SYSTEM OF IDENTIFICATION AND INFORMATION OF BLIND AND VISUALLY IMPAIRED PERSONS IN THE TRAFFIC NETWORK

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Abstract:

The mobility of visually impaired persons is the basis for their active participation in everyday activities. Therefore, the information and communication services should be adapted to this group of users. The services based on the advanced information and communication technologies provide the visually impaired persons with information about the environment while moving along the traffic network, which requires accurate information. This paper analyzes the currently available technologies (RFID, WiFi, NFC and Bluetooth) which provide precise information for the users. The mentioned analysis has been done on the example of the movement of users through a traffic intersection, when the user has to be provided with precise information about the location, surrounding and navigation to the destination. The user receives information by using a mobile terminal device and applications adjusted to visually impaired persons. As result of analysis, proposals have been given for the design of information and communication services whose function is to inform the visually impaired persons. Testing and analyzing the efficiency of single information and communication technologies have been performed on the actual traffic network system of the City of Zagreb. The users of the Croatian Society for Promoting and Development of Tiphlotechnology (Hrvatska udruga za promicanje i razvoj tiflotehnike - HUPRT) participated in checking the efficiency of single technologies and services. The results obtained by testing have provided the user with precise information about the location and environment thus improving the level of safety and the quality of living of the users.

Key words:

RFID, Traffic network, identification, navigation.

1. Introduction

According to the data of the World Health Organization (WHO) there are currently 285 million of persons in the world with poor eyesight. Out of this number 39 million are blind, whereas 246 million persons are visually impaired. In the Republic of Croatia there are currently 17,979 persons with poor eyesight, whereas in the capital, Zagreb, there are 1,985 persons with impaired vision [1].

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The City of Zagreb covers an area of 641.35 km^2 which is 1.13% of the Croatian territory. The position of the City of Zagreb in regional – Central European space marks an interrelation of three biggest cities that connect history, present and past – the triangle Zagreb-Vienna-Budapest; a lower level is the connection Zagreb-Graz-Trieste with Ljubljana in the centre, and in Croatia this is the triangle Rijeka-Split-Osijek with Zagreb in the centre. In the city of Zagreb the traffic intersections are equipped with audio and tactile information. This research presents the evaluation of the quality of the information done by the blind and visually impaired persons (the target group of users –TGU) when moving through the urban traffic network.

Today's development of information and communication technologies and services in this area can contribute to the improvement of the quality of living of TGUs when moving along the traffic network. Apart from the standard audio signal which is used for navigation through the traffic intersection also the development of new solutions and services based on RFID technologies is possible, which is shown in many scientific studies from this area [2]. In the mentioned study the aids such as guide dog, white cane and GPS system have been used. RFID technology has been tested in external spaces and interior facilities assessing the mentioned technology and services which are based on this technology through the satisfaction of the users. The movement along the traffic intersection of TGU using in the process a mobile terminal device (MTD) and the application for navigation is presented in detail by the study carried out at the ITS Institute (Center for Transportation Studies, University of Minnesota) as part of the program Using a Smartphone App to Assist the Visually Impaired at Signalized Intersections [3]. The mentioned document uses WiFi technology in order to improve the precision of locating the user. In identification systems where currently the person with low vision mostly uses the white cane, RFID technology also plays a very important role [4].

2. Analysis of Technology in the Function of selecting the precise user's Location

This paper analyzes the currently available and economically most cost-efficient technologies (RFID, WiFi, NFC and Bluetooth) which enable precise information of the users. In closed spaces and spaces that interfere with the GPS system signal, i.e. where the possibility of locating the user by means of the GPS system is difficult or almost impossible, the positioning can be done by using the mentioned technologies:

- RFID;
- Bluetooth;
- NFC - (*Near-Field Communication*);
- Locating by means of base stations:
    - GSM – *Global System for Mobile Communications;*
    - GPRS – *General Packet Radio Service;*
    - UMTS – *Universal Mobile Telecommunications System;*
    - LTE – *Long Term Evolution, and*
- Wireless LAN.

The main characteristics of the mentioned technologies in the positioning of the users are presented in Table 1. The technologies have been analyzed with the aim of obtaining the precise position of the user who uses it. The basic data on RFID technology – maximal working distance is what the advantages of this technology depend on [5] [11]. The connecting technologies Bluetooth and NFC have their advantages and are recommended in order to obtain information of up to maximally 0.20 [m], and their advantage is low energy consumption [6]. The Wireless technology is also reflected in the advantages of the speed of transmission and security of data transfer [7]. Location by means of base stations features no significant advantages, the drawback being the insufficient accuracy in determining the location [8][11].

Table 1 – Characteristics of other technologies in positioning of the user

TITLE	OPERATION FREQUENCY RANGE	MAX. OPERATION DISTANCE [m]	CAPACITY OF DATA	ADVANTAGES	DRAWBACKS
RFID	Low frequencies 50-500kHz Medium frequencies 13.56MHz Microwaves 0.9-2.5GHz	(depends on the antenna) 0.025m -0.725m – distance for medium frequencies stronger antennas even up to 150m	*Read-only* (20bit) **Passive** (read/write) (48bytes to 736bytes) **Active** (read/write) (64 bytes to 32KB)	100% reading accuracy, ability to withstand different weather conditions **Active** Battery life 2-7 years, Radio-connection supply, possibility of sending multiple data. **Passive** Less expensive, smaller	**Active** More complex and more expensive **Passive** Range up to 0.5m Less memory
BLUETOOTH	2.4GHz to 2.4835GHz	Maximum energy /mW (dBm) 100/20 ~ 100m 2,5/4 ~ 22m 1/0 ~ 6m	Data transmission speed Bluetooth v4.0 24Mbit/s	Possibility of voice and data transfer	Limited distance, Low peak flow.
NFC	13.56 MHz	0,2m	Data transmission speed up to 424 kbit/s	Low energy consumption	Small distance
Lociranje putem baznih stanica	GSM-LTE 700 MHz to 2600 MHz	GSM 35km LTE to 100km	173 Mbit/s for downlink and 58 Mbit/s for uplink	-	Insufficient precision
WIRELESS	2.4 GHz (802.11b i 802.11g standards) and 5 GHz (802.11a)	**802.11b** ~35m **802.11a** ~30m **802.11g** ~30m **802.11n** ~50m	Data transfer speed up to 54 Mbit/s	Speed of access	Security Transfer speed

Source: [9]

For more precision in obtaining information about the location of the user moving along the traffic network, it is recommended to use RFID technology. This technology is used to identify the user and to inform the traffic intersection management system.

3. Models of Guiding and Navigating Blind and Visually Impaired Persons

Models of guiding and navigating blind and visually impaired persons are based on the application of the currently available ICT technologies for the user who moves along the traffic network, and are divided into:

- model of applying ICT technologies (Mobile terminal device, application - GPS, identification system – RFID), and

- model of applying the main aid (white cane or guide dog) and RFID system of identification.

Model of ICT technologies application is based on the usage of navigation application adapted to the visually impaired persons, the mobile terminal device and identification system. Because of errors that occur when using the navigation applications (GPS as method for independent guidance and navigation), another technology (RFID, Bluetooth or NFC) is added to this working method. For using this method of work the user must have a white cane, mobile terminal device (external or integrated GPS receiver), application which enables guidance and navigation of users and RFID tag. The user's movement is divided into three zones of identification presented in Figure 1 [9] [10].

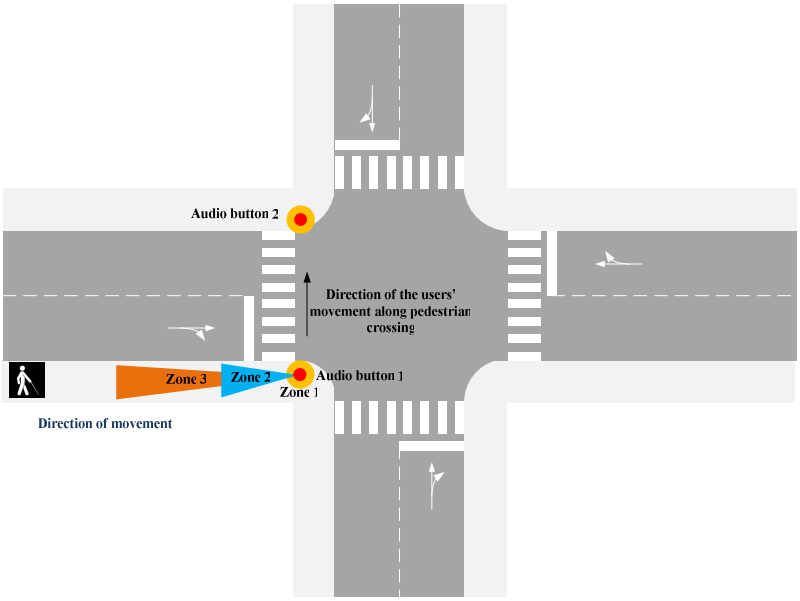

Figure 1 – Zones of identification and navigation of users

The first zone is defined in the radius of 1 m in relation to the audio indicator which at the same time defines also the initial point of crossing. The second Zone is defined at the distance of 10 [m] in the direction of the user's arrival, and the third Zone at a distance of 30 [m]. The mentioned zones are defined through the carried out research of the analysis of applications for the guidance and navigation and the conditions of traffic intersections in the City of Zagreb. For the size of the third zone the distance is considered as sufficient for the orientation of the user in relation to the audio signal which would be activated after having identified the user. The identification zones allow the obtaining of precise information received by the user about the distance that is required to arrive to the first point of crossing the traffic intersection. The user moves along the traffic network receiving along the way via mobile device the information on their movement which is based on GPS navigation and application used by the user and the pre-defined route of moving. Sound indicators are input as points of interest (POI) according to which the user is navigated. The points of interest inherently also use the information about the traffic intersection.

When the user enters the third identification zone, the system controlling the traffic lights receives the information and changes the operation mode. For the identification the user must have an RFID tag which is identified by an antenna directed towards their moving. The traffic light system receives information from the RFID controller, which, after having received the information prolongs the green phase for pedestrians, allows activation of the audio signal and provides information for the user at arrival to the initial point of crossing. The average speed has been obtained by measuring

during the analysis of the traffic intersection, and the mean value of ten performed measurements has been taken (v_k= 0.55 [m/s]).

Upon arrival to the initial point of crossing the intersection (audio button 1), the user receives information on their location and all the necessary information about the traffic intersection. The information that the user can receive includes: size of the intersection (how many lanes in which direction), street names (defined according to the geographical directions), existence of landmarks, tactile elements of accessibility, tramway lines, and possible directions of movement. If the pedestrian crossing is at an angle (example the intersection of Zvonimirova and Šubićeva Streets), the user also obtains this information and aligns the body to the respective position. For instance: *Direction of movement North – South, Šubićeva street, position of body 30° to the right.*

The user receives the information via mobile device if the point of interest has been input with a commentary or by using the technology such as *Bluetooth* and NFC which serves to read the information from the indicator. After confirmation of the traffic light system for crossing the road, the user passes along the pedestrian lane and arrives to the destination point (audio button 2). Upon arrival the user receives information that they have arrived at the destination, and the information about the possibility of further moving by using the directions of movement according to the geographical directions.

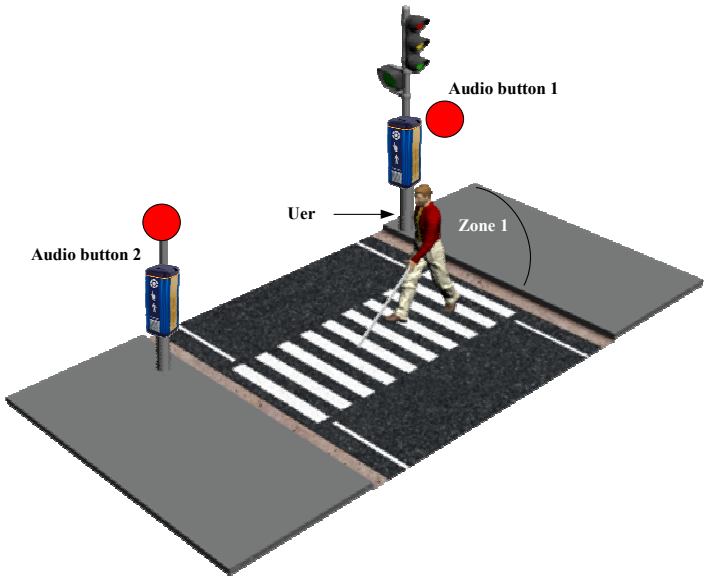

Figure 2 – Movement of users through traffic intersection

The exit of the user from the system is identified by RfID system that forwards the information to the traffic-light system which returns to the initial mode of operation. The time interval is determined according to the size of the traffic intersection and the traffic volume that runs through it. After exiting the system the user receives the information on the mobile device that they have exited the traffic intersection zone. The user can move toward the destination point by using the application for guidance or navigation (point of interest 2) or by the emitted audio signal. The user's passing is presented in Figure 2 which shows the method of user's movement and possible information that surround them.

Model of basic aid implementation is based on the use of the basic aid which the users have assessed in a survey carried out on a sample of 175 users, who move and live in the area of the City of Zagreb. The survey included 144 users, which is 82% of the total figure. The representative sample has been defined according to the data of the Croatian Association of the Blind and the Society of the

Blind Zagreb about the number of the employed blind and visually impaired persons (substantial visual impairment) in the area of the City of Zagreb, and there are 171 of them. The survey included 101 users who are employed, which is 59% of the total number of the employed, and this sample is considered as representative. This sample has been selected because these users move every day in the City of Zagreb. The users participated in the survey independently by means of on-line questionnaire, and by telephone in the form of an interview. According to the survey, 94 users use a white cane as aid, whereas 10 users use a guide dog as presented in Figure 3 [9].

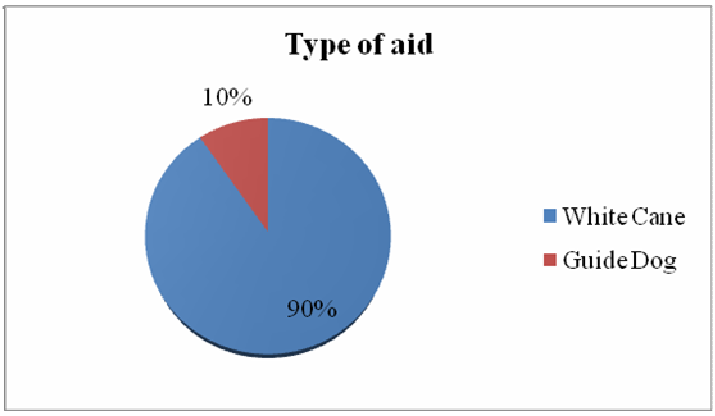

Figure 3 – Share of aids used by the blind

For moving along the traffic network, the user must have as aid the white cane, mobile device and RFID tag. The traffic intersection system is equipped with RFID system of identification as in the previous mode of operation, but the user does not use navigation applications. The identification system identifies the user (Zone 3), i.e. the RFID tag and forwards the information to the controller. After having received the information from the controller the traffic light system changes the mode of operation and allows activation of the audio signal. Apart from activating the audio signal, the green phase for pedestrians is prolonged and the information about the traffic intersection is provided. Moving towards the source of audio information the user also passes through the pre-defined identification zone.

Upon arrival into the first zone of identification, whose radius is 1 metre, the user activates the audio button (due to the possibility of intersecting the first two zones), and receives the necessary information about the traffic intersection. In order to receive the information the user uses the mobile terminal device, and as technology for obtaining the necessary information the user can use Bluetooth or NFC, as well as RFID signal reader.

After receiving the information and activating the green light for the crossing of the intersection the user crosses the intersection to the destination point at which the second audio traffic light is located. Upon arrival at the destination point, the user receives on their mobile device the information about their arrival and information about the traffic intersection. If the user wants to continue their movement along the traffic intersection, i.e. again on a pedestrian crossing, this operating method for guidance and navigation is applied as well. It may be, therefore, concluded that the model is applied to audio buttons that operate in pairs.

After the user has exited the system, after the time interval the traffic light system returns to the initial mode of operation. The time interval depends on the time during which the user is in the system (peak hours), size of the traffic intersection and the density of the motor vehicles in the intersection.

4. RFID system Architecture for user Identification

Information and communication system of identification and user service provision is based on RFID technology. The components of the system include: reader with antenna and controller, transponder (card or tag) and the central computer. Figure 4 shows the architecture of the system when the user is moving along the traffic network.

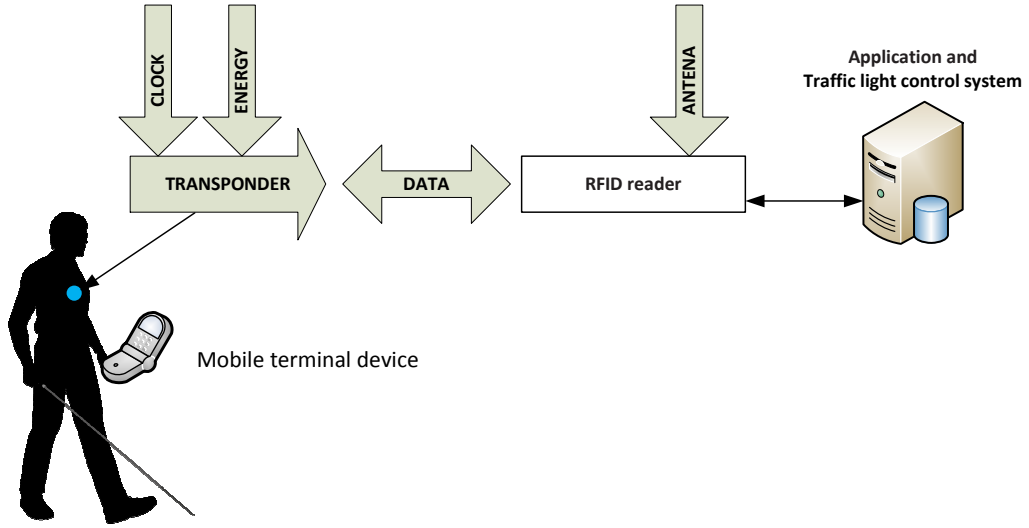

Figure 4 – RFID system architecture for identification

The identification system has to provide the basic user's requirements in order to adjust the system to the visually impaired persons, as well as to other users in traffic. The user's requirements define the basic information the system has to provide to the user [9]:

- Information on location;
- Information on guidance and navigation;
- Information on objects surrounding the user;
- Information of audio character;
- Information of descending and ascending kerb;
- Information on traffic intersection;
- Information on the method of traffic control (tactile lines, traffic light system or something else);
- Information of the right moment to cross the street;
- Information on system operation (system breakdown or upgrade), and
- Information on arrival to the destination.

Apart from this, it is important that the operation of the system is provided in all weather conditions because of the user's safety. If the weather conditions allow some changes in the operation of the system the user has to be informed. Depending on the user's requirements, the elements of the traffic control system are defined. The information received by the user from the system are based on NFC and Bluetooth technology. The elements of the system include:

- identification of the user within the identification zone (their location);
- information of the user about the location and navigation (shape of the traffic intersection and all its elements);

- information of the user about the surrounding objects;
- possibility of activating the audio signalization;
- management of real-time information of users;
- provision of information according to a large number of criteria and special points of interest;
- provision of information about the direction of movement using tactile and voice information;
- logical structure of information, more accessible according to most frequently used information;
- two-way communication, data and voice communication with the user;
- information of users, position precision of the user, and
- automatic management of the traffic light system, longer green phase for the pedestrians.

Information of the user at the initial point of crossing is done by using the mobile terminal device, Bluetooth headset or by means of device speakers and NFC reader. Mobile terminal device can have the role of a reader, transponder which communicates with the terminals and peer-to-peer data exchange.

5. Conclusion

According to the carried out survey, 87% of users stated that longer green phase would raise the level of safety in moving along the traffic network. Such method of traffic light system management is provided by the application of the RFID system of identification and navigation of the users. The results of checking the efficiency of the mentioned models have enabled safe and independent movement along the traffic intersection. The user had all the relevant information about the environment and about the configuration of the traffic intersection, thus improving the user's perception. More efficient usage of the currently available technology and its functionality would make it possible for the blind and visually impaired persons to enhance the quality of their lives. The users' requirements have enabled the adjustment to the user according to the requested information without endangering other traffic factors. By implementing new information and communication technologies and services new methods in the education of movement and orientation of the blind and visually impaired persons have been determined.

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