Design and Implementing System to Study Environmental Noise Pollution Using Microcontroller

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Abstract

This paper proposed a system and presents it's result obtained in a study on environmental noise pollution in the city of Baghdad, Iraq. The sensing system is built on Atmega128 and CC2420 platform. We designed and implemented a sensor function for wireless sensor network application using special network named (WSN) for measuring environmental acoustic noise.

Based on the readings obtained became clear that 90 % out of the locations during the peak time have equivalent sound level over 75 dBA, and 60 % out of the total number of locations measured display during the normal time equivalent sound level over 75 dBA.

Key words - *Pollution, environmental monitoring, Noise, WSN, T-Test*

Introduction

The effect of noise pollution on human health and his welfare is recently considered as an important and vital issue which encourages scientists and interested agencies all over the world, such as World Health Organization (WHO), to conduct more researches concerning assessment of its levels and harmful effects. [14] Sometimes defined in common speech the environmental noise as unwanted sound. The European Environment Agency defines environmental noise as 'unwanted or harmful outdoor sound created by human activities, including noise emitted by means of transport, road traffic, rail traffic, air traffic, and from sites of industry activity' [5]. Noise in industries such as construction equipment, electrical machines, loudspeakers, hawkers, vehicle movement, railroad work, and airplanes in the airports which cause an increased blood pressure and an irritation decreasing the work efficiency. It is therefore of utmost importance that excessive noise is controlled. We use the term decibels (dB) to explain sound intensity. World Health Organization (WHO) has illustrated that the most appropriate noise level not bigger than 75 dBA to prevent hearing loss.[10] Any level above 75 dBA will effect on human ear with time. World Health Organization (WHO) recommendations that required noise level over 75 dBA in streets and public places (outdoors) leads to weakness of hearing. [10] It is undesirable to exceed noise level the permissible limit, because it is harmful to human health and causes an inability to concentrate and nervous tension, therefore government institutions must develop appropriate solutions to reduce the pollution by noise and its effects on people's lives. The European Directive 2002/49/EC requires all Member States to provide accurate noise level mappings of inhabited areas with more than 250,000 people and make this information publicly available via web-interfaces of appropriate quality [16]. This article aims to design a digital sound intensity measurement system capable of sensing sound-frequency controlled by microcontroller & programming in C++ language. The main application areas of sound intensity sensing include deferent streets in Baghdad at two deferent times. We chose 16 of the most important areas in Baghdad (Al-Karrada, Al-Mansour, Al-Sinak, Al-Sadr City, Bab Al-Moatham, Bab Al-Sharqi, Al-Mustansiriyah, Al-Dora, Hae Al-Khadhraa, Al-Sha'ab) to measure sound intensity and to compare measured results with permissible parameters. It was measured in two separate periods, one at the peak time when end of the working hours (1:00 pm – 4:00 pm) and the other in the morning (9:00 am - 12:00 pm). This work focuses primarily on the establishment of wireless environmental monitoring systems proposed to measure noise pollution by sound within cities. There are many requirements that need attention when designing wireless sensor networks

when talking about environment in cities. In [8], System designed for monitoring environment pollution should be flexible, reliable and independent. applied a test network based on the TinyNode 8 MHz platform with a XE1025 transceiver 868MHz to observe a hydrological model of the Swiss Alps. in order to monitor environment, authors In [12] proposed a WSN framework : a Distributed Signal Processing infrastructure (SbDSP) based on the sensor to deal with sound data in a distributed manner. Anyway, a detailed application did not included in the sheet. The work done in [15] may be the closest to our project. In their work, the Tmote Sky platform [16] was applied with deploying sensors to measure traffic noise on the roads. Through the measured data, the number of vehicles and the number of different species can be calculated. The authors stress that the process of measuring noise in wide-scale using the WSN solution is possible. However, the accuracy of their measurements was not illustrated, leaving the contract calibration open, and the sensor sampling rate was determined at 8 kHz due to the reduction of the CPU / ADC. Examine the effects of noise pollution in other research has been undertaken in residents of Birj and its airport. The purpose of this research is to apply the descriptive study of the group, where took data at a specific time in a cross-sectional study. The purpose is to use 144 questionnaires by Morgan table distributed to 500 peoples living in those analyzed areas. [2] These studies have been done in narrow spaces that facilitate the handling and control the physical components and human, which confirms on the importance of introducing technology and programming to collect information and obtain results.

Method of Sampling

Our objectives were about measuring noise pollution levels in different areas with different traffic flow at different periods of time. Sound levels were measured using a controller consisting of microcontroller, sound sensor, and transceiver. In each location, the device is turned on for 10 minutes as a playback time and for a continuous measurement period of 2 to 3 hours during which several sound readings are recorded, sent and automatically saved to the computer, then calculate sound intensity. Noise levels of environmental pollution were measured in two different periods of the day to study the impact of human activity and vehicular traffic on the street. The first period was during the morning (9:00am-12:00pm). This period is characterized by relatively low traffic activity for cars and pedestrians because they are present in their jobs. The second period was during which noise measurements were carried out at the test hour (1.00pm-4.00 pm). This period is characterized by the maximum traffic of vehicles and pedestrians due to continuous working hours and the momentum of cars and other industrial and commercial activities in those streets. We correlated the obtained information of WSN sensor with XD-58C sensor to declare the effect of noise pollution on heart rate. We did the test on different levels of people were documented properly and collected in an excel File.

- Body Area Network (BAN) Implementation

For implementing such network we used XD-58C Pulse Sensor for arterial pressure and heart rate was used. This module is designed to plug-and-play heart-rate sensor for Arduino, any medical equipment that are measure heart rate may use this module. It can be worn on finger. its need 5 volts & 4 mA to work. It has open-source monitoring app that graphs pulse in real time. The high levels of pollution by noise cause every year a lot of heart attacks; therefore should be monitored heart health frequently.

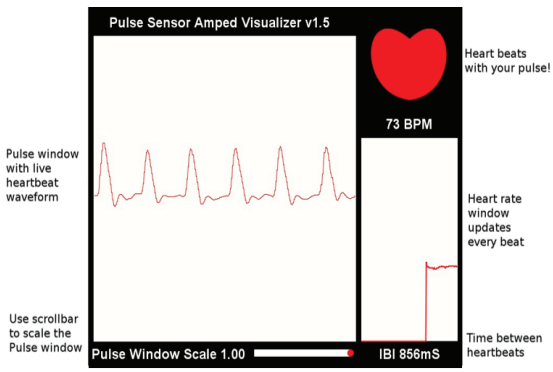

Figure 1. Module designed to plug-and-play heart-rate sensor for Arduino

To sketch the heartbeat waveform and check heart rate, we used software program “Pulse Sensor Amped”.

Collecting Data Method

A plan has been created to check research objectives and testing devices. The test was applied on group of 10 human; 5 males and 5 females them ages is between 25 and 40 years. They were subjected to noise level equal to 80 dB in average and for 20 minutes. The XD-58C sensor was hanged on a hand of each person during the test to measure blood oxygen saturation, and heart rate. There was a variation in the heart rate and changes in blood oxygen saturation levels when most of the people who were tested after exposing to noise. from this group,

one person had a significantly increased blood oxygen saturation and heart rate levels, felt in stress, and he had some pain in one ear. The results showed high heart rate and blood oxygen saturation levels values on the selected group which confirm the findings data published by the World Health Organization (WHO) regarding the harmful effects of noise pollution on human health. Figure (2, 3) shows changing in heart rate levels before and after exposure to noise.

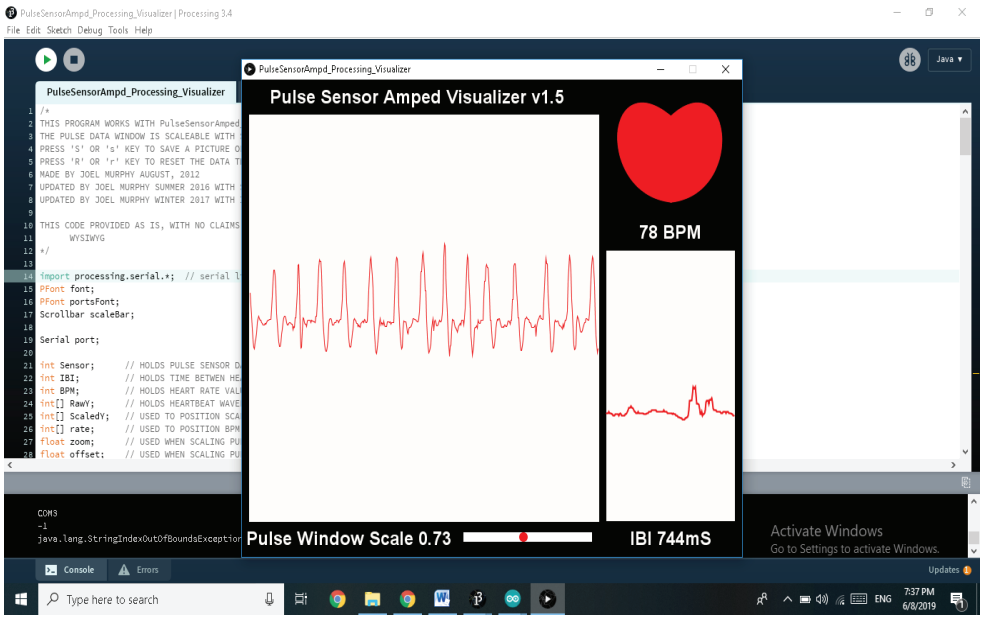

Figure 2. changing in heart rate levels before exposure to noise.

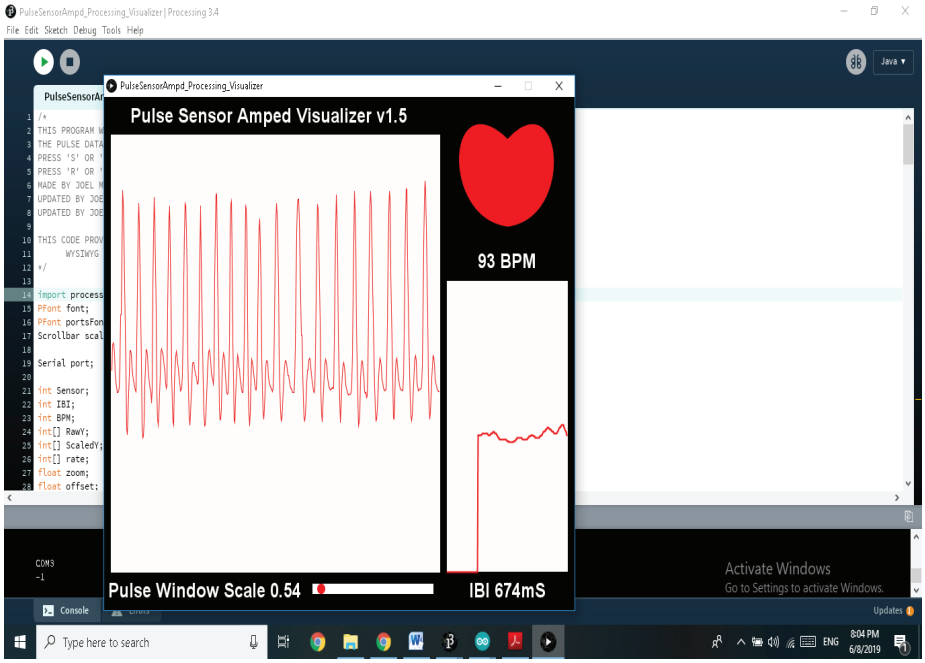

Figure 3. Changing in heart rate levels after exposure to noise.

We read sound levels, which wrote linearly through analog port of Arduino and then send it by WSN; at the base node receive data and recorded it to a computer automatically. WSN is a modern technology that is currently applied in a variety of fields including, the environment [9], natural disasters [4], public safety [3], [17], Government, Health [7] and intelligent buildings [11] and machine surveillance [13]. The sensor network contains a specific set of sensor nodes and a gateway connected to an external communications network. WSN networks are useful as well it considered low cost and low power electronic components. [14] We had used LM386 in order to measure the sound level with a KY-038 microphone sound sensor; this design had used in order to reduce the

power consumption where the circuit works with low voltage 5V. After received a signal (the sound), converts to a digital value in order to be dealt with by the computer.

$$R = \frac{Vi,max}{N\ comb} \quad \text{---------- (1)}$$

Where: VI_{max} is the maximum input voltage defined as 5V; R is the resolution; the obtained resolution value is R=4,9mV; N_{comb} is the number of combinations for 10 bits, it means 210=1024. Acquisition is used for converting to analog:

$$V_A = \frac{Vi,max\ .\ Vs}{N\ comb} \quad \text{---------- (2)}$$

Where: V_A is for converting voltage from analog to digital; VS is a pin in arduino obtained the sound level meter voltage in analog. Because the sound level meter has a DC output where 1dB of noise represents 10mV it is obtained:

$$V_S = \frac{S}{V\ aq} \quad \text{---------- (3)}$$

Table 1 - Noise Risk Zone Criteria Adopted To Be Used In This Study. [1]

Intensity of noise in dB(A)	Zones
Less than 66	Safe
66-71	Tolerable
71-76	moderate risk
76-81	high risk
81-86	High risk
Greater than 86	extremely high risk

We have selected some residential and commercial districts to measure sound intensity in two periods of the day. The result that we get it as below:

In general, sound intensity had obtained indicate an increase in sound intensity, which negatively effects on the lives of people in this city, therefore its need to develop procedures to reduce this effect. By comparing the result we obtained with the default values in table (1) we got the following table:

Table 2 - Classification of district of Baghdad city during active hours (9am–4pm)

Street	Noise Value	Zones
Al-Karada	82.03	high risk
Bab Al-sharqi	86.68	extremely high risk
Bab Al-Muazam	83.43	high risk
AL-sinak	83.95	high risk
Mansor	79.73	modrate risk

Cont... **Table 2 - Classification of district of Baghdad city during active hours (9am–4pm)**

Camp Sara	82.03	high risk
AL-shurja	83.95	high risk
AL-Bayaa	79.73	modrate risk
Hai Al-Xadhraa	74.05	Tolerable
Al-Shaab	80.53	modrate risk
Sader city	82.80	high risk
Al-Dora	76.70	modrate risk
Al-Adhamia	76.70	modrate risk
Zayona	74.80	Tolerable
Zaafarania	81.65	high risk
AL-mustansiriyah	76.28	modrate risk

Table 3 - T Test analyzing noise intensity in commercial streets

Group	**Normal time**	**Peak time**					
Mean	75.4188	89.9563					
SD	2.8578	2.1882					
SEM	1.0104	0.7736					
N	8	8					
P value	Mean	95% confidence interval of this difference		T – value		Df	standard error of difference
		Lower	Upper	Table	Calculated		
less than 0.0001	-14.54	-16.24	-12.8322	7.12	20.1586	7	0.721

The T- test [Table 3 & 4] showed that there were strong statistical differences (P <0.0001) between the noise levels during the two measurement periods as shown in (Figures 3). These data confirm that the traffic activity during the period of the beginning and end of official working hours considered the main source of noise pollution in the city of Baghdad. The statistical comparison of the results with respect to the activity of some streets indicated that there is no large difference between the results of the two measured periods, as they are areas of cars and passers-by and are considered permanent crowded areas in all active hours of a day.

Conclusion

Based on the readings obtained with the use of Arduino microcontroller and voice sensor, we found the percentage of sound pollution in the different areas of Baghdad. Became clear that Based on the readings obtained that 90 % out of the locations during the peak time have equivalent sound level over 75 dBA, and 60 % out of the total number of locations measured display during the normal time equivalent sound level over 75 dBA, and 90% of them over 75% during peak time. The most Baghdad area in the sound pollution is Bab Al-Sharqi (86 dBA), While lowest Baghdad areas in

sound pollution level were districts with low density population such as Hay Al-Khadraa, where it reached (74 dBA). The used design have accurate readability, low cost with ease of use, which makes it easy for us to compile readings, analyze them and produce satisfactory results.

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Conflict of Interest: None to declare.

Ethical Clearance: All experimental protocols were approved under the University of Mustansiriyah, Iraq and all experiments were carried out in accordance with approved guidelines.

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