AIR AND NOISE POLLUTION MONITORING SYSTEM OVER INTERNET OF THINGS

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DECLARATION

I declare that this thesis entitled "AIR AND NOISE POLLUTION MONITORING SYSTEM OVER INTERNET OF THINGS" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : .....

Date : .....

APPROVAL

I hereby declare that I have checked this report entitled "Air and Noise Pollution Monitoring System over Internet of Things" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Mechatronics Engineering with Honours

Signature : .....

Supervisor Name : .....

Date : .....

DEDICATIONS

To my beloved mother and father

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ABSTRACT

The recent scenario of tremendous increase in air and noise pollution is the largest challenge encountered by the public. Air and noise pollution had brought a huge impact to living organism and environment where it could lead to adverse effects on human health. This creates a need of measuring and analysing the air and noise pollution level from the monitoring system in order some actions and solutions can be taken. However, there is unavailable on the combination on air and noise pollution monitoring system for the Department of Environment (DOE) in Malaysia. Besides, the data and the status of the pollutions obtained by the DOE is not shared to the public. Hence, in this project, a real-time air and noise pollution monitoring system with Internet of Things (IoT) was developed in order to store the data collected in the cloud platform. Two gas sensors with model MQ135 and MQ7 were used to detect the level of carbon dioxide (CO2) gas and carbon monoxide (CO) gas in unit of parts per million (ppm) where Gravity Analog Sound Level Meter SKU SEN0232 was used to detect the noise level in decibel (dB). The data collected from the sensors was transferred and saved to an Advanced Reduced Instruction Set Computing Machine (ARM)-based minicomputer Raspberry Pi 3 which then uploaded the data to a cloud platform called ThingSpeak. The data collection time of monitoring system for one cycle was set to a minimum of 15s where the system was set to 17s.in the experiments. The sound level meter in the system had high sensitivity as it compared with a Sound Pressure Level (SPL) meter. The MQ135 and MQ 7 sensor were well functioned and capable to detect the level of CO2 gas and CO gas in the unit of ppm. All of the data collected from the system were successfully stored and uploaded to ThingSpeak which then displayed in the ThingSpeak channel graphically. The air and noise pollution monitoring system over IoT in this project was developed successfully and well functioned.

ABSTRAK

Senario baru-baru ini peningkatan yang besar dalam pencemaran udara dan bunyi adalah cabaran terbesar yang dihadapi oleh orang ramai. Pencemaran udara dan bunyi telah memberi impak besar kepada organisma hidup dan persekitaran di mana ia boleh menyebabkan kesan buruk kepada kesihatan manusia. Ini mewujudkan keperluan untuk mengukur dan menganalisis paras pencemaran udara dan bunyi dari sistem pemantauan agar beberapa tindakan dan penyelesaian dapat diambil. Walau bagaimanapun, tidak terdapat gabungan sistem pemantauan pencemaran udara dan bunyi untuk Jabatan Alam Sekitar (JAS) di Malaysia. Selain itu, data dan status pencemaran yang diperoleh oleh DOE tidak dikongsi dengan orang ramai. Oleh itu, dalam projek ini, sistem pemantauan pencemaran udara dan bunyi masa nyata dengan Internet Perkara (IoT) telah dibangunkan untuk menyimpan data yang dikumpul di platform awan. Dua sensor gas dengan model MQ135 dan MQ7 digunakan untuk mengesan tahap gas karbon dioksida (CO2) dan gas karbon monoksida (CO) dalam unit per juta (ppm) di mana Gravity Analog Sound Level Meter SKU SEN0232 digunakan untuk mengesan tahap bunyi dalam decibel (dB). Data yang dikumpulkan dari sensor telah dipindahkan dan disimpan ke komputer riba minikomputer berasaskan Setulus Pengurangan Kompaun Lanjutan (ARM) yang kemudian memuat naik data ke platform awan yang disebut ThingSpeak. Waktu pengumpulan data sistem pemantauan untuk satu kitaran ditetapkan setidak-tidaknya 15s di mana sistem ditetapkan ke 17 dalam eksperimen. Tahap bunyi di dalam sistem mempunyai kepekaan yang tinggi kerana dibandingkan dengan meter tekanan tekanan (SPL). Sensor MQ135 dan MQ 7 berfungsi dengan baik dan mampu mengesan tahap gas CO2 dan gas CO dalam unit ppm. Semua data yang dikumpulkan dari sistem berjaya disimpan dan dimuat naik ke ThingSpeak yang kemudian dipaparkan dalam saluran ThingSpeak secara grafik. Sistem pemantauan pencemaran udara dan bunyi ke atas IoT dalam projek ini dibangunkan dengan jayanya dan berfungsi dengan baik.

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LIST OF SYMBOLS AND ABBREVIATIONS

ADC	-	Analog-to-Digital Converter
USB	-	Universal Serial Bus
CPU	-	Central Processing Unit
IoT	-	Internet of Things
CO	-	Carbon Monoxide
CO2	-	Carbon Dioxide
dB	-	Decibel
ppm	-	Parts Per Million
WHO	-	World Health Organisation
HEI	-	Health Effect Institute
DOE	-	Department of Environment
API	-	Air Pollutant Index
CES	-	Compendium of Environment Statistics
ARM	-	Advanced Reduced Instruction Set Computing Machine
SPL	-	Sound Pressure Level
JAS	-	Jabatan Alam Sekitar
MPCB	-	Maharashtra Pollution Control Board
AQI	-	Air Quality Index
ACGIH	-	American Conference of Government Industrial Hygienists
OSHA	-	Occupational Safety and Health Administration
ASHRAE	-	American Society of Heating, Refrigerating and Air Conditioning Engineers
Hz	-	Hertz
HCHO	-	Formaldehyde
UV	-	Ultraviolet
SBC	-	Single Board Computer
UART	-	Universal Asynchronous Receiver-Transmitter
AWS	-	Amazon Web Services
I/O	-	Input and Output

CSI	-	Camera Serial Interface
RFID	-	Radio Frequency Identification
O3	-	Ozone
SO2	-	Sulphur Dioxide
NO2	-	Nitrogen Dioxide
PM	-	Particulate Matter

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CHAPTER 1

INTRODUCTION

1.1 Overview

This chapter presented the five subtopics which are motivation, problem statement, objective and scope of the proposed project.

1.2 Motivation

The issues of pollution had drawn a lot of concern in terms of research and everyday life as the results in Google search related to “2014 Air Pollution” is about 46 million, which was 19 million more than that of “2014 Nobel Prize” [1]. According to the survey of the environmental concern for 2019, pollution is rated at Top 4 in the survey and clarified the pollution is one of the primary causes of the other environmental concerns [2].

The public concern on the issues of pollution has significantly increased as the serious negative impact brought to human health and the environment. Hence, a large scale on the studies of the exposure of air and noise pollution to human health have been published [3].

Based on the 7 main types of pollution, the major constituents for having adverse and harmful effects on human being and the environment is air pollution and noise pollution [4]. Air pollution is the natural air which is contaminated with different pollutants whereas noise pollution is the loud noise created by human activities [5]. According to the Health Effect Institute (HEI), air pollution has become the Top 4 worldwide death killer which 6.1 million people died due to long-term exposure of air pollution in 2016. Based on the HEI’s report in 2016, China and India had the highest number of death due to air pollution which is 1.58 and 1.61 million respectively [6]. According to World Health Organisation (WHO) exposure to noise can kill people where 3% of people die in heart attack is due to traffic noise in Europe [7].

Exposure of polluted air has a different negative impact on human health including respiratory and cardiovascular diseases, neuropsychiatric complications, the eyes irritation,

skin diseases, and long-term chronic diseases [8]. Beside of air pollution, according to World Health Organization (WHO), the underestimated threat of noise pollution harmed human by causing sleep disturbance, cardiovascular effect, hearing impairment and so on [9].

Collecting and sharing the first-hand data of the pollution level to the public by installing an air and noise pollution monitoring system is helpful to raise the awareness among the public as well as inform the public about the surrounding pollution level. Low cost and high efficiency of the monitoring system can be produced with the aid of the Internet of Things (IoT).

1.3 Problem Statement

Research on the pollution monitoring system has received a lot of attention over a few ten years. The air pollution monitoring system had improved in the form of technology from the time-consuming traditional way of the pollution monitoring system [10] to nowadays which the Department of Environment (DOE) of Malaysia monitors the ambient air quality through a network of 51 stations [11]. However, there is unavailable of the air and noise pollution monitoring system for the DOE of Malaysia. It can be seen that the other type of pollution besides of air pollution has been ignored and unconcerned. Hence, combination of different types of the pollution in a monitoring system can increase the awareness of the other types of pollutions to the environment.

In addition, the data and the status of the pollutions obtained by the DOE is not shared to the public. The data collected is held by the DOE to calculate the Air Pollutant Index (API) values. The Department of Statistics Malaysia received the secondary data from the DOE and shared to the public through Compendium of Environment Statistics (CES). However, the daily and detail of the pollution data is not shared by the CES where some of the data is not updated. The incident of the Pasir Gudang happened had caused some people poisoned by the harmful gaseous. This incident can be prevented as the public was able to access the first-hand pollution data collected by the monitoring system. Hence, a real time air and noise pollution monitoring system over Internet of Things (IoT) allows the public to receive the data in a very short time.

In conclusion, a new innovation on the pollution monitoring system is required to address the demand for pollution data availability as well as the performance of the pollution monitoring system. The research will focus on developing a real-time air and noise pollution

monitoring system by transferring the data from Air Quality Sensing Module and Sound Detection Module to clouds with the aid Internet of Things (IoT).

1.4 Objectives

The aims of the Final Year Project (FYP) are

i) To develop an air and noise pollution monitoring system

ii) To design an air and noise monitoring system for storing and displaying information collected to the cloud platform

iii) To validate the reliability of the information collected from the air and noise pollution monitoring system

1.5 Scope

The extents of the area of the monitoring system are:

a) The detection of the pollution is focused on the air and noise pollution.

b) The number of sensors used in the monitoring system is three where 2 sensors are used to detect the concentration of carbon dioxide and carbon monoxide respectively whereas another sensor is a sound sensor which is used to detect sound level.

c) The coverage area of the monitoring system is set within 11L which is 360mm x 250mm x 220 mm.

d) The demonstration environment for the monitoring system is focused on the open area.

e) The monitoring system is tested in a storage box which has a size of 11L.

f) The cloud platform is focused on the open source of Internet of Things (IoT) platform.

1.6 Report Outline

Chapter 1 of this report introduced the motivation of this project. Thus, problem statement of this project is explained in details. Besides, the scope and objectives of this project are listed based on the purpose of the project.

Chapter 2 of the report covered the background knowledge of air and noise pollution as well as their monitoring system. Reviews of related works and evaluation of the methods used for monitoring system over IoT are presented.

In Chapter 3, the methodology to achieve the objectives of the proposed project is discussed. Explanation on the selected components used in hardware and the experiments conducted as well as the procedures of the experiments are described.

Chapter 4 illustrated the results obtained from the experiments and presented in the form of graphs, charts, diagrams, and tables. The discussion based on the results obtained for every experiment is done.

Chapter 5 is the last chapter of this report which the overall conclusion of this project is made as well as the recommendations and future work related to this project.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

In this chapter, the theoretical background which is related to the project including theories on pollutions and monitoring system are presented. The research of the journals and conference papers which are related to this project is studied and the evaluation based on a few criteria is done.

2.2 Study of Pollution

Pollution is defined as a harm and poison substance that presents or introduces into the environment [12]. Pollutants could be simple things such as lights, sounds, and temperature as these are introduced into the natural environment [13]. There are some major forms of pollutions such as land pollution, water pollution, light pollution, air pollution, and noise pollution. All kinds of pollutions brought great negative impacts on the environment and wildlife as well as human health and well-being [14].

2.2.1 Air Pollution

The natural form of air is made up of exact chemical composition such as water vapour, oxygen, nitrogen, and inert gases. Air pollution happened as things introduced into it artificially [13]. Atmospheric particulate air pollution came from the sources of both natural and synthetic. Hence, air pollutants can be classified into primary and secondary. A primary air pollutant is the pollutants emitted directly into the atmosphere whereas secondary air pollutant is formed by having chemical reactions involving gas-phase precursors in the atmosphere [15]. A common type of air pollution occurred is the combustion of fossil fuels which in vehicle engines, power station, agricultural activities and mining operation [16].

According to the World Health Organization (WHO), a long exposure to ambient air pollutants increases the risk of causing airborne diseases such as cardiovascular disease, respiratory disease, and lung cancer [17]. Dangerous gas such as sulphur dioxide, carbon monoxide, nitrogen oxide and chemical vapours could create acid rain, smog and greenhouse effects which caused air pollution when they have a chemical reaction with the gases in the atmosphere. Besides, through climate change, the air pollutants of carbon dioxide will affect human health indirectly [13]. According to [18], more than 2.1 million people are died with anthropogenic due to air pollution. The poor air quality in Mumbai reached the Air Quality Index (AQI) of 305 after one day of Diwali [19]. Hence, real-time air quality monitoring system from 13 stations went live on the website of Maharashtra Pollution Control Board (MPCB) for the public to check the air quality in Mumbai [20].

There are 13 cities and towns of India are in the list of top 20 in the world's most polluted places based on WHO's report. Delhi, one of the cities in India is recorded that it had only 3 clean air days in the whole year of 2017 [21]. In order to monitor the environment as well as raise the awareness among people in Delhi, Umesh Chandra and Kamal Jaina created a web-based ambient air quality monitoring system for the public to access the real-time information of air quality in Delhi [22].

Carbon Monoxide (CO) gas is one of the elements in measuring the AQI which is odourless and colourless gas. The main sources of CO gas at outdoor are vehicles, factory or machinery that burn fossil fuels [23]. This dangerous gas is toxic to the human health as it could enter the bloodstream through the lungs and reduce the oxygen gas level in human body. In the view of health, exposure to high level of CO gas can affect mental alertness and vision [24]. There is a case that an adult is dead and a youth injured after getting CO poisoning in Salmon Arm. The source of the emission of CO gas in this case is the fuel from the camp stove. Hence, CO gas sometimes called invisible killer as it may not have warning sign of its presence [25]. The Table 2.1 shows the health effects due to prolonged exposure and government limit on the various level of CO gas.

Table 2.1: Health Effects Due to Prolonged Exposure of the Level of Carbon Monoxide (CO) Gas [26]

Level of CO	**Health Effects, and Other Information**
0 PPM	Normal, fresh air.
9 PPM	Maximum recommended indoor CO level (ASHRAE).
10-24 PPM	Possible health effects with long-term exposure.
25 PPM	Maximum exposure for 8 hours work-day (ACGIH)
50 PPM	Maximum permissible exposure in workplace (OSHA).
100 PPM	Slight headache after 1-2 hours.
200 PPM	Dizziness, nausea, fatigue, headache after 2-3 hours of exposure.
400 PPM	Headache and nausea after 1-2 hours of exposure. Life threatening in 3 hours.
800 PPM	Headache, nausea, and dizziness after 45 minutes; collapse and unconsciousness after 1 hour of exposure. Death within 2-3 hours.
1000 PPM	Loss of consciousness after 1 hour of exposure.
1600 PPM	Headache, nausea, and dizziness after 20 minutes of exposure. Death within 1-2 hours.
3200 PPM	Headache, nausea, and dizziness after 5-10 minutes; collapse and unconsciousness after 30 minutes of exposure. Death within 1 hour.
6400 PPM	Death within 30 minutes.
12,800 PPM	Immediate physiological effects, unconsciousness. Death within 1-3 minutes of exposure.

Besides of carbon monoxide gas, carbon dioxide (CO2) has its effects on air pollution as its concentration increases. carbon dioxide is one of the greenhouse gases as it traps radiation at ground level which creating ground-level ozone. This phenomenon causes the increase of concentration of carbon dioxide gas contributes to air pollution. In addition, increase in the concentration of carbon dioxide gas in our environment will lead to climate change, acid rain and human health impacts. Carbon dioxide emissions will displace the oxygen in atmosphere which will increase the difficulty of human breathing [27]. There are

also other impacts of carbon dioxide gas on human health such as headaches, restlessness, drowsiness and so on. The Table 2.2 below shows the different level of carbon dioxide causes different impacts on human health.

Table 2.2: Level of Carbon Dioxide Gas and Potential Health Problems [28]

Level of Carbon Dioxide	**Potential Health Problems**
250 - 350 ppm	Background (normal) outdoor air level.
350 - 1,000 ppm	Typical level found in occupied spaces with good air exchange.
1,000 - 2,000 ppm	Drowsiness and poor air.
2,000 - 5,000 ppm	Headaches, sleepiness, and stagnant, stale, stuffy air, poor concentration, loss of attention, increased heart rate and slight nausea
5,000 ppm	• Unusual air conditions where high levels of other gases could also be present. • Toxicity or oxygen deprivation could occur. This is the permissible exposure limit for daily workplace exposures.
40,000 ppm	Immediately harmful due to oxygen deprivation

2.2.2 Noise Pollution

In general, noise pollution is defined as the exposure of unwanted sound level which may have deleterious effects on human and the environment. Noise pollution is mainly generated from human activities especially in industrial area, construction area, land or air traffic and so on. For instance, the construction sounds from the operation of heavy machines, drilling and pilling [29]. Sound is a noise which described in terms of loudness and pitch. The decibels (dB) is the logarithmic unit used to measure the loudness whereas frequency (Hz) is used to express the pitch of a sound [30].

Noise pollution has brought huge negative impacts to human, wildlife and marine life. There are various ways which noise pollution can be harmful to human health as the