

**IOT BASED INDOOR AIR QUALITY MONITORING
AND PREDICTION SYSTEM USING MACHINE
LEARNING**

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2022**



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DEGREE : BACHELOR OF COMPUTER SCIENCE WITH HONOURS
(NETWORK ENGINEERING)
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DECLARATION

I hereby declare that the material in this thesis is my own except for quotations, equations, summaries and references, which have been duly acknowledged.

18 FEBRUARY 2022



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ACKNOWLEDGEMENT

First and all, I would want to express my sincere thanks to my supervisor, Dr. Leau Yu Beng, for his helpful advice, encouragement, patience, and unconditional support during my final year project. I would not be able to complete my project on time without his help and guidance.

Apart from that, I would like to express my gratitude to my examiners Dr. Chin Kim On and Dr. Ag. Asri Bin Ag. Ibrahim, for their guidance, insights, and suggestions about the development of my final year project. I do appreciate the ideas since they helped me understand the issues I had missed and then solve those issues to improve the system.

I would like to say thank to all my friends who helped me throughout the project in the times of crisis when I needed it the most. Without their helps, I would face many difficulties while doing this project.

CHIONG WEN CHENG

24 JANUARY 2022



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ABSTRACT

Air and good air quality are important for humans to carry out their everyday activities. Bad indoor air quality (IAQ) will cause to human such as irritation of the skin, nose, and mouth, headaches, dizziness, and weakness. Current concern found by author on indoor air quality in UMS's FCI such as problem in monitoring indoor air quality condition that would eventually affect the respiratory system of a student or academic staff, no proper notify system for indoor air quality condition to alert student or academic staff and inadequate statistics on indoor air pollution index to make prediction and keep track the air pollution index level. The objective of this project is to design an IoT Based Indoor Air Quality Monitoring and Prediction System for admin in UMS's FCI using Node MCU ESP8266 deals with indoor air quality using MQ135 sensor. It then tested by detecting air quality value in Parts per Million (PPM) based on air pollution index (API). For the air quality sensors is focusing on alert message which trigger the message with certain API levels and the reading of API is collected to do prediction and reports on the stages of the API causes. In this project, Exponential Smoothing is chosen as the research element, and it will be used for prediction purpose. Author used rapid prototyping methodology where it is a model consists of phases that able to build, test and reworked as necessary until an acceptable prototype is accomplished in the project. The goal of the proposed system is to develop a web-based indoor air quality monitoring and prediction system with IoT devices that can monitor and do prediction on indoor air pollution index (API) using Machine Learning. Finally, the proposed system will display the monitoring air pollution index (API) data from sensor and used it for prediction data chart for UMS academic staff.



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ABSTRAK

SISTEM PEMANTAUAN KUALITI UDARA DALAMAN BERASASKAN IOT DAN RAMALAN MENGGUNAKAN PEMBELAJARAN MESIN

Udara dan kualiti udara yang baik adalah penting untuk manusia menjalankan aktiviti harian mereka. Kualiti udara dalaman (IAQ) yang buruk akan menyebabkan manusia seperti kerengsaan pada kulit, hidung, dan mulut, sakit kepala, pening, dan lemah. Kebimbangan semasa yang ditemui oleh pengarang mengenai kualiti udara dalaman di FCI UMS seperti masalah dalam memantau keadaan kualiti udara dalaman yang akhirnya akan menjejaskan sistem pernafasan pelajar atau kakitangan akademik, tiada sistem pemberitahuan yang sesuai untuk keadaan kualiti udara dalaman untuk memberi amaran kepada pelajar atau kakitangan akademik dan statistik yang tidak mencukupi tentang indeks pencemaran udara dalaman untuk membuat ramalan dan menjejaki tahap indeks pencemaran udara. Objektif projek ini adalah untuk mereka bentuk Sistem Pemantauan dan Ramalan Kualiti Udara Dalaman Berasaskan IoT untuk pentadbir dalam FCI UMS menggunakan Node MCU ESP8266 berurusan dengan kualiti udara dalaman menggunakan sensor MQ135. Ia kemudiannya diuji dengan mengesan nilai kualiti udara dalam Bahagian per Juta (PPM) berdasarkan indeks pencemaran udara (IPU). Untuk penerima kualiti udara memfokuskan pada mesej amaran yang mencetuskan mesej dengan tahap API tertentu dan bacaan API dikumpulkan untuk melakukan ramalan dan laporan mengenai peringkat punca API. Dalam projek ini, Exponential Smoothing dipilih sebagai elemen penyelidikan, dan ia akan digunakan untuk tujuan ramalan. Pengarang menggunakan metodologi prototaip pantas di mana ia merupakan model yang terdiri daripada fasa yang boleh membina, menguji dan mengolah semula mengikut keperluan sehingga prototaip yang boleh diterima dicapai dalam projek. Matlamat sistem yang dicadangkan adalah untuk membangunkan sistem pemantauan dan ramalan kualiti udara dalaman berasaskan web dengan peranti IoT yang boleh memantau dan melakukan ramalan pada indeks pencemaran udara dalaman (API) menggunakan Pembelajaran Mesin. Akhir sekali, sistem yang dicadangkan akan memaparkan data indeks pencemaran



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udara (API) pemantauan daripada penderia dan menggunakannya untuk carta data ramalan untuk kakitangan akademik UMS.



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CHAPTER 1

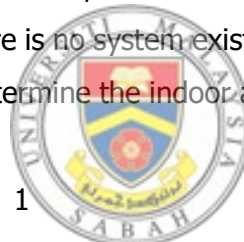
INTRODUCTION

1.1 Introduction

This section represents the idea and motivation to develop a IoT Based Indoor Air Quality Monitoring and Prediction System for Faculty of Computing and Informatics. This section includes 1.1 Introduction, 1.2 Problem Background, 1.3 Problem Statements, 1.4 Project Goal, 1.5 Objective, 1.6 Project Scope, 1.7 Project Timeline, 1.8 Organization of Report and 1.9 Summary.

1.2 Problem Background

Monitoring is the process of making observations and collecting data in a project or programme. The method is most likely to collect information about the project's requirements. Monitoring can be organized by a one or group of users where every place has their own monitoring for the indoor air quality especially inside and around the buildings of FCI in Universiti Malaysia Sabah should be included. As today's modern lifestyle, indoor air pollution is being the victim of people tending to live more indoors. The quality of the air inside and around buildings is referred to as indoor air quality. Smoke, Carbon Dioxide (CO₂) and Carbon Monoxide (CO) are among the main cause affecting the indoor air pollution index. Since we are spending most of the time indoors in Universiti Malaysia Sabah especially in FCI that would bring impact to our health issues. The main idea for the monitoring is to allow the user to identify the circumstances of the indoor air quality which can help the students having a safe air pollution index for them to breathe. Short-term health issues like fatigue and nausea, as well as chronic respiratory diseases, heart disease, and lung cancer, can increased due to poor air quality. As there is no system existed to monitor the indoor air pollution index so far, it is hard to determine the indoor air quality that eventually



cause the health symptoms of a person with respiratory diseases. Moreover, there is no notify system to notify the student about indoor air pollution index. Thus, the student is unaware and suffer from their health symptoms which linked to poor indoor air quality. In general, people assume that indoor air is less toxic than outdoor air. However, indoor pollutants are two to four higher than outdoors, according to a report (Kaur et al., 2019). So, IoT based Air Quality Monitoring and Prediction System is being developed to provides detail on indoor air pollution index which can help in monitoring and predicting air pollution index (API) causes that affecting human's health issues.

1.3 Problem Statements

One of the most fundamental and vital elements for human life is air. Clean air is important for living a peaceful and safe life. The government and the public in Malaysia are deeply worried about the quality of indoor air, and indoor air pollution is becoming a major problem in both urban and rural areas. As a student who spent most of the time indoors are worried with toxins in the air, they breathe every day, and it can lead to both short-term and long-term effects on health. To further explore the factors that impact indoor air quality especially inside and around buildings of FCI in Universiti Malaysia Sabah, we must first consider what the main contents of indoor air pollutants to collect information that can be used to examine sick building syndrome. As a result, the author has found several concerns with this project to explain the need for this system.

The following list is the current concerns faced of indoor air quality in UMS's FCI.

- I. Problem in monitoring indoor air quality condition that would eventually affect the respiratory system of a student or academic staff.
- II. No proper notify system for indoor air quality condition to alert student or academic staff.
- III. Inadequate statistics on indoor air pollution index to make prediction and keep track the air pollution index level.



1.4 Project Goal

The goal of this project is to develop a web-based indoor air quality monitoring and prediction system with IoT devices that is used to monitor and predict the indoor air pollution index using machine learning algorithm. This system is developed to help the academic staff able to identify the level of indoor air pollution index condition and have the function to help notify the admin if there are high level of air pollution index presence on the specific places via email. Thus, the admin can detect the poor air quality if existed and provide proper solution to improve the indoor air pollution.

1.5 Objective

The objectives for this project are as follows:

1. To design an IoT Based Indoor Air Quality Monitoring and Predicting System using machine learning for admin in UMS's FCI.
2. To develop an IoT Based Indoor Air Quality Monitoring and Prediction System in UMS's FCI using Node MCU ESP8266 with air quality sensor.
3. To test and verify the IoT Based Indoor Air Quality Monitoring and Prediction System performance in terms of functionality such as detect air quality value in Parts per Million (PPM) based on air pollution index (API) using butane gas from lighter for toxic gases and smoke.

1.6 Project Scope

This project will be focusing on the indoor air quality inside and around FCI's buildings. The target user for the proposed system is academic staff will be admin in Faculty of Computing and Informatics (FCI) where admin can monitor the existence of indoor air quality based on air pollution index (API) in PPM and able to receive notification when alert triggered. The condition of indoor air quality value is measured in API category as a base standard of proposed system and the accurate data collected to apply in the indoor air quality alert system.

In this project, machine learning approach will used for prediction function in the proposed system. Machine Learning is an artificial intelligence (AI) application



that uses algorithms to teach a computer how to learn data and then predicts a new dataset.

The proposed system predicts air pollution index (API) values for high accuracy dataset which provide the stages of the API causes that affects human's health issues. The Table 1.1 below show the modules that will be implement in this system:

Table 1.1 Modules of The Projects

Module	Description	Function
Login	Admin and user need to log in through ID and password to access the information and the indoor air quality value of the system. Admin will create a temporary password for new user registration into the system.	<ul style="list-style-type: none"> • Email and password verification
Administration	Admin can do modification on indoor air quality for alert system. Admin can set the value of indoor air quality for alerting purpose based on air pollution index (API) level. Once the alert triggered, a notification will send to admin and user for awareness purpose.	<ul style="list-style-type: none"> • Admin can do the modification and manage database in the system • Store data in database • Generate alert notification (SMS & email) • Generate report
Indoor Air quality monitoring	Indoor air pollution index (API) value will be read through air quality sensor and display the reading to admin by using a core device – Node MCU ESP8266.	<ul style="list-style-type: none"> • Detect the presence of toxic gases and smoke • Display the indoor air pollution index reading in the system



Indoor air quality statistic prediction	The indoor air quality (weekly progress) data analysis will present based on air pollution index in PPM. The data will be predicted by using machine learning to gain more accuracy in term of data collection.	<ul style="list-style-type: none"> • Display the predicted air pollution index in the system • Display the status about stages of the API causes • Record the data daily and generate data analysis (weekly progress)
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1.7 Project Timeline

The Gantt Chart is a technique that is often used in project management to show how the project will work. Table 1.2 below shows how the project is scheduled.

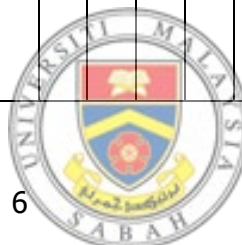
Table 1.2 Gantt Chart of the Project

Task/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Final Year Project 1 (FYP 1)														
Completion of Chapter 1: Introduction														
Completion of Chapter 2: Literature Review														
Completion of Chapter 3: Methodology														
Further correction and improvement for Chapter 1, 2, and 3														
Chapter 1, 2, and 3 report submission														
Progress presentation														



Collect data and System Design															
Completion of Chapter 4: System Analysis and Design															
Preliminary Implementation/Experiment															
Final Year Project 1 report submission															
FYP 1 presentation															

Task/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Final Year Project 2 (FYP 2)														
Further implement the system														
Testing and debug for the system														
Completion of Chapter 5: Implementation														
Completion of Chapter 6: Testing														
Further correction and improvement for FYP 2 report														
Final Year Project 2 report submission														



Chapter 6

This chapter is for testing. All the results of testing performed on the proposed system will be discussed in this chapter. The chosen testing is unit testing. Unit testing carried out during development process from time to time to make sure every unit of the system functioning properly.

Chapter 7

This chapter is about conclusion. All the chapter such as chapter 1, chapter 2, chapter 3, chapter 4, chapter 5, and chapter 6 will be summarized in this chapter.

1.9 Summary

Overall, the proposed system developed to monitor and predict the indoor air pollution index (API). This system will help to make sure the indoor air condition is safe for students and academic staffs in Faculty of Computing and Informatics building. There are four modules covered in this system, which include login module, administration module, indoor air quality monitoring module and indoor air quality statistic prediction module. Machine learning algorithm is applied and implemented in the system for prediction purpose.



CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter consists of explanation and reviews on research done, fact and existing systems that are related to the project. The resources are collected from Internet, books, and journals. This chapter includes 2.1 Introduction, 2.2 Concept of Air Quality based on Air Pollution Index, 2.3 IoT-based Indoor Air Quality Monitoring and Prediction System, 2.4 Machine Learning, 2.5 Related Work, 2.6 Decision Tree, 2.7 Random Forest, 2.8 Support Vector Machine (SVM), 2.9 Comparison of Three Machine Learning Algorithms, 2.10 Time Series Forecasting, 2.11 Literature Review on Existed Related System, and 2.12 Summary.

2.2 Concept of Air Quality based on Air Pollution Index

Humans need clean air to live a safe life. The quality of air, on the other hand, cannot be measured solely by sight. As a result, the air pollution index (API) was created to assess the cleanliness and quality of the air. API was established in response to public health concerns about declining air quality. API is used to report on the status of air pollution and is generally recognised as a key determinant of negative health effects. API is a measure of air quality that should be maintained as low as possible, indicating that the air is clear (Leong et al., 2020). Table 2.1 show the Air Pollution Index (API) Level.



API Reading	Status	Color
0 - 50	Good	Blue
51 - 100	Moderate	Green
101 - 200	Unhealthy	Yellow
201 - 300	Very Unhealthy	Orange
> 300	Dangerous	Red

Figure 2.1 Air Pollution Index (API) Level

2.3 IoT-based Indoor Air Quality Monitoring and Prediction System

IoT is a recently created technology in which physical devices, as well as controls, actuators, and sensors, are connected through the Internet (Nayak et al., 2017). IoT simplifies and aids in the monitoring of indoor air quality (IAQ) parameters. Data on air quality parameters can be obtained via the internet, making it easier and quicker to do so. With the advent of technology such as the Internet of Things, air quality monitoring is getting more advanced. IoT-enabled monitoring systems can create an autonomous ecosystem capable of creating IAQ monitoring and control systems that can run automatically. The Internet of Things allows users to monitor their surroundings from anywhere via a Wi-Fi or Ethernet link. (Hapsari et al., 2018).

The Internet of Things, embedded systems, wireless sensor networks, and artificial intelligence are examples of cutting-edge technology that can deliver feedback on observed changes in the world. As a result, fellow researchers have put in much effort to establish comprehensive air quality control and prediction systems. It also contains a web application named "PollutionWeather" that provides real-time pollution-related information on a regular, weekly, and monthly basis. Extensive study into air quality has shown a number of promising results in terms of reducing the causes that influence human health (Pandya et al., 2020).

