Information Service for the Visually Impaired Persons in Public Transport – MAppIN

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Abstract. Applying appropriate assistive technology makes it possible to ensure greater inclusion of persons with visual impairments in society. In this paper, research was conducted related to the attitudes and satisfaction of visually impaired persons with existing information services provided by public transport companies in the city of Zagreb. Functionalities of the information service for blind and partially sighted persons when using the public transport system are proposed based on the analysis of the collected and processed data. The conceptual architecture of the system for the delivery of information services of this group of users based on modern information and communication technologies has also been proposed. A test environment was created to check the operation of certain functionalities of the information service. The result of this is the proven operation of the proposed architecture of the information service delivery system. This solution can increase the degree of mobility and quality of life of this group of users, ensuring the implementation of the Society 5.0 concept.

Keywords: Assistive technology · Service delivery system · Society 5.0

1 Introduction

The development of new solutions in assistive technologies seeks to help persons with disability perform everyday activities more efficiently and safely. When using public transport services and moving part of the traffic network, visually impaired persons face several problems and challenges: waiting at the wrong stop, not being informed about the timetable, getting into the wrong vehicle, information in vehicles, and more.

This paper aims to investigate the needs of users (visually impaired) who use the public transport system and define the functionalities of the user information service. The purpose of using such a service is to raise users' quality of life to whom all relevant information is delivered in real-time via a mobile application solution.

Visually impaired persons differ in their characteristics and specific requirements that are considered when developing new innovative solutions and services. Therefore, users need to be provided with the availability and use of a reliable solution that will allow them to move quickly and safely from departure to destination. In this research, the conceptual architecture of the information service delivery system based on the technology and framework of the Society 5.0 environment was proposed.

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2 Previous Research

Currently available literature in the development of systems and services for informing users when moving the traffic network is focused on developing mobile application solutions for vehicle identification and user navigation services.

The proposed architecture of the Ariadna system allows users to be informed through Braille (a specific point of view and access to it) [1]. The system works on the principle of entering the found code, which is entered into the mobile application, after which the user receives the relevant information about the lines passing through this stop. The problem with this solution is that the user has to look for a label with a code every time, which is problematic for visually impaired users.

The OnBoard system has functionality for bus vehicle identification, where the user does not use his mobile device but a unique device integrated at the stop [2]. The user presses a button on the device, and with audio information, he receives information about the arrival of the bus and the line number and confirms the desired line. When the user confirms the desired line, the loudspeaker implemented inside the bus is activated, after which the user's sound signals indicate that he is entering the vehicle. The disadvantages of this solution are the dimensions of the device and its highly complex use.

Smart bus alert is a proposal for a bus identification service [3]. The service works on the principle of the implemented ZigBee module. The module provides the user with information about the arrival of an individual bus at the stop. Also, the user can enter their destination by voice, and the system will inform them of their arrival.

The GeoNotify mobile application, adapted to the degree of user damage, is used to navigate the user and detect unexpected temporary obstacles that could cause injuries [4]. The paper proposes using neural networks connected to data collection methodologies to define more accurate models capable of recognizing broad representations of obstacles in the real world.

The research showing the results of the Horizon 2020 project entitled "Sound of Vision: the natural sense of vision through acoustics and haptics" presented different models of designing user navigation systems and information in urban public transport [5].

The research results within the MOVIDIS project presented an alternative to help visually impaired users navigate the public transport system. The various modules of the MOVIDIS system communicate with each other via radio frequency (RF) and enable users to interact with buses and their stops. The first experimental results showed that RF communication is a viable option to help persons with visual impairments in public transport services [6].

The mentioned research describes previous research and challenges in developing navigation and information systems for the visually impaired [7]. Problems created by GPS technology in determining the exact location bring the user close to the destination, but not to the exact location, which causes challenges such as difficulties in locating the entrance to buildings or entering the public transport vehicle. Research [8] analyzed current solutions and user needs and the possibilities of applying a probing study using a new vision-based system called Landmark AI to understand how technology can better solve aspects of this problem.

In the Republic of Croatia, mobile applications are on the market of operators' providers of urban public passenger transport, ZET info, and HŽPP Planer.

The ZET Info mobile application informs users about emergencies, changes, and notifications about tram or bus traffic situations. Also, the user has an insight into the timetables of certain lines and is automatically shown the earliest time of arrival of the vehicle at the stop from the time when the application was launched [9]. HŽPP Planer mobile application provides the user with real-time information on train timetables, their location, ticket prices, changes in the time of train arrival at the station. Also, the symbol shows if the train is wheelchair accessible, which means it is insured access using lift ramps and that a vehicle seat is provided for such persons [10]. The disadvantages of advanced mobile applications are that there is no single solution for the user regardless of the traffic mode that needs to be used (bus, tram, train, taxi).

The introduction of sensor networks enabled real-time communication between devices and large amounts of data collection. In parallel, the concept of Society 5.0 was presented, which aims to enable the personalization of products and services according to the wishes of end-users. In doing so, it is necessary to balance social problems and economic growth with the development of information and communication systems, networks, technologies, and services. The Society 5.0 concept seeks to increase the quality of life of end-users. Thus, persons with various disabilities are allowed to actively participate in the community by applying assistive technologies tailored to their needs [11, 12].

3 User Needs Analysis

The World Health Organization (WHO) estimates that there are about 285 million persons with some form of visual impairment [13]. There are 19,132 users with visual impairments in the Republic of Croatia, while there are 2,498 users in Zagreb [14].

Visually impaired persons have different needs, and their way of moving is not equally pronounced in every user. Therefore, when defining the functionality of a new solution, it is necessary to consider the different needs and desires, and shortcomings in the function of user movement. Basic requirements may include information on the environment, navigation, arrival at the destination, location, and more.

Blind and partially sighted persons face various problems when using public transport services, such as:

- inability to identify a point of view due to lack of signs,
- inability to identify the vehicle at the stop,
- lack of timetable at stops that are legible to visually impaired persons.

In order to collect data on the satisfaction and attitude of visually impaired persons about the solutions and services implemented so far, a survey was conducted [15]. Based on the obtained results, the dissatisfaction of blind and partially sighted persons was noticed, indicating the need to improve existing solutions or develop and implement new solutions and services. In cooperation with the Up2Date association, the survey questionnaire collected 27 answers, i.e., 22 blind persons and 5 visually impaired persons participated. Persons using public transport services are of different age groups (Table 1).

Table 1. Age group of respondents

Age group of respondents	Percentage of persons belonging to an age group
15–20 years	15%
20–30 years	22%
30–40 years	30%
40–60 years	15%
60 years and over	18%

When asked about the type of public transport they use, the respondents with visual impairments answered that 46% travel by tram, 27% by bus, 4% by train, and 23% use taxi services. Therefore, it can be concluded that visually impaired persons mainly use trams and buses as a means of transport. Also, respondents stated that 48% travel daily, 48% several times a week, and only 4% travel several times a month on these modes of transport.

When asked what bothers them the most when using public transport services, visually impaired persons said that their biggest problems are external disturbances, such as noise and light (39%), a ban on introducing a guide dog to the vehicle (25%), incomprehension from others passengers (24%) and misunderstanding by the driver (12%). These problems and the associated data can be seen in Fig. 1.

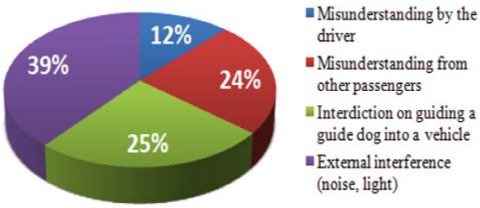

Fig. 1. Interference with the use of public transport services

Since mobile devices provide feedback in different ways, 77% of respondents want to receive audio information, 12% want information in the form of vibrations, and visually impaired persons or 11% want to increase the font.

Obtaining specific feedback for persons with visual impairments is of great importance in order to be able to orientate and create their image of traffic and the environment, which can be seen according to the results (Fig. 2). Thus, 23 respondents consider obtaining information about their location and their arrival at the point of view very important, and 4 of them consider it essential.

Navigation towards the vehicle door is very important for 22 respondents, while it is important for 5 persons. Furthermore, timetable information is very important for 19 persons and important for 7 respondents. 19 persons said that getting feedback on the location of the vehicle was very important to them, while 8 of them said it was important to them. Accident information and vehicle type information are very important for 14 respondents, important for 9 and neither important nor unimportant for 4 respondents.

15 respondents mentioned feedback on driving time as very important, 11 as important, and 1 respondent as neither important nor unimportant. Obtaining information on the number of persons within a particular vehicle is of great importance for 14 respondents, for 7 respondents it is important, for 5 it is neither important nor unimportant, and for 1 respondent it is very unimportant. Information on emergency transport is very important for 13 respondents and for 13 respondents it is important. For the possibility of an SOS call in case of danger, 13 persons stated that it would be very important to them, 10 persons would be important to them and for 4 persons the possibility would be neither important nor unimportant.

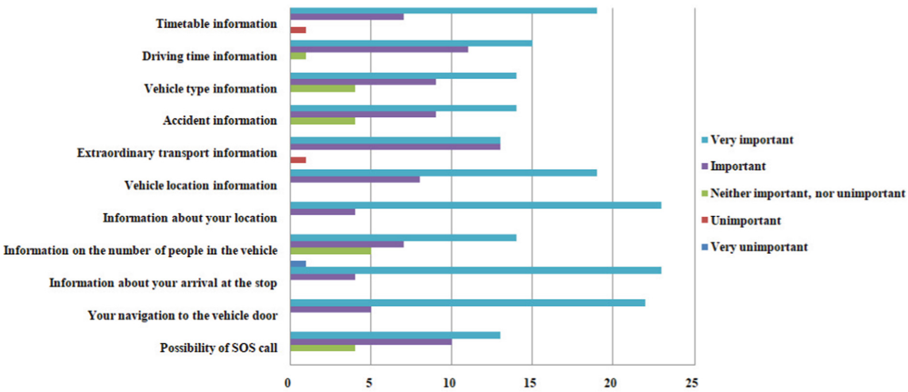

Fig. 2. The importance of getting feedback

Also, the majority of respondents (63%) expressed a desire for the possibility of buying tickets via the mobile application because they consider it safe to conduct money transactions via the Internet, and it would also facilitate the whole process of buying tickets.

It is necessary to enable users to receive feedback in a form that will be accessible to them. Therefore, blind persons need to be provided with information in the form of sound notifications or vibrations, while visually impaired persons can also use the ability to change the background color and change the font size. Respondents expressed the need for education that would enable them to get acquainted with how to use the solution, making it easier for them to navigate within the mobile application and navigate the traffic network. Given the data obtained, pointing to the fact that a large number of visually impaired and blind persons use public transport services every day, it can be concluded that it is necessary to present new opportunities for information services and develop a solution that satisfactorily meets the needs and requirements of users.

4 Functionalities of Mobile Application Solution MAppIN

Users' needs were identified based on the results obtained by implementing the survey method. Table 2 lists the functionalities of the mobile application solution for providing customer information services.

Table 2. Functionalities of the user information service in the public city transport system

Information service functionalities	
Registration (blind, visually impaired)	Proposing the choice of means of transport
Check-in/out	Education/user instructions
Informing about the timetable and driving duration	Account settings
Information on the type of transport	Travel and purchase history
Accident and emergency transport information	Navigation towards the vehicle door
Informing on arrival at the stop	Information on the number of persons in the vehicle
Buying tickets	SOS call
Ordering a taxi	Application for service provider and other stakeholders (data management)

User registration - depending on the degree of visual impairment and the possibilities of providing information, the user can choose the severity of the damage and the method of providing information (TTS - text to speech, font size, or contrast selection). The user also can enter information on the card method of ticket payment.

Check-in/out - the possibility of voice or written login/logout to the system to facilitate the launch of the user information service.

Informing about the timetable and driving duration - the possibility of providing information about lines, directions, stations, time of arrival at the stop, and the duration of the drive of each train line.

Information on the type of transport - shows the user information about the type of vehicle, whether it is a low-floor or a vehicle with stairs and a customized environment for persons with disabilities.

Accident and emergency transport information - in case of an incident situation, the information is provided to the user with instructions on getting out of the vehicle or calling the emergency services (firefighters, ambulance, police).

Informing on arrival at the stop - the stops must be equipped with Bluetooth Beacon technology which provides all the information on arriving at the stop/train line/place of entry into the vehicle. Upon the vehicle's arrival at a defined stop, the user receives information about the line and direction of movement. Based on this information, the user decides whether he wants to get into the vehicle or not. If the user has given an affirmative answer, navigating to the vehicle door begins by monitoring beeps or vibrations. If the user has decided not to enter the vehicle, he will receive information about the arrival of the following vehicle at the stop.

Buying tickets - the possibility of purchasing tickets for which the data entered during the registration of users in the system are required. The service informs the user about the successful or unsuccessful implementation of the purchase. Also, the user has forwarded an invoice about the completed purchase to his user email. If the purchase is unsuccessful, the user receives audio information about the reason for the canceled transaction.

Ordering a taxi - the possibility of choosing a taxi service provider and integration with the module of the taxi service provider selected by the user.

Proposing the choice of means of transport - depending on the different modes of transport and possible traffic jams, the user is provided with information on the mode of transport with the fastest and safest way to reach the destination.

Education/user instructions - the possibility of conducting user education on how to use the service and possible errors in how to manage the service.

Account settings - the ability to manage user information entered during user registration (name, surname, email, address, SOS numbers, card payment, type of damage, the ability to provide information, home, or work address).

Travel and purchase history – ability to view personal travel and ticket purchase history and saved invoices.

Navigation towards the vehicle door - user navigation to the vehicle entrance door using beacon technology.

Information on the number of persons in the vehicle – possibility to see the information of the number of passengers to easily avoid the crowd.

SOS call - when registering, the user enters the number for the SOS call in case of possible problems that may arise during the trip or when arriving at the starting point of the trip. The transport service provider can also make the call if this option is enabled.

Application for service provider and other stake-holders (data management) - possibility to apply for a service provider or other stakeholders interested in using the service. As one of the possible stakeholders, the taxi carrier logs into the system through the above functionality and thus can manage data for the provision of taxi services.

5 Proposal of the Conceptual Architecture of the Service Delivery System

In order to deliver the customer information service, a conceptual system architecture based on the Cloud Computing concept (CCfB) and Beacon technology has been proposed [16–18]. The CCfB architecture can connect with all stakeholders (stakeholders) of the system and manage and prepare data for different groups of persons with disabilities. In addition to the above, it is possible to integrate/connect with sensors from the environment using the IoT concept and collect them in real-time. Bluetooth beacon technology consists of small beacon devices that transmit a signal with a unique ID number identified by the user's mobile device and thus inform the user. The advantage of using Beacon devices is the reduced energy consumption enabled by Bluetooth Low

Energy (BLE) technology and the possibility of simultaneous data transfer to 20 devices within a range of up to 80 [m].

Figure 3 shows the proposed conceptual architecture of the system. The work of the proposed architecture is based on the IaaS model, where the service provider, users, and other participants are authorized to update and store new information. The information is distributed to end-users through the SaaS model via a mobile application or web browser and to other participants who develop applications through the PaaS model.

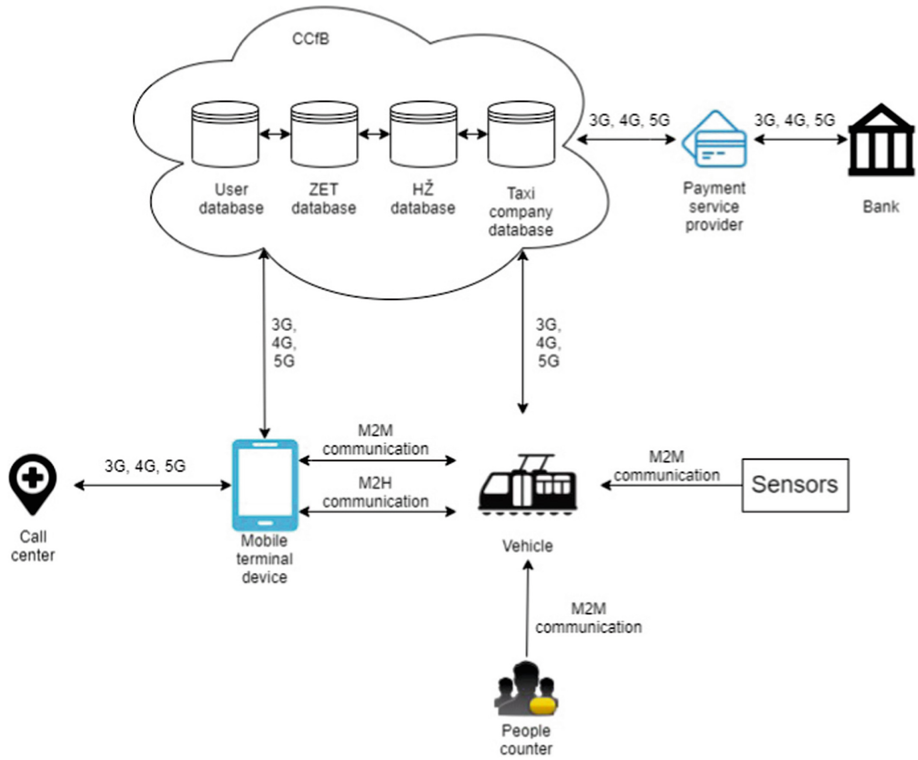

Fig. 3. Proposal of conceptual architecture

The cloud architecture consists of databases for managing information about users, public transport service providers (ZET, HŽPP, taxi transport). The user database stores data entered by the user during registration and login, during which authentication and authorization are performed. The ZET and HŽ database contains data on individual lines and timetables, emergencies, data collected from sensors, and more. The taxi company stores information about drivers, rented vehicles, transport orders, and more within the database.

A visually impaired person can access specific data stored in the cloud using a mobile application installed on a mobile terminal device. Blind users are provided with information via sound/vibrating notifications and signals, while visually impaired users can adjust the font size and background color, which improves the accessibility of the service.

Machine to Machine (M2M) communication occurs between the vehicle and the mobile terminal device, while Machine to Human (M2H) communication occurs between the mobile device and the user. The Bluetooth beacon is placed above the vehicle door so that audible signals towards the door can guide the user. In addition to the GPS module, tram, bus, or rail vehicles, implement a counter of persons according to whose data the user will decide whether to enter the vehicle or not. Information on the number of persons can be beneficial in today's Covid-19 situation that requires physical distance and a certain number of persons inside the vehicle.

The data collected by the sensors installed in the vehicle are sent to the cloud via the Internet, where they are stored and processed using M2M communication. Based on data from the cloud, the user is then provided with feedback in a customized form via M2H communication. Communication to the electronic/mobile service provider is performed via 3G/4G/5G mobile networks and communication to the CCfB environment. The user accesses the service using a mobile MAppIN (Mobile Application for Informing and Navigation) application and a mobile network.

6 Functionality Development of MAppIN Mobile Application

MAppIN is a mobile information and navigation application designed for blind and partially sighted users. In this paper, a test environment was created to check the operation of certain functionalities of the MAppIN application. MIT App Inventor is open-source software used to display and develop functionalities. It enables easy programming of mobile applications by drag and drop method for devices with the Android operating system.

The application colors used are defined in the test environment but selecting different sets may be offered in future development. The mobile application also uses a test database to store and distribute data. At startup, the user must register where the appropriate user data is entered. Different data entry conditions and restrictions are defined to alert the user. After the registration and login processes have been completed, the main menu opens for the user (Fig. 4).

The main menu consists of 4 links and, depending on the selection, data from a specific traffic area is displayed. Changes in traffic include information on accidents that have occurred, which interfere with the planned flow of traffic and include information on the organization of emergency transport. The user can view the above information in an additional menu but can also be informed at any time via a pop-up notification that appears on the screen.

By selecting tram traffic, information on tram lines, directions, and each vehicle's suitability for persons with disabilities are displayed. The list of all stops where the selected tram stops and the vehicles' arrival time at the stop is displayed after selecting a specific line. After activating the navigation button, the user confirms the start of navigation and routing to the defined location (Fig. 5).

When selecting rail traffic in the main menu, the user will be shown similar information for the tram, i.e., information on lines, timetables, directions, vehicle suitability, and

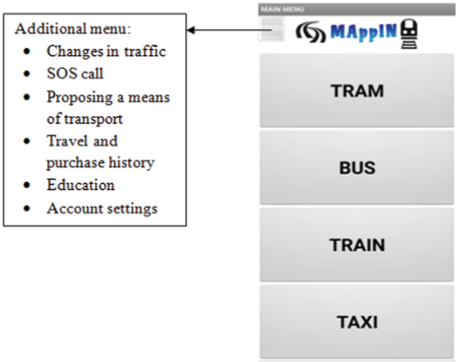

Fig. 4. Display the main menu

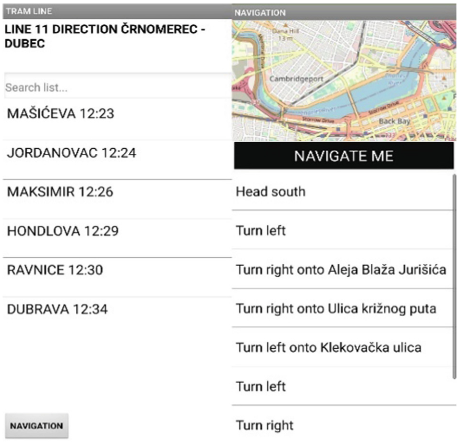

Fig. 5. Display of tram line stops and location navigation

like. Unlike tram traffic, rail can also include long-distance lines for which fair prices are defined. When the user selects the option to purchase a ticket, a new window opens (Fig. 6).

If all entered data are correct and funds are taken, the user is informed that the payment has been successfully made via a pop-up notification. Confirmation of the purchased ticket can later be found in the other menu if the ticket controller requires the person to show it.

7 Conclusion

Today's development of innovative solutions and services and their application in the Society 5.0 environment makes it possible to contribute to a sustainable social ecosystem. Assistive technologies that provide appropriate information to persons with disabilities play a significant role in the systems applied in the Society 5.0 environment.

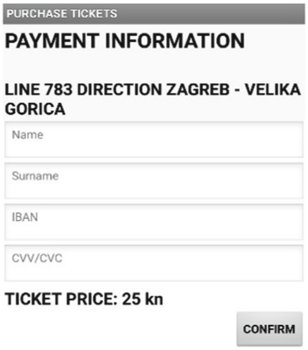

Fig. 6. Display the payment form

The proposed conceptual architecture of the system based on modern information and communication technologies aims to provide real-time information to users who move through the transport network and use the public transport system.

With accurate information, it is possible to raise the quality of life and equal integration in the society in which the user is located. Examining users' needs when using the public passenger transport system in the city of Zagreb is the starting point for defining the functionality of the information service. By applying the basic principles of universal design, the test layout of the application was proposed, as well as the verification of the operation of individual functionalities, which proved the operation of the proposed system architecture. Future research will focus on other technologies and frameworks of the Society 5.0 environment in different application scenarios to better integrate persons with disabilities into society.

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References

1. Markiewicz, M., Skomorowski, M.: Public transport information system for visually impaired and blind people. In: Mikulski, J. (ed.) TST 2010. CCIS, vol. 104, pp. 271–277. Springer, Heidelberg (2010). https://doi.org/10.1007/978-3-642-16472-9_30
2. Mehra, D., et al.: Bus identification system for the visually impaired: evaluation and learning from pilot trials on public buses in Delhi. 16 (2015)
3. Sowmya Priya, V., Soundarya, M., Niketha, V., Thanuja, I.: Smart bus alert system for easy navigation of the blind. Int. J. Res. Appl. Sci. Eng. Technol. **6**, 1656–1659 (2018). https://doi.org/10.22214/ijraset.2018.5270
4. Kim, E., Sterner, J., Mashhadi, A.: A crowd-sourced obstacle detection and navigation app for visually impaired. In: Paiva, S., Lopes, S.I., Zitouni, R., Gupta, N., Lopes, S.F., Yonezawa, T. (eds.) SmartCity360° 2020. LNICSSITE, vol. 372, pp. 571–579. Springer, Cham (2021). https://doi.org/10.1007/978-3-030-76063-2_38

5. Strumillo, P., et al.: Different approaches to aiding blind persons in mobility and navigation in the "Naviton" and "Sound of Vision" projects. In: Pissaloux, E., Velázquez, R. (eds.) Mobility of Visually Impaired People, pp. 435–468. Springer, Cham (2018). https://doi.org/10.1007/978-3-319-54446-5_15
6. Sáez, Y., Muñoz, J., Canto, F., García, A., Montes, H.: Assisting visually impaired persons in the public transport system through RF-communication and embedded systems. Sensors **19**, 1282 (2019). https://doi.org/10.3390/s19061282
7. Real, S., Araujo, A.: Navigation systems for the blind and visually impaired: past work, challenges, and open problems. Sensors **19**, 3404 (2019). https://doi.org/10.3390/s19153404
8. Saha, M., Fiannaca, A.J., Kneisel, M., Cutrell, E., Morris, M.R.: Closing the gap: designing for the last-few-meters wayfinding problem for persons with visual impairments. In: The 21st International ACM SIGACCESS Conference on Computers and Accessibility, pp. 222–235. ACM, NY (2019). https://doi.org/10.1145/3308561.3353776
9. ZET: ZET Info. https://zet-info.com/. Accessed 15 Dec 2021
10. HŽPP: HŽPP PLANER. http://www.hzpp.hr/hzpp-planer-vas-suputnik-na-putovanju-vlakom. Accessed 15 Dec 2021
11. Peraković, D., Periša, M., Cvitić, I., Zorić, P.: Information and communication technologies for the Society 5.0 environment. In: Radojičić, V., Bojović, N., Marković, D., Marković, G. (eds.) PosTel 2020 – XXXVIII Simpozijum o novim tehnologijama u poštanskom i telekomunikacionom saobraćaju, pp. 203–212. University of Belgrade, Faculty of Transport and Traffic Engineering, Belgrade, Serbia (2020). https://doi.org/10.37528/FTTE/9788673954318/POSTEL.2020.020
12. Periša, M., Peraković, D., Zorić, P.: Challenges of assistive technologies implementation into Industry 4.0: a review. In: Janošević, D. (ed.) The Seventh International Conference Transport and Logistics, pp. 5–10. University of Niš, Faculty of Mechanical Engineering, Niš, Srbija (2019)
13. WHO: Disability and health. https://www.who.int/news-room/fact-sheets/detail/disability-and-health. Accessed 10 Dec 2021
14. Benjak, T.: Izvješće o stanju osoba s invaliditetom u Republici Hrvatskoj (2020)
15. Anić, V.: Razvoj funkcionalnosti mobilnog aplikativnog rješenja za pružanje usluge informiranja osoba oštećenog vida u prometu, University of Zagreb, Faculty of Transport and Traffic Sciences, Zagreb, Croatia (2021)
16. Periša, M., Marković, G., Kolarovszki, P., Madleňák, R.: Proposal of a conceptual architecture system for informing the user in the IoT environment. PROMET - Traffic Transp. **31**, 37–47 (2019). https://doi.org/10.7307/ptt.v31i1.2677
17. Periša, M., Cvitić, I., Peraković, D., Husnjak, S.: Beacon technology for real-time informing the traffic network users about the environment. Transport **34**, 373–382 (2019). https://doi.org/10.3846/transport.2019.10402
18. Periša, M., Cvitić, I., Sente, R.E.: IoT services for increasing user mobility in the smart city environment. In: 37. skup o prometnim sustavima s međunarodnim sudjelovanjem "Automatizacija u prometu 2017", pp. 147–151. Rijeka, Croatia (2017)