they understand scale and can translate distances on a map into distances in the environment [13]. Espinosa and Ochaita [14] estimated the effects of three instructional methods - direct experience, cartographic representation and verbal description - on the spatial knowledge of 30 adults who were blind. According to the results, the participants' practical spatial knowledge was better when they learned the route with a tactile map than with either of the two other conditions.

One other primary category of orientation aids is verbal aids. Verbal aids are spoken or written descriptions of spatial layout or ways to travel within the environment [15]. Verbal aids can include detailed information about landmarks, suggestions for the use of specific techniques for specific travel situations, historical routes to be travelled, and cultural and aesthetic information for particular environments. One great advantage of verbal aids is that they can include much more information on these issues in comparison to tactile maps. Furthermore, verbal aids do not require braille skills nor sufficient remaining vision to read print [15].

Despite the advantages of tactile maps, numerous limitations have been mentioned [16]. Many individuals with visual impairments have difficulty in accomplishing the task of reading the tactile map [17]. In general, individuals with visual impairments read a tactile map slower and understand it less than sighted people who see a visual print of the same map [17]. Recognition through touch is not direct, as in the case of sight. First, we see the whole, and then we observe its parts. However, in the sense of touch, the construction of the whole is a mental process that takes place after the perception of the parts [18]. Jacobson [16] mentions the low fingertip resolution compared to eye's, the problems that cartographers are facing when rendering visual maps, such as simplification, generalisation, classification and symbolization of information included, extended use of Blaille labeling and the use of separate legends, as limitations of the tactile maps. Besides, not every visually impaired person can read Braille.

Multimodal interactive maps undoubtedly represent a solution to overcome these problems [19]. The benefits of tactile maps have been combined in previous studies with those of the verbal aids through the use of technological devices, such as the touchpad (Touch-Tablet) [20]. Touchpad offers at the same time access to the benefits of tactile maps and verbal aids. The implementation of multisensory environments on the field of maps' construction for individuals with blindness can be of great significance, particularly in the field of construction of Orientation and Mobility (O&M) aids. In the case of Audio-Tactile maps, in addition to tactile symbols and braille labels, audio and Audio-Tactile symbols (e.g. a tactile symbol that when a user touches it, he/she can hear additional information like names, descriptions etc.) are used as well. That means that a considerable piece of information is presented in auditory modality.

2 The Audio-Tactile System

The implementation of the Audio-Tactile navigation system included the following steps: 1) development of digital maps, on which specific spatial information for people with visual impairments was added, 2) production of tactile maps 3) research on the readability of the tactile maps by blind individuals and development of revised tactile maps, 4) installation of digital maps on special touchpads and addition of audio/verbal information, and 5) study to derive the most appropriate locations where 10 audio tactile devices will be installed in the indoors of University of Macedonia.

Special techniques of digital tactile cartography were applied for the development of the tactile maps. Initially, the basic cartographic background was created, i.e. digital maps of the indoors of the University through a process of converting raster to vector, which was implemented on screen digitizing of the floor plans of the University. Then, the following steps took place: 1) a detailed recording and mapping of the changes that have occurred from the date when the building was delivered for use onwards and are not depicted in the floor plans of the building. This was implemented with On-site inspection of the premises and labeling changes 3) a detailed recording and mapping of specific information for individuals with blindness not mapped in the derived plans (e.g. obstacles and information that are useful to a blind person) 4) generalization of cartographic elements (point, linear, areal symbols and labels) so as to be recognizable by touch - not all information collected were depicted on maps since the large amount of information may affect negatively the readability of the tactile map (the choice was based on the importance of each information) 5) the development of tactile symbols (points, linear, and areal) using appropriate haptic variables (shape, size, texture, value, orientation and rise) that are used for converting the optical language to haptic, and 6) printing of maps in tactile form - the Stereo-Copying process was used with microcapsule paper. A total of 10 tactile maps of university indoors were produced, in order to be placed at the respective locations in the indoors of the university.

The readability of the produced tactile maps was tested in a study with 10 blind participants aged from 20 to 35 years old. Nine of them were braille readers while six of them were students or graduates of the University of Macedonia. The participants were not experienced readers of tactile maps.

The aim of the study was to evaluate the symbols of the map in order to select the most appropriate ones. The study evaluated the time of symbol recognition, the number of symbols identified, the possible confusion between symbols and the preference of individuals with blindness to specific symbols regarding their suitability. During the test procedure two maps were used. The two maps depicted the ground floor and the first floor of the University of Macedonia building respectively. The duration of the test procedure was 90 minutes on average and the participants were tested individually. The evaluation process included the following stages: 1) matching between tactile symbols and information. Specifically the participants touched one by one the tactile symbols included on map key and then the researcher informed them about the information that was represented by each one of the tactile symbols 2) searching of each tactile symbol on the tactile map and recording of the correct and false answers as well as the time of detection, 3) evaluation of the suitability of each symbol based on a 5-point Likert scale ("Not suitable at all" to "Perfectly suitable"), 4) detection of lecture rooms and academic staff offices and recording of correct and false answers as well as the time of detection, 5) independent scanning on the map and identification of the represented information, and 6) feedback from participants on the improvement of the symbols.

The research revealed a number of key findings, which were then used to revise the tactile maps. In particular, after analyzing the responses of subjects tested, major changes to the maps were made, such as: 1) replacement of symbols, 2) greater differentiation of the thickness of linear symbols 3) enlargement of symbols and increase of the distance between them for better tactile effect and 4) erasure of information/details.

In the next phase the digital tactile maps were installed on the touchpads and all audio information was added to them. The software application Iveo Creator pro 2.0 together with the device touchpad, was used to develop the Audio-Tactile map. Both of them are products of "ViewPlus® Technologies" company. The Iveo Creator pro 2.0 is a WYSIWYG editor [21] and has the potential to create and/or edit any type of image format. The files produced by the software are saved in Scalable Vector Graphics (SVG) format. The touchpad device is a pointing device consisting of spe-cialized surface that can translate the motion and position of a user's fingers to a relative position on the computer screen and has the potential to offer tactile, kinaesthetic and auditory information [22].

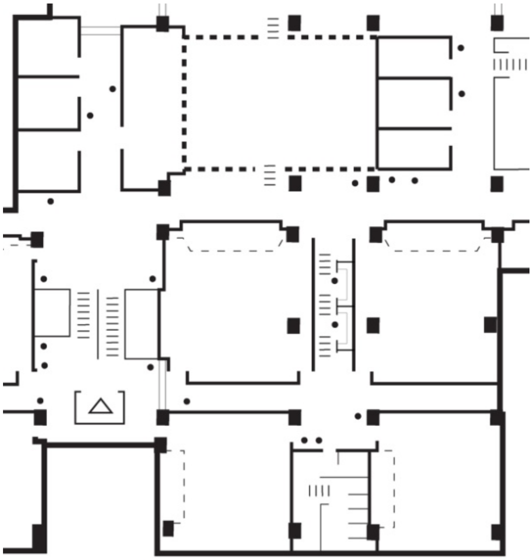

Fig. 1. Tactile map of part of university building with lecture theaters, lecture rooms and offices

Audio information consist of: descriptions of routes to and from specific locations of the university (such as the library, restaurant, information desk, elevator to each floor), lecture classrooms and theaters, changes of the material of the walking surface producing different sounds on white cane, pillars, benches, tactile cues, ramps, garbage bins, fire extinguishers, furniture, photo copying machines, poster boards, glass windows, counters, etc. The creation of the verbal descriptions of lecture classrooms and lecture theaters as well as of walking routes are based on existing theoretical data regarding the orientation and mobility of blind individuals and the creation of cognitive maps through verbal descriptions.

It was decided that the verbal descriptions should be adapted to the way with which individuals with visual impairments are coding their surroundings preferably by serial encoding and not encoding in the bird's eye form. In order to decide the final form of verbal description of the indoors and lecture rooms of the University of Macedonia, three types of verbal descriptions were produced: 1) a general description with basic elements of the respective space, 2) a more detailed description and 3) a very detailed description of the respective space. Then, the verbal descriptions were tested by 10 blind individuals aged from 21 to 47 years old. Seven of the participants were students or graduates of the University of Macedonia. The opinion of individuals who were not students of the university was also taken into consideration since it is important that the descriptions of the indoors of the university can be used by visitors and individuals who are not familiar with the university buildings. The participants were asked to evaluate each one of the three above mentioned types of descriptions, for three different types of rooms respectively. A large lecture theater, a medium sized lecture theater and a small lecture room (9 verbal description files in total).

All descriptions were converted from text files to audio format files (.mp3) using a Text-to-Speech software. The participants were then asked to listen to the three different audio files for each one of the three selected spaces and choose which one of them they thought it is more helpful for them for spatial understanding. Moreover the participants were asked to justify their choice, report any corrections, enhancements or suggestions that they consider necessary in order to be applied to the verbal descriptions of all the university buildings. The main changes pointed out concerned: a) the order of space information presented. The most frequent order of information occurred was: a general description of the hall, location of the entrance, of lecturer's desk, of the walkways between the students' seats, of pillars, of student seats, b) the number and type of detailed information of space to be included in the descriptions. Their suggestions were used in order to create the final verbal descriptions integrated on the audio tactile maps.

It was decided that the 10 touchpad devices will be installed in the indoors of the University of Macedonia as follows: 2 on the ground floor, 2 on the first floor, 3 on the second floor where most of the lecture theaters and lecture rooms are located and 1 on each one of the 3 sections of the university building (each section has 3-4 floors where the offices of the academic staff and some laboratories are located). A study was held in order to determine the optimal locations for the installation of 10 touchpad devices in the indoors of the university of Macedonia. Five blind students and graduates of the university participated in the study. The preferences of the blind students as well as the necessity of minimum additional building constructions were taken into consideration in order to determine the final locations. In particular the following process was followed: 1) the university's technical department was asked to indicate suggested locations within the university premises that would allow easy access to power supply for the audio tactile devices and that would not hinder students' mobility, 2) feedback from participants regarding the number of locations at each floor, their indoors movement and suggestions for the optimal location for installing the touchpad devices, and 4) evaluation of the locations indicated by the technical department in step 1.

The audio tactile navigation system provides information related to the location of important university services such as the administration offices of each academic department, offices of academic staff, lecture classrooms and lecture theaters, the ceremony hall, the library, the computer laboratories, the restaurant, the information desk, toilets, canteen, etc. It also provides information that helps the mobility of students with visual impairment such as elevators, stairs, main entrances and exits, emergency exits, ramps, changes on the walking surface that produce different sounds on the white cane as well as the location of "dangerous spots" such as class windows, steep slopes, low and high obstacles, railings etc.

3 Conclusion

Such an application could help individuals with visual impairments to familiarize themselves with unknown areas, to learn routes on these areas and to be aware of the important spatial features. This implication is of great importance since individuals with visual impairments do not often travel independently and when they do so they prefer to travel in familiar areas and follow familiar routes. Regarding familiar areas, the combined use of tactile maps and verbal aids as suggested in this study, could help individuals with visual impairments to update their cognitive maps and learn new routes before deciding to navigate within these areas.

The Audio-Tactile system provides solutions on the difficulties individuals with visual impairments are facing during their indoors movement within the university, providing access to spatial information allowing them safe and independent movement. Another important advantage offered by the construction of digital Audio-Tactile maps is the fact that it allows easy updating of the maps and the information they contain, if new information or changes in the indoors of the University occur.

The project will benefit students and graduates with blindness, but also a large number of individuals with visual impairments who are visiting daily the University of Macedonia and use the provided university services.

Future research should examine the contribution of Audio-Tactile maps for the development of cognitive maps and their update. Moreover, the choice of tactile, audio and Audio-Tactile symbols that are suitable for different types (mobility maps, thematic maps, maps of indoor places, etc) of Audio-Tactile maps should be considered.

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