UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND DEVELOPMENT OF A SENSORY INSTRUMENTATION SYSTEM USING INTERNET OF THINGS FOR AIR QUALITY

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours.

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APPROVAL

This report is submitted to the Faculty of Electrical and Electronic Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours. The member of the supervisory is as follow:

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ABSTRAK

Pengukuran kualiti udara sedia ada hanya bertujuan secara profesional, dan kos system adalah mahal. Di samping itu, sistem yang sedia ada untuk kualiti udara hanya memberi tumpuan kepada satu atau dua bahan pencemar dan tidak dilengkapi dengan mekanisme yang dapat meningkatkan kualiti udara apabila kualiti udara dalaman yang tidak sihat dikesan. Projek ini mencadangkan sistem sensor instrumentasi untuk kualiti udara menggunakan Internet Pelbagai Benda (IPB). Sistem ini terdiri daripada tiga sensor yang dapat mengesan lima jenis parameter pencemaran udara, suhu, kelembapan, karbon dioksida, kompaun organik yang tidak menentu dan habuk. Data yang dikumpulkan daripada sensor akan dihantar kepada ESP32 sebagai penyambungan berasaskan internet untuk menyimpan data di platform ThingSpeak. Ia dapat dilihat dalam bentuk grafik untuk pemantauan masa ke semasa. Selain itu, status tahap bahan pencemar udara boleh dilihat di panel kotak untuk yang diwakili oleh LED. Sistem ini juga mampu memantau pencemar udara dan mengawal kepekatan bahan pencemar udara apabila ia melebihi nilai ambang. Ujian dengan rokok dan lilin dijalankan untuk menganalisis prestasi sistem. Pembersih udara akan dihidupkan apabila kualiti pencemaran melepasi tahap tidak sihat. Ujian mengesahkan bahawa banyak faktor boleh mempengaruhi pencemaran udara dan pencemaran udara sentiasa berubah. Justeru itu, sistem ini mampu mengawasi lima parameter dan mengawal tiga bahan pencemar udara dalaman.

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ABSTRACT

The existing air quality measurement are professionally intended only, and the system's cost is expensive. In addition, the existing system for air quality only focus on one or two pollutants and does not equip with a mechanism which can improve the air quality when bad indoor air quality detected. This project proposed a sensory instrumentation system for air quality using Internet of Things (IoT). The system consists of 3 sensors which could detect air pollutant five parameters, temperature, humidity, carbon dioxide, volatile organic compound and particulate matter. The collected data from the sensors will be sent to ESP32 as internet-based connection ThingSpeak platform for data storing and it can be viewed in graphical form for real-time monitoring. Besides, status of level of air pollutants can be viewed on the box panel for status of air pollutant which represents by LED. The system capable in monitoring the air pollutants and controlling the concentration of air pollutants whenever it exceeds threshold value. Testing with cigarette and candle are conducted to analyze the performance of the system. The air purifier will be turned on when the concentration of pollutant exceeds the threshold level. The testing confirmed that many factors may influence the air pollutants and the air pollutants are constantly changing. Thus, the system is capable in monitoring five parameters and controlling three indoor air pollutants.

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DEDICATION

I would like to dedicate my work to my beloved parents, Shamsulakmar Bin Haji Ismail and Maslina Bte Abu Said, my siblings and my friends.

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LIST OF ABBREVIATIONS

PM	Particulate Matter
CO_2	Carbon Dioxide
CO	Carbon Monoxide
O_3	Ozone
NO_2	Nitrogen Oxide
SO_2	Sulphur Dioxide
VOC	Volatile Organic Compound
IoT	Internet of Things
LED	Light-emitting diode
ppm	Parts per million
ppb	Parts per
IEQ	Indoor Environmental Quality
TCE	Trichloroethene
O_2	Oxygen

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CHAPTER 1

INTRODUCTION

This chapter presents the project's background, problem statements, objectives, the scope of work and organization of the report. It focuses on the problem statements, the objectives to be achieved, the project's scope of work and outcomes.

1.1 Project Background

According to Amin et al., 2019, Malaysia have been experiencing severe pollution especially during drought seasons in the last few decades due to haze which could be great potential risk to public health risk. The series of hazes is caused by the illegal industrial agriculture process of slashing and burning practices, mainly practiced in Sumatra and Kalimantan. In addition, the other causes of the air pollution are rapid economic growth and seasonal trans-boundary pollution (Sentian et al., 2019). This is because Malaysia's air pollution has been characterized by large seasonal variations over the years which are significantly attributed to transboundary pollution. Air pollution is defined as any substance of any origin within the atmosphere which occurs in either a solid, liquid or gas state that has deleterious effects or is capable of manipulating the environmental properties of the atmosphere and causes a health hazard to the living things or causes degradation of the environment and the ecosystem (Sentian et al., 2019). Commonly, contaminants originate from both natural sources such as plant pollen, wind dust, volcanic emissions, and lightning-induced forest fires) and human-induced sources

such as transportation pollution, manufacturing emissions and emissions from other production activities. (Sentian et al., 2019) stated the common air pollutants include particulate matters (particularly PM_{10} and $PM_{2.5}$), carbon monoxide (CO), carbon dioxide (CO_2), ozone (O_3), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and organic compound volatile (VOC) which fits the national air qualities described by the United States Environmental Protection Agency (US EPA).

When the haze hits the unhealthy level, people are advised to stay indoors and refrain from any unnecessary outdoor activities. However, according to Abraham and Li, 2014, the United States Environmental Protection Agency (US EPA) discovered that indoor pollutant concentrations could have been significantly greater than outdoor pollutant concentrations and because of this, air quality is classified as one of the environmental impacts on people's health, supported by Marques et al. (2019). This is due to the fact that the health, safety, productivity, and comfort of people are greatly affected by the air quality.

Therefore, a sensory instrumentation system using Internet of Things (IoT) is proposed to help residents to monitor real-time indoor air quality. A ThingSpeak channel is created and libraries are installed in Arduino IDE. The program code is then uploaded to the microcontroller board for data transmission. It consists of three sensors which helps in monitoring five parameters of air quality. The sensor data is then transmitted to the ESP32 NodeMCU and being sent to the cloud of Internet of Thing (IoT) platform. The sensor data will be visualized on ThingSpeak. When the air pollutant exceeds the unhealthy level, a mechanism which is an air purifier will perform an act to improve the air quality. The unhealthy and ideal level of air pollutants will be indicated by red and blue LEDs respectively.

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1.2 Problem Statement

In today's world globalization, indoor air quality acknowledged as one of the main elements which have an effect on human health, safety, productivity and comfort. However, the existing air quality measurement are professionally intended only, and the system's cost is costly and beyond the grasp of ordinary customers (Abraham and Li, 2014). In addition, the existing system for air quality is not sufficient for the detection of various gasses and particulates for indoor air quality determination. One or two pollutants is the focus of most of the previous system (Kim, Chu and Shin, 2014). Apart from that, most of the existing air quality measurement device does not equip with a mechanism which can improve the air quality when the device detected bad indoor air quality as it is only for the use of monitoring (Yang, Yang and Zhang, 2017).

Therefore, this project is proposed to help resident in detecting and monitoring five parameters of air in their home with internet-based connection. Sensors is used to detect the presence of pollutant in indoor area. The sensor data is then transmitted to the NodeMCU and being sent to the cloud of Internet of Thing (IoT) platform. When the air pollutants exceed the unhealthy level, a mechanism which is an air purifier will perform an act to improve the air quality and red LED will light up indicates the level. Whereas, under ideal level, blue LED will light up.

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1.3 Objectives of the Project

The following are the main objectives of this project:

1. To develop a sensory instrumentation system prototype using Internet of Things (IoT).

2. To monitor and control indoor air pollution using sensory instrumentation system.
3. To analyse the performance of sensory instrumentation system.

1.4 Scope of the Project

This designation project mainly focuses on the residential area. This scope of the project covers on two physical parameters (temperature and humidity) and three common indoor air pollution (Carbon Dioxide, Volatile Organic Compounds and Particulate Matter). This project implements an air purifier as a mechanism to improve the indoor air quality and LEDs acts as level indicator for monitoring the level of indoor air pollution. Hence, the prototype implements Internet of Things (IoT) and the system develops by using Arduino IDE. This project intended for a medium space area room. The hardware prototype will be tested with candle and cigarette smoke. The performance of sensory instrumentation system will be analysed.

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1.5 Organization

The report is presented as following manner: Chapter 1 presents the introduction; Chapter 2 reviews related work and Chapter 3 illustrates the methods and components used in the implementation of sensory system. Chapter 4 discusses the results and analysis of the project. Chapter 5 concludes the discussion of the project and recommends improvement ideas for future development.

CHAPTER 2

LITERATURE REVIEW

This chapter concentrates on the Indoor Air Quality (IAQ) concept and fundamental principle. Review on related literature studies and research on indoor air quality monitoring development throughout this section. This review adds for a better understanding of project development and gives basic ideas on how it might help in the development of the current project.

2.1 Indoor Air Quality

National air qualities criteria are described by the (United States Environmental Protection Agency | US EPA) on the basis of seven common atmospheric pollutants; carbon monoxide (CO), carbon dioxide (CO_2), ozone (O_3), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), particulate matter (PM) and organic compound volatile (VOC). However, the three most common sensors for monitoring indoor air quality are VOC, dust and CO sensors (Kim *et al.*, 2014).

The quality of indoor air contributes significantly to the quality of life, since most people fill their time indoors with a ratio of 0.9 regardless of the fact that IAQ is not precisely related to occupational health (United States Environmental Protection Agency, 2013; Klepeis *et al.*, 2001). In 2017, a study was conducted to characterize the quality of indoor air during sleep in Portugal. For this study, four different natural ventilation settings (open door open window, open door closed window, closed door open window,

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closed door open window) a bedroom of an apartment with a single occupant was applied. It has been observed that the lowest mean CO_2 level was for open door open window ventilation setting, while the greatest mean CO_2 level was closed door closed window ventilation setting. High CO_2 concentrations was concluded to be associated with low ventilation rates. (Canha *et al.*, 2017). Besides, Simoni *et al.* (2010) discovered children in schools which exposed to more than 1000 ppm of CO_2 had a significantly higher risk of dry cough and rhinitis.

Thus, carbon dioxide (CO_2) has major impact on public health (Marques, Ferreira and Pitarma, 2019). Carbon dioxide (CO_2) is a CO is a colourless and odourless gas. Human exhalation of CO_2 formed in the body during metabolic processes and main combustion of gas, is the greatest contribution to indoor concentration (Jones, 1999). Carbon dioxide is a gas that can cause unconsciousness or death by suffocation due to lack of oxygen (O_2) (Komínek, Weyr and Hirš, 2018). ASHRAE recommended to maintain the concentration of carbon dioxide (CO_2) at less than 1000 ppm as it indicates an adequate fresh air supply (Alberts, 1994; Hong, Kim and Lee, 2018).

As said by (Carrer *et al.*, 2002), the existence of VOC sources such as paints, cleaners, interior finishing materials and furnishing has been mentioned by the European Union's official committee on Indoor Environment Quality (IEQ) in European schools. Previous research performed by (Choo *et al.*, 2015) clearly stated that the large percentage of pre-school mobilized wood furnishings that can emit formaldehyde gasses over time. The newer the furniture placed into the enclosed space, the higher the concentration of the volatile organic compound (VOC) is the hypothesis that the research can make. The production of Volatile Organic Compound (VOC) is also influenced by the temperature and humidity. In non-industrial areas, the majority of recorded TVOC concentrations are

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