

Nirob: A Next Generation Green Earth Technology Based Innovative System for Metropolitan Sound Pollution Management

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Abstract—Sound/noise pollution is one of the most severe problems in metropolitan areas with a thriving population. Excessive sound pollution is apparent everywhere in these cities, whether walking along the road or riding any mode of transport. The problem can be further amplified in “silent zones” - such as for students in schools, or patients in hospitals. To minimize its unhygienic and harmful impact on the human body, the authors of this paper have consequently developed a necessary and urgent solution: a green earth based technological system called Nirob, to target the problem from two different angles within developing metropolitan areas: to raise awareness amongst the general population to encourage change by measuring and displaying the high noise levels; to reduce noise in “silent zones”, by creating a system to regulate and minimize the use of honking by drivers.

Keywords— Sound Pollution Management, Arduino Uno, Sound Measure, Awareness, Wifi Module and Sound Sensor

I. INTRODUCTION

According to World Health Organization (WHO), the sound level of 60 dB sound can cause a person temporary deafness, while sound levels of 100 dB can lead to deafness permanently [1]. WHO also opines that approximately 5% of the entire world population suffer from various health hazards related to the complexities of noise pollution [2]. In line with that fact, from a study conducted in 2017, the Department of Environment (DoE) in Bangladesh finds that due to noise pollution, about 11.7% of the total population in Bangladesh have lost their hearing abilities [2]. Moreover, when 12 places within Dhaka are selected for a study, it can be seen that the sound levels in all of these areas exceed this healthy level of 60 dB, from 65 dB in residential areas like Bashundhara R/A, to 73 dB in Nadda Bus Stand, to as high as 77 dB in industrial areas such as in Mirpur [3]. A visual demonstration of the data obtained about noise levels from different areas within the city of Dhaka can be found in Fig. 1 and Fig. 2.

Due to rapid and uncontrolled urbanization, industrialization and an increasing human population with exponentially increasing activities, the problem of noise pollution in cities such as Dhaka get worse by the day. While noise from construction and industrial work is a contributing factor, it is to be acknowledged that

approximately 12 million people now live in the capital city of Dhaka, where traffic congestion is a regular phenomenon almost in every road, lane and by-lane. This traffic congestion is the major cause of noise pollution; the DoE finds that 500-1000 vehicles can honk at the same time when stuck in traffic in Dhaka, leading to highest noise levels to exceed 130 dB [2]. Most of the motor vehicles, especially buses, mini-buses and trucks have hydraulic horns, and the drivers are conditioned to honk continuously clear space in front of them. There is also a clear lack of knowledge on the drivers' part about their harmful contribution towards noise pollution, and the consequent harmful effects of it.

Hence, the authors have focused on noise pollution emitted from excessive honking of vehicles on the road. If proper steps are taken using technology, the noise levels on the roads can be significantly reduced to a good extent. Apart from that, creating a growing amount of awareness among the drivers can debar them from honking about inconsiderately. Implementation of noise monitoring systems and regulations and use of noise barriers can also help people combat the harmful effects of noise pollution, leading to a better environment. Hence the technology used becomes a part of green earth technologies. In the long term, Nirob can effectively even change drivers habits to lead to less congested and safer roads.

Location	Avg. Noise Level (Db)	Comment
Rampura	68	Very High
Gulshan	73	Very High
Dhanmondi	74	Very High
Nadda Bus Stand	73	Very High
Airport	77	Very High
House Building	75	Very High
Mirpur	73	Very High
Niketon House Area	61	High
Baridhara DOHS	63	High
Bashundhara R/A	65	High
Uttara Model Town	73	Very High

Figure 1. Noise levels across different areas within Dhaka

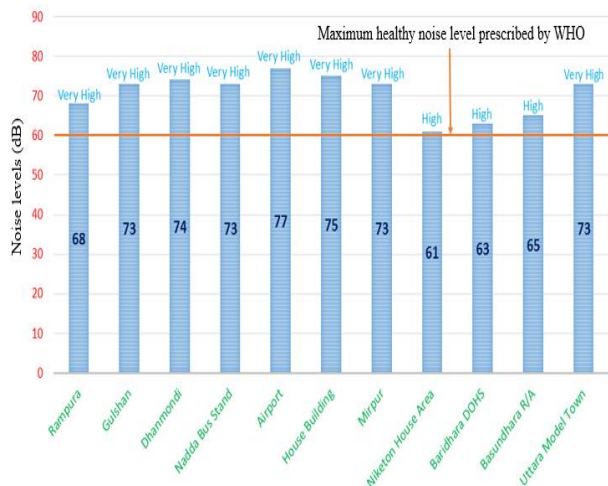


Figure 2. Noise levels across different areas within Dhaka [3]

II. RELATED WORK

Much work has been done to assess and evaluate the harmful impact of sound pollution, prompting need for urgent solutions to mitigate noise. For example, a lot of metropolitan cities have establishments such as high rise buildings situated right along busy roads full of traffic. In Tehran, Iran, it has been studied that noise impact from the motorway affect the front facades, (especially the bottom front) of buildings the worst, where the highest noise impact occurs, in comparison to all other building panels [4]. Consequently, the front façade of such buildings, as well as its side panels, do not even prove to be suitable for commercial purposes, let alone residential purposes. In these areas, specific types of noise control approaches are required to combat the high traffic noise impact.

Furthermore, several studies have also been conducted in Bangladesh. Nationally, the Environmental Conservation Act-1995 (ECA'95) and Environmental Conservation Rules 1997 (ECR'97) categorizes areas with educational institutions and hospitals as silent zones. In such areas, upto a radius of 100m, the standard sound limit is set to be 45 dB during the day [5]. Contrary to this standard, hospitals, schools, colleges and universities are majorly affected by sound pollution during the work-week of five days.

Poorly located along major roads full of traffic, most educational institutions are vulnerable to a constant level of noise in Dhaka. The actual sound levels experienced are routinely around 75dB, which is much higher than the threshold of 45dB [5]. Such high noise levels not only disrupt the focus of young students, but the regular exposure can eventually lead to health damage.

Unfortunately, patients of healthcare facilities do not fare any better. Most hospitals and clinics in Dhaka also experience high noise levels regularly. With noise levels around these healthcare facilities averaging at 70 dB (25 dB more than the standard of 45dB), already vulnerable

patients are put at higher risk, since the unhealthy noise levels can cause severe problems for those suffering from critical illnesses such as heart and brain defects [5].

III. PROPOSED SYSTEM

The proposed solution is a two-tiered sound pollution management system known as Nirob. The system consists of hardware and a mobile based application system that uses technological systems based on sensors, Wi-Fi, and microcontrollers to implement methods of reducing sound pollution. The design and implementation this noise pollution regulation system aims to combat and reduce the large unhealthy amounts of noise pollution within cities such as Dhaka city and bring increased health benefits. The system mainly consists of 2 concrete phases:

A. Phase 1: A measurement system to create awareness amongst the populace.

The 1st phase involves a device that detects the overall sound in a particular place. This device would be located along intervals on the roads, complete with a sound sensor, and a display board. The sound sensor measures the total sound level and shows it on the digital display, along with a message tailored to raise awareness among the public.

B. Phase 2: A system to control and reduce noise pollution in areas which require even lower noise levels i.e. "no-honking zones" such as schools, hospitals and mosques, complete with a reporting system for regulation.

The 2nd phase caters towards the aforementioned silent zones where honking is strictly prohibited, such as schools, colleges, hospitals, and religious places. These places highly forbid honking of cars, as not only does it cause disturbance in focus and concentration, but it can also be severely injurious, especially for patients. For these particular places a unique system is to be built to automatically stop the honking of the vehicles in the restricted area. There are to be devices implemented within vehicles, as well as a router attached to the wall at the perimeters of the silent zone(s). Within this setup, when any vehicle approaches the silent zone, their horns will automatically stop emitting loud noises, eliminating any possibility and source of noise pollution from the vehicles.

This particular system is to use a Wi-Fi module along with an Arduino microcontroller. By connecting to the central Wi-Fi network of the silent zone, regulation of noise levels within the designated area is activated. Upon exiting these specific zones with particular Wi-Fi networks, the activation or deactivation of the horn is no longer controlled; the driver can use the horns at his own will again.

However, emergency cases are also accounted for in this phase, as it cannot be guaranteed that scenarios where the horns are necessary will not arise. For such cases, an emergency button is available within the vehicle. When a driver has to warn a pedestrian or another vehicle, they are able to activate his hydraulic horn again by pushing this emergency button.

Nevertheless, to ensure that drivers don't take advantage of this emergency push button within the Wi-Fi

covered “silent no-honking zones”, this push button also activates the device within the vehicle to start tracking the number of times the horn is used in silent zones. Each time the horn is used in these Wi-Fi areas, the driver receives a demerit point.

These demerit points are also reported to a central database using the Wi-Fi network, which can also be accessible by the concerned regulatory authorities. Since each device is to be registered and associated with the vehicle and the vehicle owner/driver, when the demerit points hit a set threshold i.e. if it is used 15 times or more within silent zones, it is on his record. Consequently, the driver receives a warning message on his phone, and the authorities get notified, such that authorities can take action as needed and penalise the driver accordingly.

IV. SYSTEM DESIGN

The entire technological system of Nirob can be constructed using hardware costing under BDT 4134. Table 1 details the components and their associated cost.

Table 1: Components used for Nirob Technological System and their associated cost

Component	Cost (BDT)
Arduino Uno(2*410)	820
SYM900A GSM/GPRS Module V4.0	1595
ESP8266 Wi-Fi Module	210
3.3/5 Power Supply Module	139
Sound Sensor Detection Module (2*120)	240
Wi-Fi router	900
Horn	80
Relay	25
Battery	80
16 x 2 HD44780 LCD Display	120
Breadboard	80
Wires	5
Variable resistor	20
Total	4314

It should be noted that 2 Arduino Uno microcontrollers and 2 Sound sensors were purchased to be used for the two different phases. The design of the system can be further broken down into the two separate phases, and are described accordingly in the next few sections, with the aid of flow charts.

A. Phase 1: Measurement and awareness system

The Arduino Uno is programmed to have the sound sensor detect surrounding noise levels, and have the noise in decibels shown on the LCD Display. Further conditions are set such that depending on the noise level,

accompanying messages are also shown on the display. The operations are explained via the flowchart in Fig 3.

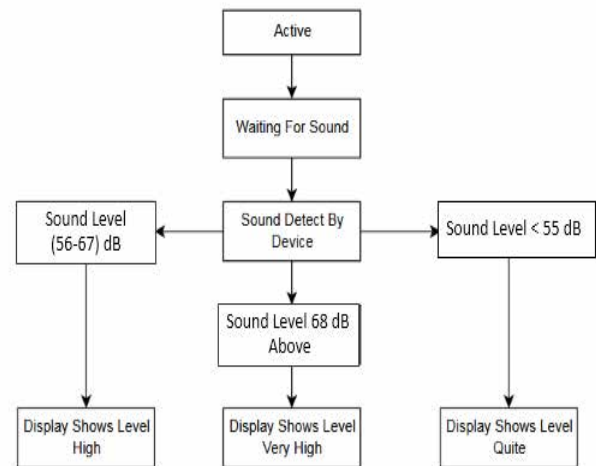


Figure 3. Flow chart demonstrating the algorithm of operations for Phase 1

B. Phase 2: System to control and reduce noise pollution in “no-honking zones”, with a reporting system to regulate drivers

The second Arduino Uno is connected to the Wi-Fi module and the horn. The microcontroller then follows programming code such that when its Wi-Fi module connects to the Wi-Fi network, power supply to the horn is cut off, so it is essentially disabled for use. Subsequently, following the flow chart of algorithm for this phase as demonstrated in Fig. 4, the emergency switch can reactivate the supply to the horn and enable it. However, in this case, the sound sensor starts detecting the number of times the horn is pressed for regulation.

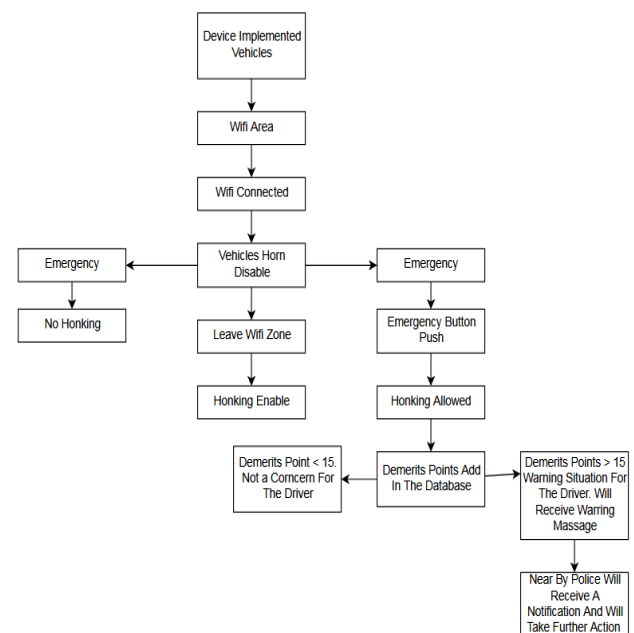


Figure 4: Flow chart demonstrating the algorithm of operations for Phase 2

For the latter emergency scenario, an app is to be created where both drivers and the police can log in to view their record of honking in silent zones. A database is also to be built using the GSM module to store the records of how many times vehicles travelling through silent zones used their horns.

V. OVERVIEW OF TECHNOLOGY AND ARCHITECTURE

The overall cost of the prototype of the Nirob system stands at a reasonable BDT 4314, or just about USD 50. This includes the cost of trial and errors. Hence, the cost can be reduced even further with further refinement of the system.

A. Operating Environment

1) List of Hardwares

- Arduino Uno (microcontroller)
- SYM900A GSM/GPRS Module V4.0
- ESP8266 Wi-Fi Module
- 3.3/5 Power Supply Module
- Potentiometer
- 16 x 2 HD44780 LCD Display
- Wi-Fi router
- Relay
- Battery

2) List of Software and Programming Language

- XML
- Java
- PHP
- Android Studio
- Arduino IDE

B. Hardware and Circuit Description

a) Making 1st phase using sound sensor: In this section, we have used sound sensor to connect with arduino and also we have used LCD display. We have done code in arduino ide to burn into the arduino to input some command that the hardware working properly. And yes it is working properly to desired our expectation. The system, sound sensor can detect the sound and it shows in the display level of the sound, along with a message when we create sound.

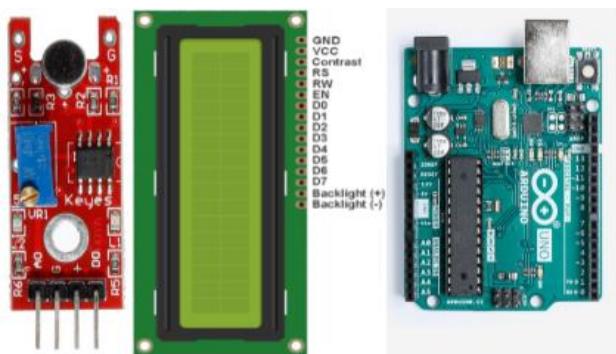


Figure 5. Hardware (1) of Nirob Technology

b) Making 2nd phase using wifi module: In this section, we have used ESP8266 Wi-Fi Module to connect with arduino and also we have used SYM900A GSM/GPRS Module V4.0. We have used relay because of vehicles horn works with 12V but arduino can supply 3.3/5 volt. For this reason we have used relay which is connected with horn, 12V battery and arduino for converting voltage. Arduino Uno was rated at 5V, it seemed to lack in supply and was not able to provide a stable power supply to the Wi-Fi module rated at 3.3 V, causing it to act unstable. Stability of the Wi-Fi module was finally achieved by using it in conjunction with a 3.3/5 Power Supply Module. We have done code in arduino ide to burn into the arduino to input some command that the hardware working properly or not. And yes it is working properly to desired our expectation. The system, when we tried the wifi module connect with router the device is successful in connecting to the Wi-Fi network, upon which, pressing the switch for the horn emitted no sound.

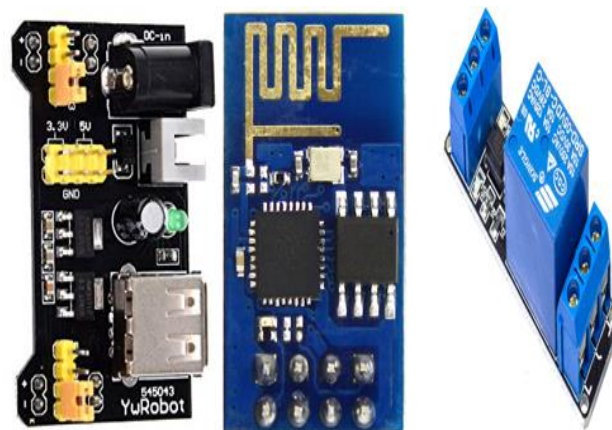


Figure 6. Hardware (2) of Nirob Technology

C. Application Description

In the system we have designed an android mobile platform. In the app we divided two section which one is driver section and another is police section. The driver need to registration and need to put it some information like name, email id, password, vehicles no, and mobile no etc. In the same way police need to registration to check database. The app user interface allowed users to log in to view their record, while the database logged all incidents of honking

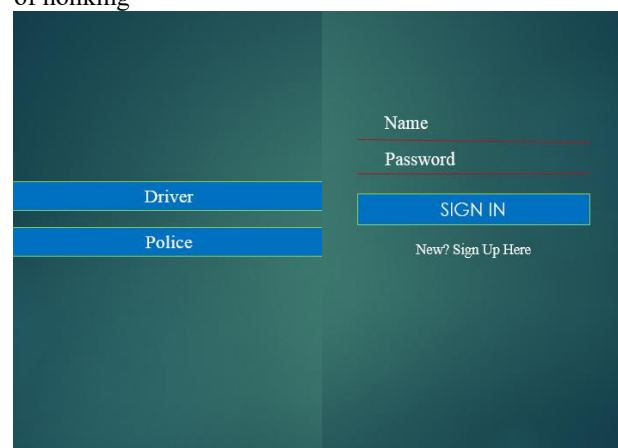


Figure 7. User interface of the app for Nirob Technological System

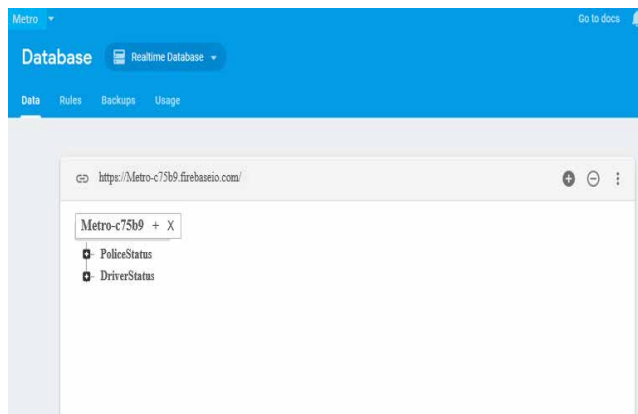


Figure 8. Database for Nirob Technological System

VI. RESULTS AND DISCUSSION

Satisfactory results were obtained as the systems were built according to plan, with final outcomes adhering to initial expectations. However, there were issues that reasonably slowed down progress, most of which were related to the incompatibility of voltage and power ratings of different components.

A. Phase 1: Measurement and awareness system

The sound sensor successfully detected noise levels, distinguishing between three different thresholds, and displayed appropriate messages as follows:

- Below 55dB: "Library QUIET"
- 56-67dB: "HIGH"
- Above 68dB: "VERY HIGH"



Figure 9. Prototype of Nirob Technological System

However, there were problems leading up to this final outcome. Firstly, the sound sensors weren't detecting sound well; thinking that the component was faulty, replacement sound sensors were bought. Later on it was discovered that creating a hollow funnel effect around the sound sensor created more effective sound detection.

Secondly, the LCD screen initially displayed blurry messages, or continuously blinked. This problem was

solved via using a potentiometer to create a more stable voltage and power supply to the LCD.

B. Phase 2: System to control and reduce noise pollution in "silent no-honking zones", with a reporting system to regulate drivers

The device was successful in connecting to the Wi-Fi network, upon which, pressing the switch for the horn emitted no sound. Furthermore, the app user interface allowed users to log in to view their record, while the database logged all incidents of honking, as demonstrated by Figs. 7 and 8.

Nevertheless, power supply issues were prevalent in this phase as well. To begin with, while the Arduino Uno was rated at 5V, it seemed to lack in supply and was not able to provide a stable power supply to the Wi-Fi module rated at 3.3 V, causing it to act unstable. Stability of the Wi-Fi module was finally achieved by using it in conjunction with a 3.3/5 Power Supply Module.

Furthermore, the horn was rated to function at 12V, while the circuit was operating at 3.3V. A relay was subsequently used to solve this incompatibility issue.

VII. FUTURE WORK

Moreover, following on from the emergency scenario of Phase 2, the Nirob technological system could be further upgraded to prove even more effective. For future work, the device within vehicles implementing the operations of operations of Phase 2 can also be programmed to continuously monitor the horn usage of vehicles at all times on the road, outside of silent zones.

The device installed on each vehicle can be associated with its registration number. This device then acts as a counter, to monitor how the driver employs his hydraulic horn. Besides counting the number of times a driver honks, the microcontroller within the device can also be programmed to record duration of long incessant honking. The device can then relay this information back to the central database at regular intervals upon connecting to Wi-Fi networks in designated areas; most travelled roads within the city can be candidates for such areas.

A threshold can be set for maximum acceptable number of times (or duration) for honking; if the driver exceeds this threshold, this would be noted in the database, which would then proceed to inform the owner and/or driver associated with the vehicle via SMS that they have committed an offence, and may consequently face appropriate action. The concerned authorities are also alerted of the offence such that they can keep track of offenders and penalize as needed.

Considering all the prospects, the green earth technology based Nirob system can cause much good for the environment. Nirob has the potential to be scaled up to be used city-wide across capital cities like Dhaka, with co-operation from the Government. If the initiative proves

successful in one city, the model can also be replicated in other metropolitan areas like in India or Hong Kong, where sound pollution is a major issue by being a health hazard.

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