Title of the Paper: Recommendations for the Development of Information and Communication Services for Increasing Mobility of Visually Impaired Persons
The Name of the author(s): Marko Periša, Ph.D., Ivan Jovović, B.Eng., Prof. Dragan Peraković, Ph.D.
Affiliation (University/Institution, City, Country): University of Zagreb/ Faculty of Transport and Traffic Sciences, Zagreb, Croatia
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E-mail: marko.perisa@fpz.hr; ivan.jovovic@fpz.hr; dragan.perakovic@fpz.hr

1   Introduction

In designing the interfaces of mobile terminal devices available for the visually impaired persons it is important to satisfy everything to the aspect of accessibility "Design for Usability". Mobile terminal devices depend on their characteristics, and therefore it is possible in case of iPhone device to use the recommendations of research about the touch screen functionalities [1]. The methodology of Touch screen functionality has been analysed according to the users' needs, where as concluding observations the most frequently used movements of single users are defined [2]. In order to improve the basic functionalities for the movement by mobile terminal devices the system programmers have to have satisfied user-experience-enhancing requirements [3]. The persons with damaged vision often use screen readers as aids for using mobile terminal devices and therefore it is important to adjust the content to the readers. The non-availability of contents fails to provide the visually impaired person with full information which is also indicated by the research about the analysis of the information availability [4].

Designing of services for mobile terminal devices with the aim of providing information and guiding of the blind or visually impaired persons has been dealt with in several scientific and professional papers. The methods of collecting, processing and presenting the data about the users' requirements have to be performed in a systemic manner [5], thus enabling higher quality design of applications and services for mobile terminal devices and the contents availability. Precise information that creates the contents of user information about their location for mobile terminal devices (Android) is enabled by the application of TTS technology, GPS maps and navigation applications [6]. In case of the mentioned solution the voice support has been successfully tested, allowing information and navigation of the users.
The problem of the precise location and all the relevant data necessary to increase the level of users' safety have not been observed in any of the mentioned papers. In designing ICT solutions and services for safe movement of persons with reduced and difficult mobility in the traffic network of the city of Zagreb the current situation needs to be analysed. The analysis will encompass the users' satisfaction parameters (assessment of the availability of the current technology and parameters that affect the perception of safety), and the analysis of technical and technological characteristics of the applicable user equipment and available applicative solutions taking into consideration the diversity of the user platforms MTU (Android, Windows and iOS).

2 State of the Art

To collect the data (users' opinions and attitudes) the method of interviewing was applied among 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 involved 144 users, which is 82% of the total figure. The representative sample was defined according to the Croatian Blind Union and the Zagreb Association of the Blind Persons according to the number, which is 171, of Blind and Visually Impaired (significant amblyopia) people employed in the City of Zagreb. The poll involved 101 users who are employed, which makes 59% of the total number of employees, so this sample is considered to be representative. This sample had been selected because these customers move around the city of Zagreb daily. The users participated independently in the survey via online form, and via phone in the form of interviews.

In analysing the assessment of traffic elements while moving along the traffic network the users assessed the current traffic signalisation intended for the persons of impaired vision in the City of Zagreb, adjustment and accessibility at the traffic intersections for the blind and the visually impaired persons and which intersection they find the least safe in their movements. In the City of Zagreb, as of 31 October 2012, there were 76 traffic intersections equipped with audio signalizers and a total of 698 signalizers. The defined traffic intersections were selected by the users who participated in the survey and they were used in testing the efficiency of the model.

In selecting the traffic intersections, five traffic intersections most frequently used in the movement of the blind and visually impaired persons were offered. These are the intersections that are in the zone of the movement of the blind and visually impaired persons. These were used to test the applications for guidance and navigation of the users, and for performing the analysis of availability of ICT technologies and services. Figure 1 shows the assessment of the users regarding the safety level of the proposed intersections.
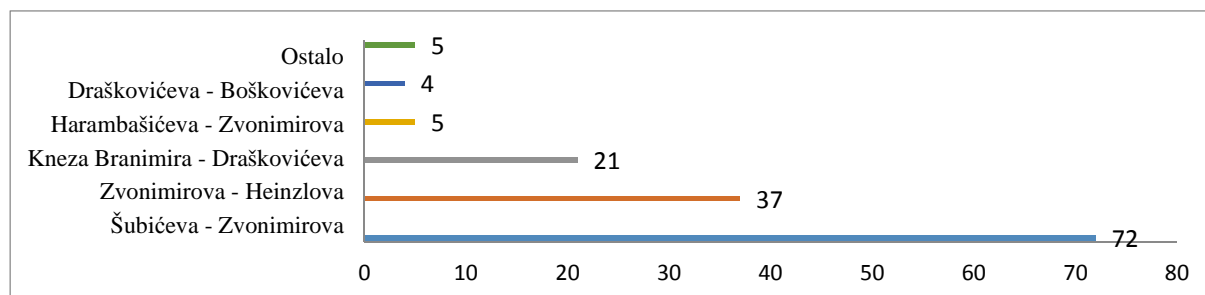

Figure 1 – Traffic intersection of reduced feeling of safety

As a traffic intersection with the lowest level of safety (some users claimed that they could never cross it on their own) is the intersection of the Šubićeva Street and Zvonimirova Street, 72 users. The traffic intersection with the lowest level of safety is considered to be the intersection where the user while moving along it, feels the least safe, i.e. where they have reduced possibility of defining the configuration of the traffic intersection and the elements that surround them.

The assessment of the audio signalisation is presented in Figure 2a, which shows the users' dissatisfaction with the current audio signalisation on the routes along which they move. The assessment of tactile signs that are currently found at the traffic intersections is shown in Figure 2b. Thirty-five users assessed the current tactile signs set at the traffic intersections as very

poorly designed, fifty-eight found them poorly designed, the situation was assessed as good by forty-seven users, four users found that the tactile signs have been designed very well, and one user considers the design as excellent.

Assessment of current audio signalisation

100
50
0

18   62   45   17   2
1   2   3   4   5

■ Very bad ■ Bad ■ Good ■ Very good ■ Excellent

Assessment of tactile signs at traffic intersections

100
0

35   58   47   3   1
1   2   3   4   5

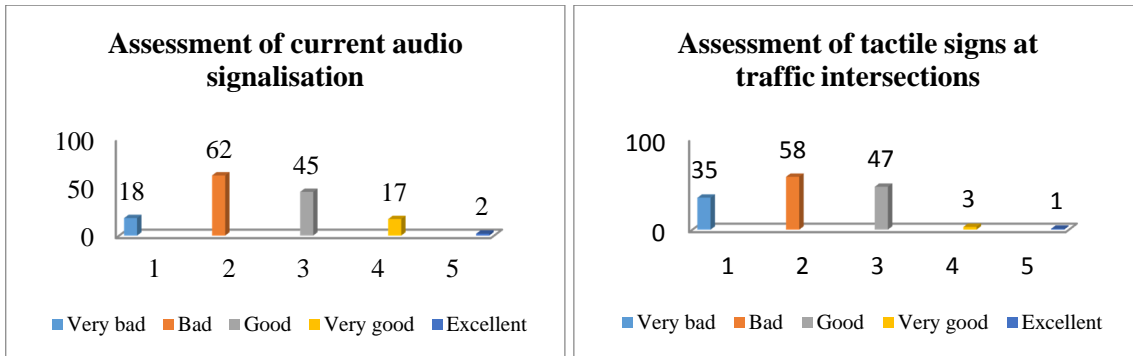■ Very bad ■ Bad ■ Good ■ Very good ■ Excellent

Figure 2a and 2b – Users' satisfaction with audio (2a) and tactile signs (2b)

The proposal of the development of new services in the zone of safe movement of persons with impaired vision is based on the application of new information and communication solutions. For this purpose the presence of mobile terminal devices and their functionalities have been analysed. Ninety-four percent of users use computer technologies which is very important in designing new services and solutions.

3   Assessment of Functionality of Mobile Terminal Devices

The surveyed users have assessed the availability of hardware characteristics of single devices, which refer to the significance of the availability of major functionalities. The major functionalities refer to the methods of usage when defining the trip plan, information methods, checks of information precision, data input methods and others. The users were interviewed at the defined intersection using the most represented manufacturers of mobile terminal devices as shown in Figure 3.

100
80
60
40
20
0

97   19   14   9   5   4   2
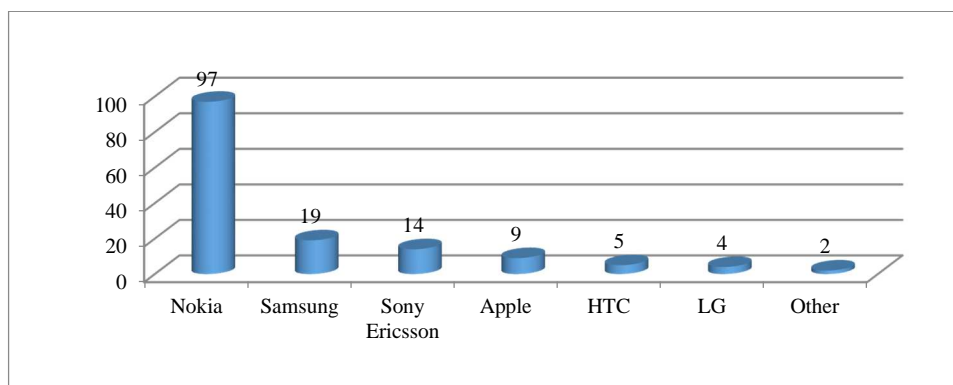Nokia   Samsung   Sony Ericsson   Apple   HTC   LG   Other

Figure 3 – Most represented manufacturers of mobile terminal devices

The mentioned figure shows the most represented manufacturers whose mobile terminal devices are used by the interviewed persons. The devices and components that were used for the assessment of information and communication technologies are presented in table 3.1.

Table 3. 1: Overview of analysed characteristics of mobile terminal device components

Model	Operation system	Application	GPS Receiver	Input units	Output units
Nokia E51	Symbian OS 9.2	Loadstone	A-GPS out –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

The users evaluated the devices that they use by the significance grade 1 (unimportant) to 5 (extremely important). According to the analysed data, the users found in the hardware part of the equipment as the most important parameter the existence of a keyboard as the input unit. As output units (voice) the most frequently used are TTS applications such as: Mobile Speak, TalkBack, Talks and those that are integrated into the operating system. The operating systems that have been analysed are important from the aspect of designing the accessibility of applications used by the users.

The applications have been analysed according to the parameters indicated in Table 3. 2. The users assessed with grades of importance (1 – not important, 5 – very important) single functionalities.

Table 3. 2: Overview of analyzed functionalities of navigation applications and their accessibility

	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 OpenStreetMaps OpenCycleMaps	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-a	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

As the result of analysed functionalities of single applications the most common application is Loadstone GPS, which is also the most accessible to the users. The application operates with Symbian platform of series 60 and it can be connected with various GPS modules either external ones or those already installed in the mobile device. Loadstone does not use ready-made maps for movement and navigation, but the users need to define the maps and movement routes

themselves, and after defining them the users can send them to the Loadstone central server so that other users may make use of the developed maps or routes. The application can run both offline and online which requires connection to the Internet, and the decision on the usage is to be made by the end-user. The advantage of this application is language support (Croatian) and running with Symbian screen readers which include Talks and Mobile Speak [7]. The drawback of this application is the impossibility of integration on newer operating systems, but due to its open source code many users have already started to adapt this solution to the Android system.

4 Recommendations for Design of Information and Navigation Services of Users

The proposal of developing new services in the field of safer movement of the visually impaired persons is based on the application of new information and communication solutions. For this purpose the presence of mobile terminal devices as well as their functionalities have been analyzed. There are 94% of users who use computer technologies which is extremely important when designing new services and solutions.

Recommendations for the design of services for mobile terminal devices are based on the results performed in this research, and all this with the purpose of accurate navigation and information of the users about the environment. The recommendations for the design of services for the guidance and navigation can be classified according to users' requirements which have to be met. The information that needs to be provided to the user by the system includes:
- Information about location;
- Information about guidance and navigation;
- Information about objects surrounding the user;
- Information of audio character;
- Information of descending and ascending curb;
- Information about traffic intersection;
- Information about the traffic control method (tactile lines, traffic light system or something else);
- Information about the proper moment to cross the street;
- Information about the system operation (failure of the system or upgrade), and
- Information about arrival to the destination.

The service of informing and navigating the users from the starting to the desired point has to provide accurate information about the user's location and environment and all the relevant information for guidance. Therefore, the user's mobile terminal device should be equipped with the application that satisfies all the standards of universal design. It is recommended that the application features the offline/online operating mode, mostly because of the economic aspect.

According to the elements of universal design the application has to be available for all groups of users, which means that its design and possibilities should not deviate from the standard solutions. The design has to be equally adapted for the left-handed and for the right-handed persons. The flexibility of usage is important when satisfying the users' requirements and for this purpose it is recommended, during the user installation, to define the user profile in order to provide the user always with the requested information. The management elements then need to provide logic structure of information, more accessible according to the most frequently used

information. The information structure needs to be divided according to the following categories:
- Basic information about the user;
- Information about the route of movement (where all the above mentioned pieces of information need to be provided);
- Public urban transport services;
- Possibility of defining the information for real-time information, and
- Accompanying facilities surrounding the user.

Because of the possibility of connecting the application with the web interface the mobile and web application need to have satisfied standards in selecting the colours for the visually impaired persons, as well as the possibility of increasing or reducing the font size [8].
The contents of application have to provide clear and understandable information, mostly because of the compatibility with screen readers. When defining the basic information about the user it is important to make it possible for the user to define their own level of impairment so that the information can be adapted.

By defining the level of the user's impairment better accessibility to the requested information is provided and it can be adapted to the users' requirements. Image information need to be accompanied by description, and the information needs to be understandable, regardless of the user experience, knowledge, language skills or current level of concentration. The information provided by the application also needs to have language support for the majority of world languages.

The application design must be such as to reduce the threats to a minimum, and to prevent the consequences of random or unintentional action. The information management elements should be set in such a way as to reduce to the minimal measure the threats and errors due to the application running: the most used elements; the most accessible ones; eliminated dangerous elements, isolated or covered. The warnings of danger or possible errors should be enabled. Protective elements should be enabled. Unconscious actions in creating information that require full user's concentration should be disabled. Working with the application should not inflict any physical or mental effort, such effort should be reduced to a minimum.

For the running of application that features the service of informing the users about all the relevant traffic information that surround them, information should be also provided about the public urban transport. This information would provide the user with a higher quality access to public urban transport, which is reflected through:
- better information about the time of arrival of tram or bus;
- monitoring the work of application if the user is changing the transport mode;
- information of users about the environment in the vehicle during the ride;
- information of users about the environment at the station, and
- possibilities of arranging special transport services.

Real-time information of passengers, the service which informs the user with sound or voice information about the changes on their route of movement. *Example:* if there are works on the pedestrian crossing and it is impossible to use it, the user gets the information about this, and suggestions of alternative routes for safe moving. Two-way information, data and voice communication with the user is important before moving along the traffic network. The users have the possibility of creating their own route within the application, data that have not been

input the users can enter themselves during their movement. For safety reasons the information can be very important, for instance if there are works blocking the direction of the user's movement or the information found at the intersection are not correct.

The supporting facilities that surround the user can be defined within the application as points of interest (POI). The possibility of such information can be used if the user wants to receive information about the supporting facilities such as cafés, restaurants, museums, shopping centres, hospitals, etc.

Because of the possibility of connecting with web applications it is necessary to ensure compatibility of devices. The current data about the number of represented devices are in favour of the devices that have a keyboard, whereas the devices with *touch screen* as input unit are used to a lesser extent. Because of its input unit the iPhone device provides a keyboard as an additional component which is also used by some of the interviewed users.

The recommendations for the development of new services are based on the application of key relevant parameters whose purpose is the creation of the user knowledge base. The interconnection of the parameters into one whole (base) and their sequence is important because it is set on the basis of the learned basic methods on orientation and movement of the blind and visually impaired persons. The user learning processes while moving along the traffic network are shown in Figure 4. An important segment in this presentation is the peripatologist or instructor of orientation and movement whose task is to implement the program with the blind and visually impaired persons in order to facilitate their movement along the traffic network. Based on the obtained information (based on ICT technologies) the user is provided with coordinated movement along the traffic network thus regulating their speed, and thus also the time of movement.
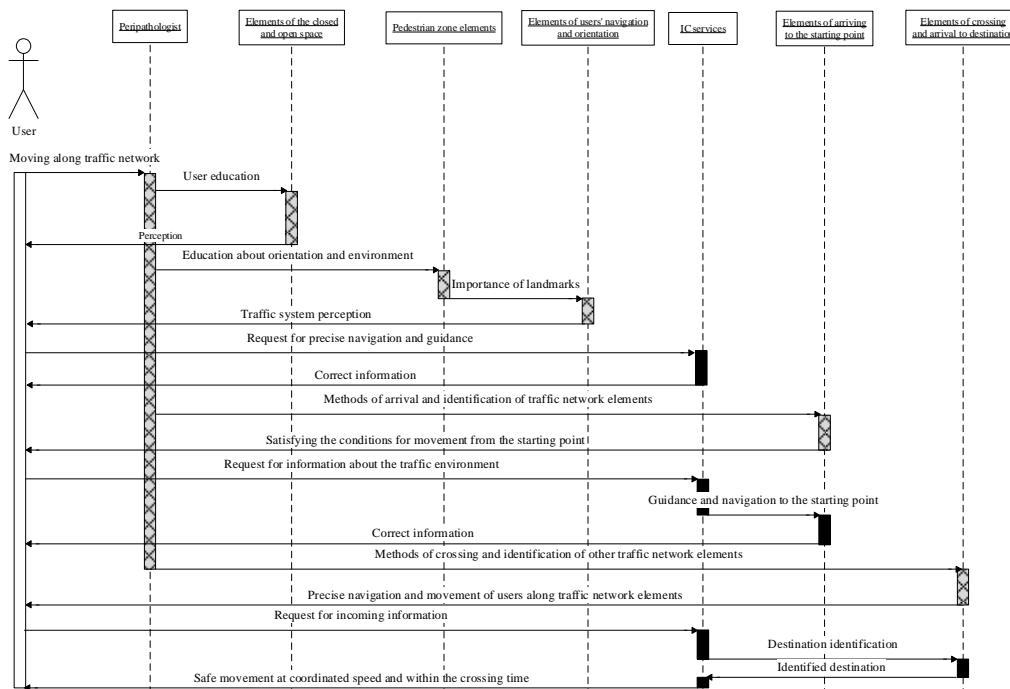

Figure 4 – Generalised overview of creating the user knowledge base

The implementation of new information and communication technologies (information and communication parameters) in the function of the users' mobility along the traffic network allows better information of the users. The information of the users is considered from the aspect of the user's surroundings and exact information about the navigation and guidance of the user to their destination, which affects directly the speed and time of movement. The exact information about the users' surrounding and their guidance contribute to raising the level of safe movement along the traffic network.

5 Conclusion

This research gives recommendations for the development and design of new services based on the most common mobile terminal devices and technologies. The prevalence of the devices is based on the previously performed analysis in the target group of users. The users tested the currently common applications for guidance and navigation at the traffic intersection where their level of safety is the lowest. This meant defining of all the relevant information necessary for better and more efficient movement of the users. The drawbacks of the current applications have been used as the basis in defining the recommendations for the development of future applications, all this with the aim of increasing the users' safety.

New services as the basis of the decision-making process use the generalized presentation of the user knowledge base, and all this with the aim of increasing the level of the quality of living of the visually impaired persons in the city of Zagreb. In the Republic of Croatia 66% of the surveyed users pass the training of orientation and movement and therefore the peripatologists have to have education about new ICT solutions and services. The mentioned services would then become a component of every user training who wants to move independently along the traffic network.

The design and development of mobile applications in the function of guiding and navigating the visually impaired persons along the traffic network need to be developed according to recommendations and standards. Therefore, for this purpose it is necessary to satisfy the mentioned criteria in research. The more precise location of the users is possible with the application of additional technologies such as RFID, NFC or WiFi thus directly combining information about the user environment.

6 Acknowledgment

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