The development of information and communication services and devices for the visually impaired

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Abstract—**The availability and full functionality of mobile devices represent one of the basic principles of universal design for the visually impaired. Navigation applications for the users must also be customized and are available to the users' needs. In this paper, the software and hardware characteristics of the currently most used mobile devices were analyzed. Applications for managing and directing the blind and visually impaired transport network have been analyzed in terms of determining the accuracy of the location where the users are located. The applications that are the most common among the users according to the Croatian Association for Promotion and Development of Tiflotechnic (HUPRT) were used. This sample of subjects has been made in Zagreb where according to data there are 1985 visually impaired people. To conclude, the recommendations have been made for the development of information and communication services and mobile devices for the visually impaired.**

Keywords-assistive technology, visually impaired, transport network, IC services

I. INTRODUCTION

To activate the blind and visually impaired person (user) in the transport system, it is necessary to ensure access to all amenities that surround the person himself or herself. Mobility and accessibility are the essential conditions for the introduction of blind and visually impaired people to everyday life. Adaptation of the environment includes access to the whole functionality of the usage of mobile devices. Scientific literature in this area is still at the early stage, so the recommendations for the development of the design of the mobile devices exclusively can be found through the technical specifications of individual manufacturers and conceptual proposals [1], [2], [3]. Scientific project, which is solely based on the recommendations for the design and development of applications for visually impaired people was defined by Ray Project [4]. Virtual mobile operator providing mobile services and participates in the production and distribution of mobile devices for the visually impaired. [5] Development of applications for user navigation are based solely on GPS (Global Positioning System) technology [6], [7], [8], [9].

The problem, which occurs when using the GPS application, is to determine the exact location of the user. In this paper, the most commonly used applications for accurate guiding of the users from the starting point of movement to the destination have been analyzed.

Apart from these preliminary analyses, there are also basic functions of the device through the most common operating systems available.

II. RESEARCH METHODOLOGY

To collect the data (opinions and attitudes of users) the method of interviewing was applied within people who reside in the City of Zagreb.

The survey was planned to be applied on a sample of 175 users, who move and live in the City of Zagreb. The survey has involved 144 users, which is 82% of the total figure. Representative sample has been defined according to the Croatian Blind Union[1] and the Zagreb Association of the Blind Persons[2] of according to the number, which is 171, of Blind and Visually Impaired (significant amblyopia) people employed in the City of Zagreb. The poll has involved 101 users who are employed, which make 59% of the total number of employees, so this sample is considered to be representative. This sample has been selected because these customers are moving around the city of Zagreb daily. Users participated independently in the survey via online form, and via phone in the form of interviews. Mobile terminal device is used by 143 users, as Figure 1 shows.

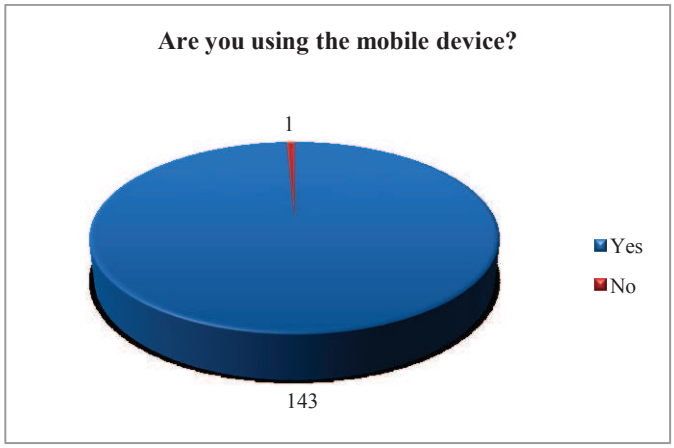

Figure 1 The representation of mobile devices

[1] More on the web: http://www.savez-slijepih.hr/en/
[2] More on the web: http://www.udruga-slijepih-zagreb.hr/index-v.html

Some of the users use more than one mobile device, which the detailed figure 2 shows. The picture shows figure representation according to manufacturers of mobile terminal devices.

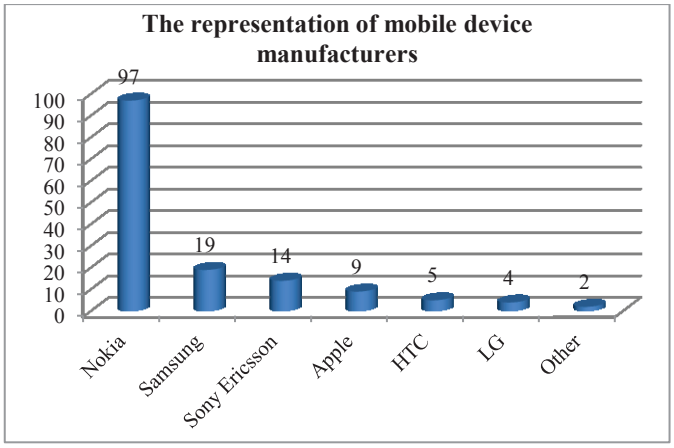

Figure 2 The representation of the manufacturers of the mobile device

Nokia is according to the data, the most commonly used company with the surveyed users (97 users). This company is among the firsts to develop applications that help blind and visually impaired people to easily use their mobile terminal devices. The applications also have very good language support, which is to many users an important parameter.

121 users use mobile terminal devices independently (using all major functionality of mobile devices), while 23 of them have some difficulties when using. In percentage, these figures are shown in figure 3 (84% of users can independently use all important functions, 16% are the others).

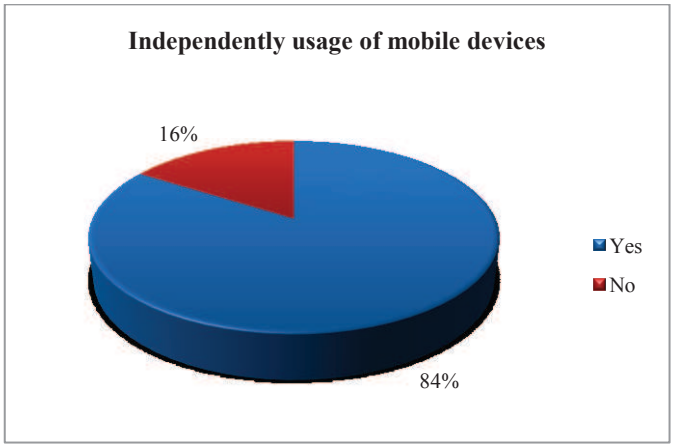

Figure 3 Independent usage of all major functions

Input unit is an important parameter for evaluation of the usage of mobile devices because nowadays we are facing an increasing trend of development Touchscreen options as input units. Blind and visually impaired people mostly use the keyboard as an input Unit (111 of them), while 23 users use Touchscreen option, 9 of them use these two features (Figure 4).

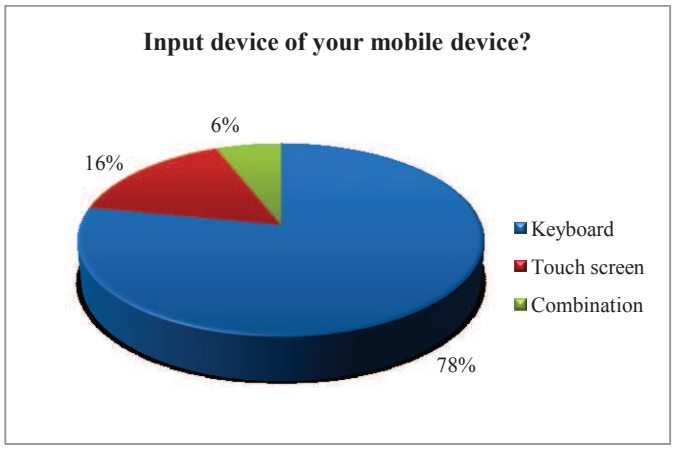

Figure 4 - Share of representation of technology input units of mobile devices

In the implementation of the analysis of the application for control and routing, there were 16 users from the Association HUPRT who use mobile navigation application in their transport around the city of Zagreb (Figure 5) [10].

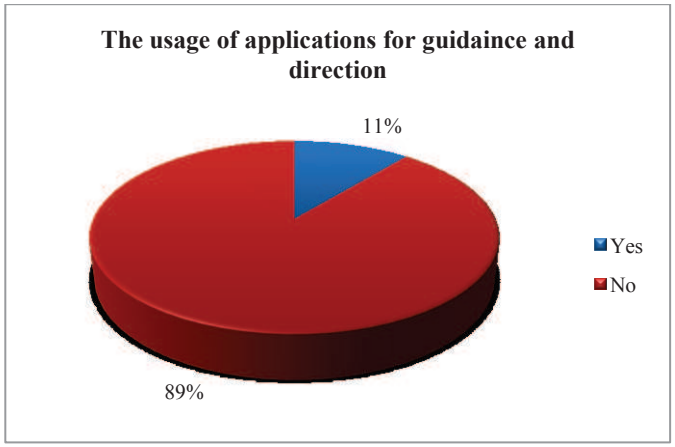

Figure 5 - The proportion of users who use applications for navigation

The problem is that the navigation maps are using GPS technology to locate users and in some applications, there are many large errors in determining the exact positions. People commonly use Loadstone application, which is free, and according to analysis, there are the smallest deviation in determining the exact position of the users.

III. Analysis Of The Availability And Adaptability Of Mobile Terminal Devices

In the study, in addition to users of application for managing, were also other users from Association HUPRT, with the aim to evaluate the availability and adaptability of mobile devices. Applications for managing and directing the blind and visually impaired people were analyzed in terms of determining the accuracy of the location where the user was located. The applications and mobile terminal devices that are mostly represented among the users according to data from the Association HUPRT [10] were used for these.

A. Hardware and software features

Besides accuracy in determining the location, Operating Systems for mobile terminal devices, types of GPS[3] receivers, input-output devices, and the ability to score the importance of voice control applications and mobile devices were analyzed (Table I). Users have rated devices by the grades of the importance from 1 (not important) to 5 (extremely important).

TABLE I. OVERVIEW OF THE CHARACTERISTICS OF THE MOBILE DEVICES [11]

Device Model	OPERATION SYSTEM	APPLICATION	GPS RECEIVER	INPUT UNITS	OUTPUT UNITS
Nokia E51	Symbian OS 9.2	Loadstone	A-GPS extern – Iblue 737A	Keyboard	Talks
Nokia 6220 Classic	Symbian OS 9.2	Loadstone Nokia maps	BT-Q818XT 66 channels	Keyboard	Talks
HTC Mozart	Microsoft Windows Phone 7	Outdoor navigation	Integrated, A-GPS	Touch screen	Voice navigation
Sony Ericsson Xperia mini pro	Android OS, v4	Intersection Navigation WalkyTalky	BT-Q818XT 66 channels	Touch screen	TalkBack
Nokia C7	Nokia Belle OS	Nokia maps	Integrated A-GPS	Touch screen	Mobile speak
HTC Vario 4	Windows Mobile 6.5	MobileGeo	Prestigio Bluetooth GPS	Combined	Mobile speak

According to the analyzed data, the most important detail for users according to hardware is the keyboard as the possibility of input unit. As output unit (voice), TTS applications[4] such as Mobile Speak, TalkBack, Talks and those that are integrated into the operating system are mostly used. Operating systems, which were analyzed, are important in terms of the accessibility of applications, which users use.

Applications were analyzed according to the parameters listed in Table II. Users have evaluated the importance of certain functionality (1 - I don't care, 5 - very important).

Loadstone GPS - application is free of charge, in fact this is the open source version of GPS navigation application, which is specially designed for visually impaired users. The application works with Symbian Series 60 platform, and it can be connected to various GPS modules either external or those that come built into the mobile device. Loadstone does not use ready-made maps for movement and navigation, but the user should define the maps and routes of movement, which can be subsequently sent to the Loadstone Central Server so that other users can benefit from already produced maps and routes. Work applications have the ability to work offline or online. If online it requires a connection to the Internet, so there is an option for the end user to decide to use or not. The advantage of this application is the language support (Croatian language), and functioning with Symbian screen readers including Talks and Mobile Speak.

Outdoor Navigation - Windows Phone 7 application that has the option of choosing maps (Google Maps, or OpenStreetMaps OpenCycleMaps) to use. The application also supports offline / online mode, which is extremely important for users (social aspect). A large number of features such as the ability of independent (individual) input of points of interest (import KML and Geocaching LOC file), defining an emergency call, which can be in the form of text messages or e-mail contacts, sharing of defined routes through Facebook account, or by sending an email.

TABLE II. REVIEW OF ANALYSED FEATURES FOR NAVIGATIONAL APPLICATIONS AND THEIR ACCESSIBILITY [11]

	LOADSTONE GPS	OUTDOOR NAVIGATION	MOBILE GEO	INTERSECTION EXPLORER	NOKIA MAPS	WALKYTALKY
Language support - CRO	Yes	No	No	No	Yes	No
Mode (*offline*/ *online*)	Yes	Yes	Yes	No	Yes	No
Map type	Google maps	Bing maps Open Street Maps Open Cycle Maps	TomTom	Google maps	Nokia maps	Google maps
Automatic detection of use (pedestrian / vehicle)	No	No	No	No	No	No
Voice control	No	No	No	No	Yes	No
Points of Interest entry (POI)	Yes	Yes	Yes	No	Yes	No
Starting method	Slow due to extern GPS-	Fast	Slow	Slow due to extern GPS-a	Fast	Fast
Multitasking	Yes	Yes	Yes	Yes	Yes	Yes
Method of creating movement routes	Extern (via computer)	Yes	Yes	No	No	No
Ability to automatically create return routes	No	No	No	No	No	No

[3] GPS receiver – Receiver of Global Positioning System signal

[4] Application to change the text to speech

Mobile Geo - application can be installed on any mobile device supported by Windows Mobile platform. Mobile Geo works directly with the Mobile Speak screen reader for smart phones and allows customers to use mobile phones with built-in GPS modules or to combine them with other commercial modules. Using GPS solutions developed in the Sendero Group, Mobile Geo gives great portability and flexibility in providing a variety of information to the users, by using the installed folder in the memory of a mobile terminal device and at the same time allowing the development and 100 per cent control of new routes or upgrading the existing ones.

Intersection Explorer - an application that is exclusively designed for blind and visually impaired users, it doesn't have a function of specifying the routes for the users, but provides information about the location of the intersection for them. Working as Google's Street View tool, and allows users to virtually explore the location and orientation using panoramic images taken at street level. Blind or visually impaired people can research surrounding with the ability to facilitate the perception of the environment (traffic junction).

WalkyTalky - an application that is also designed for visually impaired people, works together with the application Intersection Explorer (Android). Purpose of the application is guiding and directing the user to the intended target using a Google map. The application allows the users to view points of interest, but there is no possibility of their entries.

Nokia Maps - an application that is used mostly by newer generation of Nokia mobile devices (Nokia Belle OS and Nokia Anna OS), but its folder is now available for download for the iOS and Android operating system. Nokia Maps allows you to store and share routes provided by the users via social networks or emailing. Detailed overview of points of interest and their input are defined according to users needs.

The analysis of applications show the deficiencies such as lack of automatic creating feedback routes of movement and language voice navigation in the Croatian language unless the user does not have installed the voice application. Way to launch and configure some applications is very complicated for a blind or visually impaired person who wants to use the application. Automatic detection mode, for example, shows that, if one user shares his or her movement on foot and then got into the vehicle of public transport the application does not provide any details or change.

B. Applicative solutions for guiding and directing users

Applications (MobileGeo, Loadstone and Nokia maps) have very small errors in determining the location of the users (figure along the application name) on open intersections, which can be seen from Table 3.

The work of Loadstone and MobileGeo applications is based on the input of points of interest (POI) for each user to individually create, produce, and coordinate his or her position according to his or her needs. This means that such applications are relatively empty, ie, they don't have any content which makes user very insecure.

TABLE III. THE ERROR ANALYSIS OF NAVIGATIONAL APPLICATION AND GUIDANCE THROUGH BUSY INTERSECTIONS [11]

	Maksimir street - Svetice	**Street of King Zvonimir - Harambašićeva street**	**Street of King Zvonimira - Šubićeva street**	**Zagrebačka street – Street of Dragutina Golika**
Location error of pedestrian crossing [m]	Loadstone - 0,5 Nokia maps - 0,5 WalkyTalky - 8 Navigation - 40 Outdoor Navigation - 30 MobileGeo - 1	Loadstone - NV Nokia maps - 0,3 WalkyTalky - 5 Navigation - 30 Outdoor Navigation - 30 MobileGeo - NV	Loadstone - 2 Nokia maps - 1 WalkyTalky - 12 Navigation - 40 Outdoor Navigation - 40 MobileGeo - 2	Loadstone - 0,2 Nokia maps - 0,3 WalkyTalky - 8 Navigation - 20 Outdoor Navigation - 15 MobileGeo - 1
Error leading through the intersection [m]	Loadstone - 0,5 Nokia maps - 0,5 WalkyTalky - 8 Navigation - 40 Outdoor Navigation - 30 MobileGeo - 1	Loadstone - 0,2 Nokia maps - 0,3 WalkyTalky - 5 Navigation - 30 Outdoor Navigation - 30 MobileGeo - 1	Loadstone - 2 Nokia maps - 1 WalkyTalky - 12 Navigation - 40 Outdoor Navigation - 40 MobileGeo - 2	Loadstone - 0,2 Nokia maps - 0,3 WalkyTalky - 8 Navigation - 20 Outdoor Navigation - 15 MobileGeo - 1

On a busy intersection of King Zvonimir street and Harambašić street the applications Loadstone and MobileGeo haven't been able to evaluate (mark NV) because they were very close to all points of interest, a large dot density is a problem in determining the exact information about the location of the user, and sometimes the inability to determine the exact location, as stated here.

Navigational maps used by applications have had a problem to update the information, ie those maps haven't got any new information about streets or new amenities. These maps have had large discrepancies in determining the position of users (Google maps, Openstreet maps, Opencycle maps). Maps which were used in applications MobileGeo and Nokia maps have had updated data and high accuracy in determining the location of the user.

Busy intersection of King Zvonimir and Šubićeva street were evaluated with very low scores, where users pointed out that they alone would not be able to handle. Pedestrian crossings are set at an angle which is also a problem for reading navigational routes for pedestrians. Examples of pedestrian routes of individual maps are shown in Figures 6 a, b, c and d.

From the displayed images it is evident that there are no marked pedestrian trails, so the navigation has to be done by road users. Performance of applications on the busy intersection of Maksimir - Svetice didn't show any larger deviations. When using Loadstone and MobileGeo applications, defined points of interest that were placed at each site crossing the intersection were shown first, as in Figure 6 d.

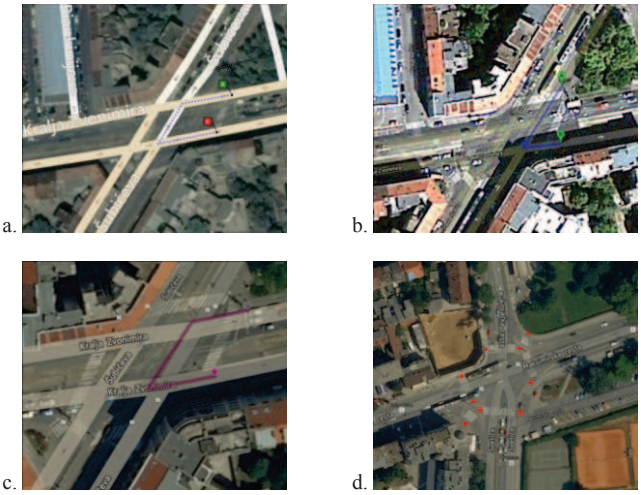

Figure 6 Traffic intersection of King Zvonimir and Šubićeva streets (Bing Maps) (Google maps) (Nokia Maps) in Svetice

Red dots are showing the entered points of interest that occur when a user is in need to use application for managing and directing. Errors in location when using Loadstone and Nokia Maps application are 0.5 [m], while in MobileGeo application error is 1 [m].

The analysis of applications in real environment, it can be concluded that their use of Loadstone, Nokia maps and MobileGeo applications an error occurs but the error is not large, so it can be said that the error would not jeopardize the safety of the person who is using the application. The problem can occur when the negative effects of parameters affecting the determination of a user's location using GPS navigation, which may at some point, raise an error.

Lack of applications is the recognition of the intersection, so if the user defines the route of movement and approaching the busy intersection that has no sound or tactile signals, the person can lose a sense of independence, perception of safety and orientation.

IV. CONCLUSION

In this research, the basic principles of "universal design" were used and the following segments were analyzed: applications for guiding and directing the blind and visually impaired; customization and basic functions of mobile devices; communication technology of small coverage area (Personal area); major equipment traffic intersection in the City by the elements of accessibility and sound signaling; the importance and identification of relevant traffic and education and rehabilitation parameters in function of safe movement around traffic and network models of assistive technology. Qualitative application of these aspects provide a greater degree of security and independence of movement when the blind or visually impaired use transport network, which also contributes to a higher degree of orientation and perception of the situation in which the user is located.

In the analysis of the available applications is noticed the variations in the user's location using GPS receivers (external and integrated into mobile terminal devices). Variations in location of blind or visually impaired people can compromise safety and lead to deadly consequences or injuries. Application Loadstone proved to be the best evaluated, in terms of getting the most accurate information and simplicity of usage. The analysis of mobile devices we have evaluated adaptability of blind and visually impaired people and the importance of basic functionalities. Recommendations for the development of mobile devices are reflected through the existence of tactile keyboard compared to newer solutions, or touch keyboard. Applicative solutions allow greater adaptability for visually impaired people (accurate information, voice information, easier navigation through the functionality of the device, etc.).

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