IOT-BASED COMMUNITY-LED AIR QUALITY MONITORING SYSTEM

THEAH SOON AIK

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Tajuk Projek : IoT-based Community-led Air Quality Monitoring System

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Dr. Sao Yee Guan
Pensyarah Kanan
Fakulti Kejuruteraan Elektronik Dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya
76100 Durian Tunggal
Melaka.

Tarikh: 1/6/17

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Supervisor's Name : DR SOO YEW GUAN

Date : 1/6/17

Special dedicate:

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ABSTRACT

Air pollution is the introduction of impurities such as solid particles and gases into the atmosphere. Current air monitoring station is limited in number causing less information on current air quality. This project is to develop a system to monitor air quality in real time for a decent number of places using WemosD1 Mini and dust sensor Sharp GP2Y10. Moreover, a Cloud-based platform that manages data coming from air quality sensors is developed. Lastly, a HTML webpage will display a Google map with markers to indicate sensor location and also data with respective to the location. There are 6 marker colors whereby each color will represent different level of air pollution.

ABSTRAK

Pencemaran udara adalah pengenalan kekotoran seperti zarah pepejal dan gas ke atmosfera. Stesen pemantauan udara semasa terhad dalam bilangan menyebabkan kekurangan maklumat kualiti udara semasa. Projek ini adalah untuk membinakan satu sistem untuk memantau kualiti udara dalam masa sebenar di bilangan tempat yang mencukupi dengan menggunakan WemosD1 Mini dan sensor debu Sharp GP2Y10. Selain itu, platform berasaskan awan akan menguruskan data yang diukur dari sensor kualiti udara yang telah dibinakan. Akhir sekali, halaman web HTML akan memaparkan peta Google dengan penanda untuk menunjukkan lokasi sensor dan juga data masing-masing. Terdapat 6 warna penanda di mana setiap warna akan mewakili tahap pencemaran udara yang berbeza.

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LIST OF ABBREVIATIONS

AQI	-	Air Quality Index
API	-	Air Pollution Index / Application Programming Interface
etc	-	Et cetera
FTP	-	File Transfer Protocol
HTML	-	HyperText Markup Language
HTTP	-	HyperText Transfer Protocol
IoT	-	Internet of Things
IDE	-	Integrated Development Environment
LED	-	Light Emitting Diode
PC	-	Personal Computer
PCB	-	Printed Circuit Board
PD	-	Photo Diode
PM	-	Particulate Matter
URL	-	Uniform Resource Locator

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION

Chapter 1 will explain the project overview, objective of the project, problem statement, the scope of the project, project workflow and report structure.

1.1 Project Overview

Air is important to human beings as they need to breathe to stay alive. However, the air is polluted with a lot of things such as vehicles, power generating stations, open burning and many more. The exposure to this polluted air in a long time will cause negative health impacts to human beings. Therefore, this project aims to monitor air quality in real time which can raise awareness to the publics and appropriate actions can be taken to curb the polluted air. Concentration of dust density will be measured by using dust sensor. The concentration of dust density is then used to define the Air Quality Index which consist of 6 color and levels indicating the current air quality.

1.2 Objective

The objectives of this project are:

- To develop an IoT-based Air Quality Monitoring System
- To deploy the system to the residential area as the community-led climate project
- To display the air quality index in a map

The first objective is to develop an IoT-based Air Quality Monitoring System. This system will use a microcontroller with Wi-Fi module which is to connect the microcontroller to the Internet and air pollutant sensor which is to measure the air quality.

The second objective is to deploy the system to the residential area as the community-led climate project. A few ready and working prototype will be set up at neighborhood area to measure the air quality.

Lastly, the objective is to display air quality index in a map. The air pollutants concentration will be converted to air quality index. The map will show the installation of sensor area indicated with markers. These markers will have color according to the air quality index value.

1.3 Problem Statement

Air pollution happens in most of the countries and causes most of the health problem such as asthma, lungs infection, etc. In Malaysia, haze is an on-going problem, which is mainly caused by slash-and-burn practice used by farmers in Indonesia. Thus, air quality monitoring system is vital to prevent such chaos. Currently, static air pollution monitoring stations controlled by official authorities are responsible to monitor the air quality. These stations provide high level of accuracy and precision readings of air pollutants. However, building and operating these stations is very costly which limits the number of stations. So far, there is only 2 air monitoring station in Malacca which means less information on real time air quality to the public. Community in area located further than the monitoring station will not know their area air quality and must depend on their judgement.

1.4 Scope

This project will monitor dust density only. Dust is considered as particulate matter which is one of the main air pollutants. Among other air pollutants such as nitrogen dioxide, carbon monoxide, sulfur dioxide, lead, and ozone, particulate matter is the most harmful to human health as it can go deeply into lungs and worst, diffuse into blood streams. This project will only cover certain neighborhood area in Malacca.

1.5 Project Workflow

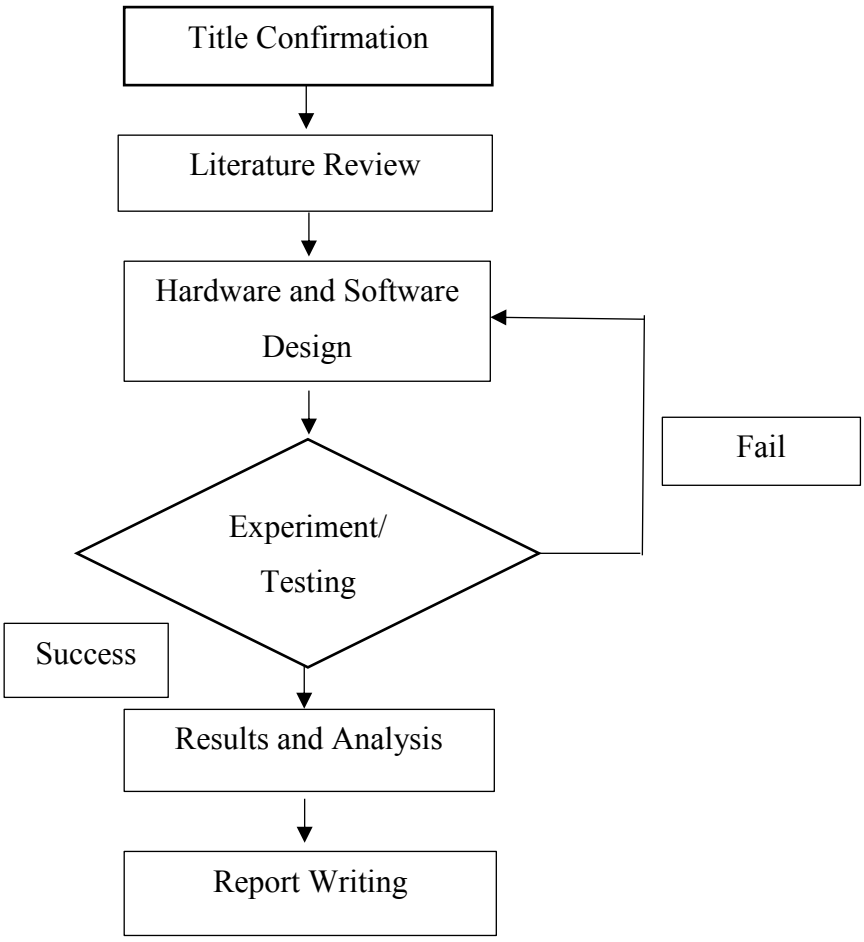

Figure 1.1: Overall project workflow

This project started with title confirmation. Then, literature review based on previous work related to the title will be carried out. The method, problems, results and improvement of previous work will be noted down. With these information, the best method will be chosen to design and develop the new project. Next, hardware and software design of the project will be carry out. Experiment or testing of hardware and software will be performed to check whether the project is successful or not. If fail, the hardware and software design need to be revised again. If successful, the results will be recorded and analysis of the results is done. Finally, a report is written which consist of introduction, literature review, methodology, result and analysis and conclusion.

1.6 Report Structure

Chapter 1 explains the project overview, objective of the project, problem statement, the scope of the project, project workflow and report structure.

Chapter 2 explains literature review based on previous and current existing technologies to create specific research on this project. The theory to be use for the project is also discuss in this section.

Chapter 3 describes the flow of the project such as how the software and hardware are design, integrate and implement.

Chapter 4 discusses the results of the project in detail. Apart from that, analysis will be done to provide useful information from the results obtained.

Chapter 5 concludes the project findings. Several suggestions for future works in making this project more effective are included.

CHAPTER 2

LITERATURE REVIEW

This chapter explains literature review based on previous and current existing technologies to create specific research on this project. The theory to be use for the project is also discuss in this section.

2.1 Air Pollution

Air pollution is the existence of impurities in a sufficient volume, causing diseases, allergies and even death to all living organisms on Earth. These impurities can be categorized into either anthropogenic (arising from human activities), or by natural events (such as volcano eruption, forest burning), or by the decomposition of organic compounds[1]. Ozone, particulate matter, carbon monoxide, nitrogen oxide, sulfur dioxide and lead were the common air pollutants. A previous study states that PM, particulate matter causes the most negative health impact to human among any other air pollutants[2][3][4]. Particulate matters can be classified into PM2.5 and PM10 which represent particles with a diameter of 2.5µm or less and diameter between 2.5µm and 10 µm respectively. The PM10 and PM2.5 particles were able to go deeply into the various parts of lungs as well as damage the normal circulatory system and cause cardiovascular and respiratory diseases[5] [6]. In year 2014, a study is conducted and the effect of PM10 to human health in Taiyuan, China were identified[7]. Based on the Figure 2.1, the effects of PM10 were premature death, chronic bronchitis, outpatient visit, emergency room visit and hospital admission.

Year	Annual average concentration ($\mu g/m^3$)	Premature death	Chronic bronchitis	Outpatient visit	Emergency room visit	Hospital admission
2001	196	4948	1786	275,292	1798	46,247
2002	177	4794	1673	253,670	1641	50,550
2003	172	4859	1659	233,060	1504	46,738
2004	175	5354	1717	244,853	1583	57,621
2005	139	4041	1400	193,584	1230	30,840
2006	142	3774	1476	201,450	1281	18,582
2007	124	3320	1229	174,484	1100	16,027
2008	94	2399	858	133,863	832	12,769
2009	106	2751	1053	178,388	1115	17,711
2010	89	2138	835	133,835	829	14,437

Figure 2.1: Table of number of cases caused by PM10 in Taiyuan, 2001-2010 [7].

2.2 Internet of Things

The Internet which play a significant role in IoT is launch in 1989[8]. Ever since then, connecting "Things" to the internet developed widely. In 1990, the first Internet 'Thing', a toaster that controlled over the Internet was created by John Romkey. In 1999, Kevin Ashton, executive director of the Auto-ID Centre, MIT originate the Internet of Things from initially a concept into a term. In 2000, LG electronics grab the opportunity in commercializing IoT after announced its plans to develop a smart refrigerator that could identify the storage levels and notify user if the food stored is finished. The introduction of IPv6 in 2011 further enhance the growth in this field. A lot of educational and commercial initiatives with IoT has been done by IT giants like IBM, Ericson, Cisco, etc.

The Internet of Things consist a network of physical objects, like sensors and actuators, collecting and exchanging data[9]. With Internet of Things (IoT), massive amount and variety of data generated by the objects such as home appliances, monitoring sensor, vehicles, surveillance camera and many more can be put into good use[10]. For example, development of applications which provide services such as smart home system, remote health monitoring, environmental monitoring and so on to the publics.

2.3 Existing Air Pollution Monitoring System or Application

Over the years, a lot of air pollution monitoring system had been done. Different ways of medium deployment of IoT such as wired communication and wireless communication have been used. Due to disadvantage of wired communication, hence IoT air quality monitoring system using wireless medium will be analyzed.

According to Yang et al.,[11] wireless air quality monitoring system is better than wired air quality monitoring system. This is because wireless system is not constrained by condition of wiring as it doesn't require any wiring. In reality, it is impossible for wired communication to be achieved everywhere. Low mobility and expensive installation cost are the drawbacks of wired communication. Thus, a simple alternative for deploying IoT would be the wireless medium as it is higher mobility and cheaper compared to wired. Moreover, wireless system only needs an Access Point and wireless network adapter. Three types of 2.4 GHz short distance wireless communication technology which are Wi-Fi, Bluetooth and Zigbee were compared in terms of speed, distance, power and security as shown in Figure 2.2. Wi-Fi technology was chosen due to its speed of 11-54 Mbps and coverage distance of 20m-200m. The only aspect that need to be improved for Wi-Fi is the security. The significance of data security depends on the application itself. If the data transferred is not private and confidential, then the security can be ignored. Besides that, comparison between common dust sensor available in the market were also done in Figure 2.3. Sharp GP2Y1010AU0F was chosen as it has lowest cost and acceptable sensitivity compared to GE SM-PWM-01A, and the SHINYEI PPD42NS PPD4NS. Lastly, an indoor air monitoring system which consists of Arduino Yun, a smartphone that support HTML 5.0, dust sensor that detects PM 2.5 and PM 10, temperature/humidity sensor and a Volatile Organic Compound (VOC) sensor was developed. Arduino Yun used an Atmel ATmega32U4 microcontroller and an Atheros AR9331 Wi-Fi chipset.