DESIGN AND DEVELOPMENT OF AIR QUALITY AND ENVIRONMENT POLLUTION MONITORING SYSTEM FOR FOREST MONITORING APPLICATION

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DECLARATION

I declare that this thesis entitled "DESIGN AND DEVELOPMENT OF AIR QUALITY AND ENVIRONMENT POLLUTION MONITORING SYSTEM FOR FOREST MONITORING APPLICATION 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.

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Date : 5/7/2021

APPROVAL

I hereby declare that I have checked this report entitled “Design and Development of Air quality and Environment Pollution Monitoring system for forest monitoring Application” 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

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Date : 5/7/2021

DEDICATIONS

To my beloved mother and father

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ABSTRACT

This project describes the design and development of air quality and environment pollution monitoring system for forest monitoring application. Recent years, there are many forest fires occurs nowadays. The air pollution/ gas level forest fires very dangerous for ecosystem and very hazardous and can be deadly poisoned for the human. Conventionally, there are no existence system that mounted and located in the forest to monitor the forest health. The existence of the forest fire and gas leaked, could not be detected and should be monitored closely by the rangers. Therefore, the device that can measure and analyse the air pollution/ gas /flame to determine the pollution level in the forest. The air quality sensors for fire and heat detection system activities with the GPS device and IoT gateway connected with the LoRAWAN device will be used on the proposed device. The correlation of the gases and a flame sensor and the lab analysis will be done. In the end, the notification system by using Blynk mobile application, Cayenne and Telegram will be developed for effective warning system for the forest management authorities.

ABSTRAK

Projek ini menerangkan tentang reka bentuk dan mencipta alat mengesan kualiti udara dan sistem pemantauan kebakaran untuk aplikasi pemantauan di hutan. Sejak kebelakangan ini, terdapat banyak kebakaran hutan dan jerebu berlaku. Pencemaran udara dan kebakaran hutan sangat berbahaya bagi ekosistem dan boleh membawa maut kepada manusia. Secara konvensional, sistem untuk memantau pembakaran hutan di hutan masih belum dipasang. Jika berlaku kebakaran hutan, pihak yang terlibat tidak dapat mengesan dimana dan punca yang berlaku. Oleh itu, dengan adanya alat yang dapat mengukur dan menganalisis pencemaran udara / gas / api ,ianya dapat memantau secara efektif untuk menentukan tahap pencemaran dan tahap suhu di hutan. Oleh itu, Alat pengesan kualiti udara untuk sistem pengesanan kebakaran sangat berguna, dengan peranti tambahan GPS dan gerbang IoT yang dihubungkan dengan peranti LoRAWAN sangat membantu. Kajian terhadapan gas pembakaran di hutan perlu dipandang serius. Akhir sekali, sistem alat ini akan menghantar notifikasi dengan menggunakan aplikasi Blynk, Telegram dan laman sengsawan Cayenne. Dengan adanya alat pengesan ini, ianya sangat efektif bagi pihak berkuasa pengurusan hutan untuk memantau pembakaran yang berlaku dihutan.

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LIST OF SYMBOLS AND ABBREVIATIONS

IoT	-	Internet of Things
M2M	-	Machine to machine
GPRS	-	General Packet Radio Services
USB	-	Universal serial Bus
MSCM	-	Multi-sensor Combination Module
API	-	Air pollution index
LPWAN	-	low power wide area network
PPM	-	Part per million
W	-	Watt
V	-	Voltage
A	-	Ampere
%	-	Percentage
SF	-	Spreading Factor
CR	-	Code rate
RSSI	-	Receive signal strength indicator
SNR	-	Signal to noise
BW	-	bandwidth

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CHAPTER 1

INTRODUCTION

1.1 Introduction

In this chapter will explain the development of Air quality and environment Pollution Monitoring system for forest monitoring Application. This system can monitor the gases air and temperature in forest from forest fire occurs. Moreover, this chapter also include project background, objective, scope, and problem statement

1.2 Background

Recently, the world has change drastically because of technology growing. In term of pollution, there are more than one pollution happen including air, water and sound happen. The World Health Organization (WHO) defines ambient air pollution is the potential air pollutants emitted from industries, households and vehicles. The level of pollution in the ambient air must be reduced. Air pollution is the introduction into the earth's atmosphere of pollutants, particulates, biological materials or other toxic materials which may harm humans, human deaths, natural, or constructed ecosystem damage to other living organismsThe issue of worldwide change to forest health and sustainability is a two main causes of pollution and global warming. In the reported area of the forest, there is a dangerous tendency. Over the course of the years, the forest cover has decreased and hence the scarce agroforestry systems are under increased strain. Due to a massive significant growth of forest resources, forest officials are regularly confronted with local people and occasionally the controversial forestry property is illegally burned. Due to human activity interferences have been reported to consume for about 95% of forest fires. However according statistics from the National Forestry Survey, about 53%-54 % of the forest region is impacted annually by occurrences of forest fires, which include agricultural and shifting activities [2].

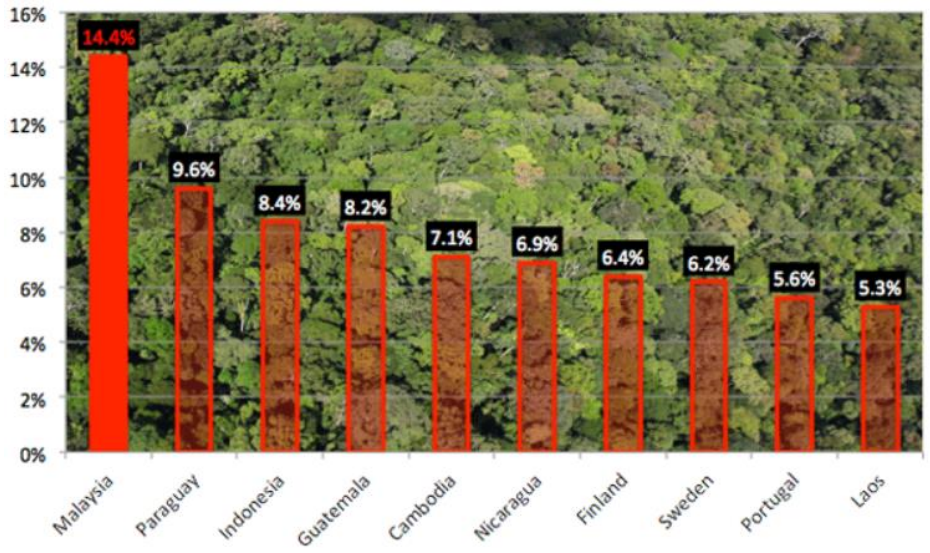

Figure 1- 1 Percentage for forest loss between 2000 until 2012 in major forestcountries

Malaysia differs from those of the major countries that are diminishing their forest area to the greatest rate of forest loss [1]. Moreover, Forest fires originating from illegal activities, mostly in the Indonesian islands of Sumatra and Kalimantan, produced the severe South-east Asian smoke. In the summer months, the haze rapidly spread. From the end of June to the end of October, haze first touched Indonesia and in September 2015 became an international concern. It was the latest incidence of a long-term problem in every summer months in the region. Measurements were reported on the Unhealthy Air Pollution Index, (API), which was the hardest impacted by the haze in 24 locations in Kedah, the state of Sarawak [1].

1.3 Motivation

In the era globalization, forest are one of the most important for ecosystem and living organisms. Most of the forest were destroy by human activities including illegal forest fire. This can also happen in different respiratory conditions, due to significant

to polluted air. As the technology created, the air pollution can be monitor through API system that consist the grade value of air quality.

Hot and dry season has exposed our environment to natural disasters, particularly the fire that has led to hazy environment in recent months. Haze can also happen when occurs forest fires in the forest, this definitely effect urban area. On the other hand, illegal logging generally effect to global and this should be monitor as soon as possible. Therefore, a development of low-cost monitoring system able to help any parties involve to overcome and avoid those illegal and gases air happen.

1.4 Problem Statement

In simple terms, the air pollution index or API is an indicator to measure the seriousness and pollution of the air. The higher the API, the more risky the air quality to human health . Hot and dry season has exposed efectively to environment more disasters occurs, especially forest fire in forest. Hence, the problem where sense quality of air and temperature are low and not accurately detect. The accurate the system result the effective product can be used and help in control forest fire air quality. Next, the detection of harmful gases in air with long range feasible solution and efficient controlling measure need to be improve because of some system only detect in a short distance, with the help of LoRaWAN the detection of harmful gases can be monitor wisely and long distance without internet connectivity. The accuracy of the temperature detection and air pollution gases are low and need to improve. The system contains high cost maintenance and need to modified as easy to monitor the system.

1.5 Objective

The main objective of this project are:

- To design and development air quality and environment pollution monitoring system for forest monitoring application through IoT using LoRaWAN

- To develop an outdoor air pollution monitoring system by using sensor, ESP32 and LoRaWAN module to form a complete system.
- To evaluate the performance of developed system through based on sensor validation, long range data communication and mapping.

1.6 Scope

i. Arduino Uno and ESP32 used as the controller for data logging and processing with the configuration of hardware and IoT platform.
ii. Air quality/ smoke sensor can be used to identify the API of air pollution monitoring system.
iii. The temperature and humidity sensor will be used to identify the heat in the forest.
iv. Lorawan will be used to send data for long range communications.

LITERATURE REVIEW

2.1 Introduction

In chapter, it will discuss the relationship between this project reliability with another research as to determine if there are any identical research based on this project. Moreover, in this chapter, it will help to ensure there are no repetitive research study based on the same case area. This project title Air quality and Environment Pollution Monitoring system for forest monitoring Application will provide necessary system which help to monitor gases and temperature in forest.

2.2 Overview of Air Quality and Temperature in Malaysia

2.2.1 Overview of Air Quality

In Malaysia, air quality is monitored by the Department of Enviroment through ground stations located nationwide. The Department of the Environment (DOE) in 1989 developed the Recommended Malaysian Air Quality Guidelines (RMG), which provided out concentration limits of selected air pollutants that could possibly effect the health and well being of the general public[3]. Year 1993, DOE had create MAQI which is call Malaysia Air Quality Index in Malaysia in order to provide the protection of healthy air. This organization provide a significant role to inform current status air level in Malaysia.

The system was revised in 1996 based on pollutant standard index (PSI) that was adopted by the United States Environmental Protection Agency (USEPA) which was later changed to air quality index (AQI) in 1999. The index system (API) is divided into several categories such as good, moderate, unhealthy and emergency as shown in table 1 [3]. It is categorized on the basis of the highest values of the index of five major air pollutants: particulate matter below 10μm (PM10), ozone (O3), carbon monoxide (CO), sulfur dioxide (SO2) and nitrogen dioxide (NO2) over a specific period of time, and where PM10 and SO2 are averaged over a 24-hour running period, CO is averaged over an 8-hour period and O3 and NOx are read hourly before an hourly index is

calculated using the sub-index functions for each pollutant from the human health implications point of view [3].

The index is rounded to the nearest integer and the highest Ip is identified as AQI for each pollutant in Table 2-1, from 0 to 5000 and above which is divided into 5 groups of categories (Excellent, good,mediocre, bad, and harm).

In order to gain optimum air quality parameters and noise levels for increasing performance or replicating environmental composition of specific geographical areas to obtain locally imported products, the current development of forest monitoring systems aims to manage in the control environment pollution [9]. The environmental parameters include air pollution and fire heat that will affect forest and environmental growth.

2.2.1.1 Air quality measurement

Main air pollutants are chemicals emitted by sources, such as plant chimney, exhaust pipe and suspension of polluted wind pollutants. The quantity produced at the source itself will also be analyzed in principle. They source from chemical reactions of primary air pollutants which most probably involve the atmospheric natural components, particularly oxygen (O2) and water (H2O)[15]. In general, standard air quality measurements based on the air pollution index (API) status in table 2-1 [3]. Air pollutant are measured by micrograms per cubic meter (μg / m 3) or parts per million (ppm).

Air quality monitoring is the first step to an AQMP identifying the way to further air quality monitoring activities. Stakeholders examine the effectiveness of past control steps, the air pollution status, and the validation of air quality models for projection by assisting air quality monitoring. The efficiency of the AQMN for the above applications could, however, only be accomplished by the use of stable, real-time monitoring instruments [17]. The equation for the API for each pollutant is as shown in Table 2-2.

Table 2- 1 Air Quality Index (AQI) system [4]

AQI (CO_2) ppm	Air pollution Level	Health implication
0-600	Excellent	normal outdoor air level
700-1000	Good	normal outdoor air level
1100-1500	Mediocre	drowsiness and poor air.
1600-2100	Bad	headaches, sleepiness and loss of concentration.
>5000	harm	Permissible exposure limit for daily workplace

Table 2- 2 API equation of each pollution

Pollutant		API calculation equation
CO (Based on eight-hour average concentration)	conc <9ppm	API= conc. x 11.11111
	9 < conc. < 15	API = 100 + {[conc. - 9] x 16.66667}
	15 < conc. < 30	API = 200+ {[conc. - 15] x 6.66667]
	conc. > 30 ppm	API = 300 + {[conc. - 30] x 10]
O_3 (Based on one-hour average concentration)	conc < 0.2 ppm	API = conc. x 1000
	0.2 < conc. < 0.4	API = 200+ {[conc. - 0.2] x 500]
	conc. > 0.4 ppm	API = 300 + {[conc. - 0.4] x 1000]
NO_2 (Based on one-hour average concentration)	conc < 0.17 ppm	API = conc. x 588.23529
	0.17<conc.<0.6	API = 100 + {[conc. - 0.17] x 232.56]
	0.6<conc.<1.2	API = 200+ {[conc. - 0.6] x 166.667]
	conc. > 1.2 ppm	API = 300+ {[conc. - 1.2] x250]
SO_2 (Based on 24-hour average concentration)	conc < 0.04 ppm	API= conc. x 2500
	0.04<conc.<0.3	API= 100 + {[conc. - 0.04] x 384.61]
	0.3<conc.<0.6	API= 200+ {[conc. - 0.3] x333.333]
	conc. > 0.6 ppm	API= 300+ {[conc. - 0.6] x 500]
PM_{10} (Based on 24-hour average concentration)	conc < 50pg/m^3	API = conc.
	50 < conc. < 150	API = 50 + {[conc. - 50] x 0.5]
	150 < conc. < 350	API = 100 + {[conc. - 150] x 0.5]
	350<conc.<420	API = 200+ {[conc -350] x 14286]
	420 < conc. < 500	API = 300 + {[conc. - 420] x 1.25]
	conc. > 500pg/m^3	API = 400 + [conc. - 500]

2.2.2 Overviews of forest fire in Malaysia

The greatest national concern in Asia is land and forest fires in tropical environment. Forest fires occur directly or indirectly throughout Southeast Asia. The reason is generally linked directly to the purposeful or unintended brand of human action as well as to agents leading to a fire. An example of direct causation is the use

of open burning technology to satisfy the requirements of agricultural, housing and commercial centres. Furthermore, the usage of fire, such as tossing cigarettes in the woods, camping, hunting, fishing and others, contribute directly to the cause. As weather phenomena, indirect causes of forest fires involve. The major factors involved with wildfires includes dryness and moisture. Based on wether investigation in Malaysia, in between May and September were the Monsoon where dry weather occured accompany by wind. This might be one of the factors that makes fire propagation and more hard to detect (human carelessness, forestry clearance, etc.)

2.3 Internet of Things

Nowadays, Internet has become synonymous around the world, connecting people and effecting our daily life significantly [7]. Thus, open a new era of computation technologies besides traditional personal computer that only be used for storing data. Internet of Things is a network connection which can connect us and multiple electronics object seamlessly [8]. In 1999, the terms Internet of Things was first introduced by Kevin Ashton in form of supplies chain management system which integrated with RFID technologies that quite new during that time [9]. Hence, as Internet technologies getting worldwide adoption during the 20th centuries, IoT terms are also expending which allows communication and data exchanged between electronics devices and application. IoT enable system able to complete the task automatically after an intelligence system has been incorporated to the object. The idea of devices that directly connect each other as shown in **Figure 4-2.**

Figure 2- 2 Internet Of Things (IoT)

IoT has been prove useful in connecting wide area of industries and application. From smart home, agriculture, healthcare services, transportation, and analytics application etc as shown in **Figure 4-2**. User can easily use IoT platform to navigate around various services and system which provide the infrastructure. Internet enable the transmission of data between IoT infrastructures easily and seamlessly. Its is applied to monitor in various area.

The Internet of Things architecture and wildfire monitoring systems are distinguished by wildfire monitoring on three parts: a data collection wireless sensor network, a wireless sensor network, and a wildfire monitoring system, based on the Internet of Subjects architecture [13]. The aggregation node then sends data via the existing wired or wireless transmission network to the monitoring station for wildfires [15]. The wildfire control system, through the communicated monitoring data, analyzes and processes the essential factors of wildfire, which enables decision-making on wildfire monitoring.

According to the wildfire monitoring needs of the wild land, a wireless sensor network will provide a wireless sensor data collection, interpretation and early warning system, which can effectively identify diverse conditions and emergencies. Furthermore, it will more promptly and effectively monitor forest conditions and prevent forest fire of land-based air pollution and ecosystems

Basic IoT architecture can be split into 3 layers, perception layers, network layers and application layers [7] as shown in **Figure 5-2**. Perception layers consist of physical object such as sensors which collect information from its surrounding. Then, network layer is a layer which connect network devices and servers via Internet or