Smart city: A system for measuring noise pollution

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Abstract

This paper deals with the development of Smart city services, with the focus on IoT services for measuring the noise pollution. Decreasing noise in the human environment can contribute to increasing the satisfaction of life in the big cities and urban areas where traffic jams are almost inevitable. The aim of this paper is to increase traffic noise awareness and to influence noise reduction through collecting and analyzing the environment data. We have designed, implemented and tested a system for measuring noise pollution, based on Internet of things, web and big data technologies. The system measures and analyses noise level and sends data to the server, where they are further stored, merged and prepared for visualization. As a support to the system, a web and mobile application have been developed. Mobile application enables us to collect large amounts of data from different parts of the city in a quick and efficient. Collection of data can be done by any citizen who has an Android device with installed application. The collected data are stored in the MongoDB. After analyzing data from different parts of the city, we have the ability to create noise maps that indicate the magnitude of the noise pollution for those city blocks. The analyzed data are compared with the legally defined norms and if the norms are not met, the competent authorities are alerted to solve the noise pollution problem.

Keywords: Smart cities, Internet of Things, noise pollution, Big data.

1. INTRODUCTION

A huge number of people live in cities (Kourtit, Nijkamp and Arribas, 2012). The trend of migration of population from rural areas to cities is evident. Cities tend to become "smarter" and to improve the quality of life. Information and communication technologies (ICT) are enabling the further transformation of traditional cities into smart cities (Mohanty, Choppali and Kougianos, 2016).

There are cities that have the ability to become smarter using the Internet of Things (hereinafter: IoT) technology and crowdsensing applications for real-time data collection and processing (Cardone et al., 2013). Mobile crowdsensing is an approach that allows people with mobile devices, such as smartphones, tablets and wearable devices to collect geospatial information through mobile device sensors and send or share this information with other users or the community (Goodchild, 2007) (Kamel Boulos et al., 2011) (Stojanovic et al., 2016). IoT technologies should be used for building IoT infrastructure for the smart city. IoT infrastructure should enable connecting intelligent devices in a unique network, and using different kinds of sensors, actuators, tags and readers in residential and commercial buildings, roads, street lighting, etc. (Radenković et al., 2017). Some examples of the implementation of IoT applications in smart cities are: traffic control systems, smart parking solutions, detection of the air and noise pollution levels, monitoring weather conditions, alarming in emergencies, etc. (Bahga & Madisetti, 2014).

This paper shows the system for measuring noise pollution in the smart cities. The system is developed within the Department for e-business, Faculty of Organizational Sciences, University of Belgrade. The system should enable measuring the noise level in traffic in the city, and making conclusions based on the obtained data. As a support to the system, a web and mobile applications were developed. The developed mobile application is used as a crowdsensing tool and enables sound recording in any time and any place. A web application enables users to monitor and preview all the recordings from the noise level in traffic.

2. LITERATURE OVERVIEW

From literature analysis, it can be concluded that a small number of cities are taking care of noise pollution. However, there are cities like Lanzhou that have been dealing with this issue since 1989 (Ma et al., 2006). Different studies and surveys indicate traffic as the main source of noise in cities. Traffic does not only make noise pollution, it also causes an unpleasant sensation among residents of cities, much more than other forms of noise (Nel, 2005). In developing countries where the number of cars is growing, the noise is also exacerbated by excessive traffic. Also, in these countries, the noise level is above the prescribed norms (Ali et al., 2002). Analyzing research on the effect of noise on human health, it has been found that noise primarily effects the mental health, it causes hearing, heart, eye and digestive damage (Muralikrishna & Manickam, 2017).

One of the main problems with noise pollution is its identification (Iyyanki, 2017). In recent years, awareness of noise pollution is growing and systems for protection against this type of pollution are being implemented (Dhaou, 2015). There are several applications that are used to detect noise, such as: EarPhone, NoiseSPY, WideNoise and NoiseTube. Unlike other applications, the NoiseTube application besides the mobile also contains a community-based web application for the citizens in order to keep them informed with the noise level measurements in their city (D'Hondt, Stevens and Jacobs, 2013).

3. SYSTEM FOR MEASURING NOISE POLLUTION
IN THE SMART CITIES

This paper presents the development of a system for measuring noise pollution in the Smart cities using IoT and mobile technologies. The system allows sending of aggregated data via web services and storage of data in the cloud environment.

The system is able to record noise on city streets that are most affected by traffic jams. During the implementation of the prototype of the system, Raspberry Pi and the noise measurement microphone were used. Also, a mobile application was developed to record short audio tracks with a specific location where the noise was detected (locations mapped using GPS). The received data is sent to the cloud environment for further processing and analyses.

The system for measuring noise pollution in the Smart cities is shown in Figure 1. The system is developed as a project of E-business Department, at the Faculty of Organizational Sciences, University of Belgrade.
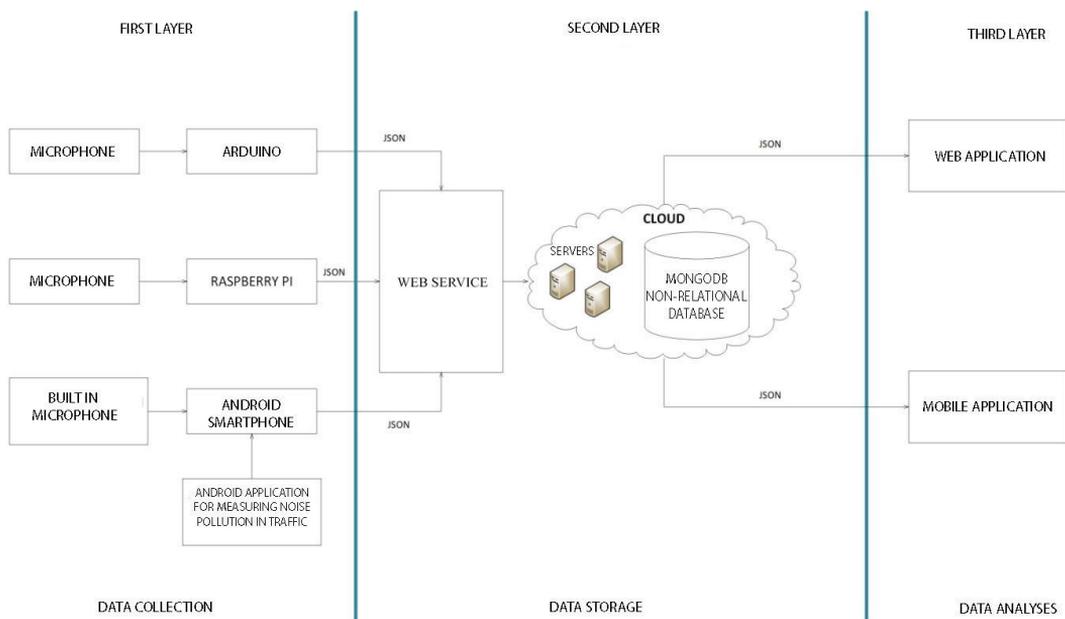

Fig. 1. System for measuring noise pollution in the Smart cities
Source: Nedeljkovic, 2017

Two types of stations are used to measure noise:
- Fixed stations - Raspberry Pi device is used to record noise at a specific location,
- Portable/mobile stations - Mobile devices and applications are used to record noise at different locations in the city.

In both types of stations, an external sound card and a 3.5 mm microphone are connected to the Raspberry Pi device. Web server is located on the Raspberry Pi that allows wireless control of the system. In order for the device to send data in real time, it is necessary to be connected to the Internet, via a cable or WiFi.

The station is managed through a web application. The application design was developed using HTML and CSS technologies and Bootstrap framework, while logic is based on JavaScript and PHP programming language. To display, search and sort data, a DataTables plugin was used, and to visualize the data, Google maps, and Google charts. As a central unit, the main server has an API that communicates with all the elements of the system: stations, mobile and web applications. RESTful API is made with Flight micro-framework. All data is stored in MongoDB database. The reason for the implementation of the MongoDB database in this system is due to the need to store a large amount of data.

As a support to the system, a mobile application has been developed. The main functionality is sound recording. In addition to recording, the application graphically shows the recorded sound volume. The mobile application, which is shown in Figure 2, is written in Java programming language. At the beginning of the recording, the application automatically saves geolocation data which are sent to the main server later with the processed noise data. The recorded data is transformed using the FFT transformation (Gao et al., 2017).
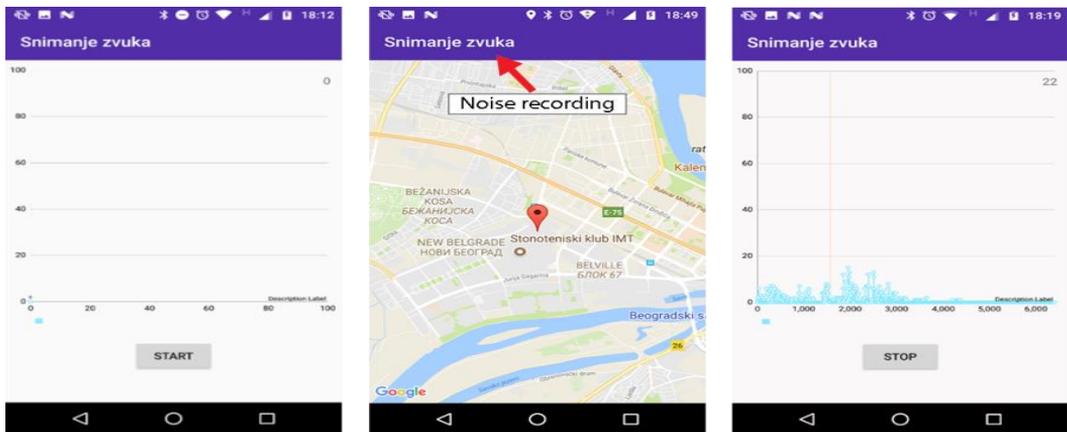

Fig. 2. Mobile application – noise pollution recordings and location data

Figure 3 shows a web application. On the left side, there is a list of all noise recordings, which can be sorted and searched by different criteria. By clicking on the magnifying glass it is possible to get more detailed information about the recording. On the right side, there is a map with placed markers on the location of the recording. Clicking the marker also provides more detailed information about the recording (Figure 4).
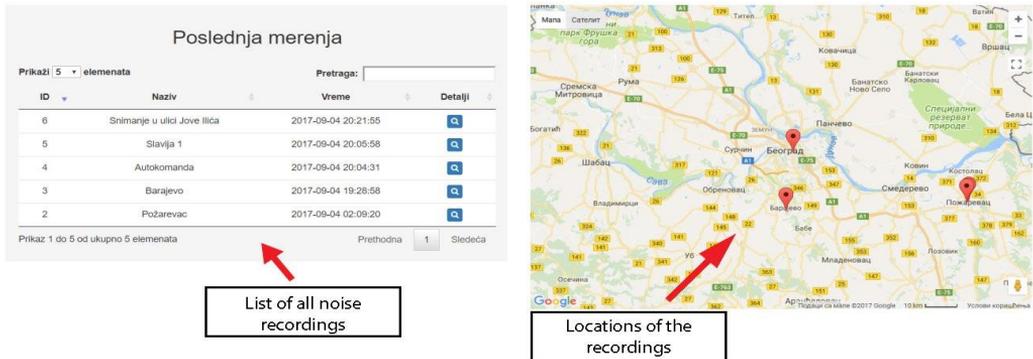
Fig. 3. Web application – noise pollution recordings

Figure 4 shows a detailed view of a single recording that includes metadata such as: name, geolocation, date and time and description. In addition, a complete audio track is available as well as a map with the exact location marked. Also on this page, you can see a chart with noise values that were obtained using FFT.
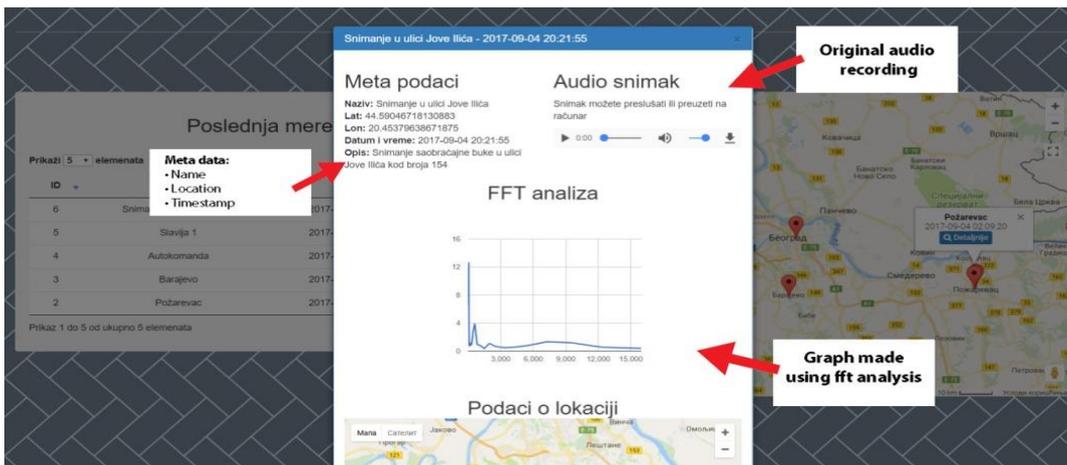
Fig. 4. Web application for recording noise pollution in the smart city

4. RESULT ANALYSIS

The aim of this paper is to measure noise values in urban areas, which are created as a result of traffic jams. Measured values are analyzed in order to take concrete measures and thus increase the quality of life in big cities.

Traffic noise was measured several times during the day and night. The time period in which the measurement is performed during the day was between 9 am - 10:30 am, 02 pm - 03:30 pm and 06 pm - 07:30 pm, and during the night from 00 am - 1:30 am and from 3:30 am - 5 pm.

According to the rules, the permissible level of municipal noise in the city center, the zones along highways, main and city roads is 65 decibels during the day and 55 decibels during the night. For this research, the measurements were made in one of the busiest part of the city of Belgrade, on Voždovac. Traffic noise was recorded for a week, in the evenings. The display of the average values is shown in Figure 5. The average values are: 55.46, 66.71 and 71.25 decibels. The values obtained are above the normal limits.
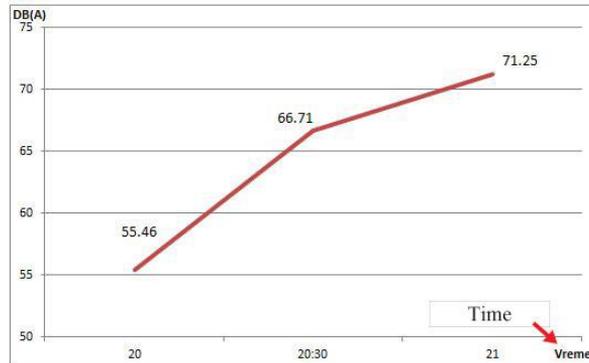

Fig. 5. Traffic noise during night in Belgrade

Noise can be treated as one of the major environmental pollutants, and the negative effects of the products are numerous. The impact of traffic noise on human health can cause: nervousness, chronic fatigue, anxiety, loss of hearing and sleep, stress, disorders, cardiovascular problems and decreases productivity.

By comparing the measured values with the prescribed limit values, it can be concluded that the introduction of concrete measures for lowering the noise level in traffic is inevitable. Noise is created as a consequence of living in urban areas and can not be eliminated, but it is possible to take some of the protection measures (Nedeljković, 2017).

5. CONCLUSION

This paper presents a system for measuring noise pollution in the Smart cities. The system was developed within the Department for e-business, at the Faculty of Organizational Sciences, University of Belgrade.

The purpose of this research is to measure traffic noise, analyze the measured data and, based on the results obtained, draw conclusions that will influence the noise reduction in the immediate human environment. Noise reduction will contribute to increasing the satisfaction of life in large cities and urban areas where traffic jams are almost completely inevitable. Noise cannot be eliminated but can be reduced by traffic regulation, night traffic restrictions, air corridor changes, strict vehicle technical regulations, double windows, insulation walls and personal protective equipment.

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