การพัฒนาระบบตรวจจับฝุ่นแบบทำด้วยตนเองราคาต่ำ

Development of a Low-Cost DIY Dust Detector System

ณัฐพิชญ์ เจ็งศรีวงศ์ และ ศุภกานต์ จันทร์เสรีวิทยา*

Nattaphit Jengsriwong and Suppakarn Chansareewittaya*

สำนักวิชาเทคโนโลยีสารสนเทศ มหาวิทยาลัยแม่ฟ้าหลวง

School of Information Technology, Mae Fah Luang University

*E-mail : suppakarn.cha@mfu.ac.th

บทคัดย่อ

บทความนี้ได้นำเสนอระบบตรวจจับฝุ่นแบบทำด้วยตนเองราคาต่ำ ไม่เพียงแต่เครื่องที่ได้รับการพัฒนาแล้วได้รับการนำเสนอแต่การประยุกต์ใช้การแสดงผลได้ถูกนำเสนอด้วยเช่นกัน แนวคิดของเครื่องที่นำเสนอคือเรียบง่ายและราคาต่ำ ราคารวมของเครื่องที่นำเสนอนั้นอยู่ที่ประมาณ 1,500 บาท ณ ปัจจุบัน ไม่มีค่ารายเดือนเว้นแต่ค่าใช้บริการอินเตอร์เน็ตและค่าไฟฟ้า กำลังไฟฟ้าที่ใช้อยู่ที่ 80 มิลลิวัตต์โดยประมาณ ชนิดของฝุ่นที่ตรวจได้คือ pm 1.0, pm 10, และ pm 2.5 และแสดงผลบนเครื่องที่นำเสนอ มากไปกว่านั้นข้อมูลค่าความหนาแน่นของฝุ่นที่ตรวจจับได้จะส่งไปยังระบบคลาวด์และสามารถติดตามได้ผ่านอินเตอร์เน็ต โปรแกรมประยุกต์บลิงค์และไอเอฟทีทีได้ถูกใช้เพื่อนำเสนอข้อมูลค่าความหนาแน่นของฝุ่นที่ตรวจจับได้ เครื่องที่นำเสนอสามารถติดตั้งได้ทุกที่ตามที่ผู้ใช้ต้องการเพื่อตรวจจับและวัดปริมาณความหนาแน่นของฝุ่น มากไปกว่านั้นผู้ใช้สามารถเข้าถึงการแสดงผลได้จากทุกที่ผ่านอินเตอร์เน็ตโดยไม่เสียค่าใช้จ่ายใด ๆ มากไปกว่านั้นผู้ใช้สามารถเพิ่มเครื่องที่ได้รับการพัฒนานี้เข้าไปในระบบได้ตามต้องการในอนาคตในการเสดงผลค่าความหนาแน่นของฝุ่นในหลาย ๆ สถานที่พร้อมกัน

คำสำคัญ : ไอโอที อินเตอร์เน็ตของสรรพสิ่ง ระบบตรวจจับฝุ่น

Abstract

This paper presents the low-cost DIY dust detector system. N Not only is the designed device proposed, but also the monitoring application. The concept of the proposed device is simple and low-cost. The overall cost of this proposed device is about 1,500 THB (45$) at the present. No monthly charge except the internet fee and the electricity bill. The electrical power usage is 80mW approximately. Type of pm 1.0, pm 10, and pm 2.5 can be detected and displayed by the proposed device. Moreover, the information of density of dust can be transmitted to the cloud system and can be monitored on the internet. The Blynk application and IFTTT are used to display the information. This proposed device can be installed wherever the user wants to detect and measure the density of dust. Moreover, the user can access the display to view the information via the internet from everywhere with no service charge. Moreover, the user can increase the developed devices into the system in the future up to the requirement to display the value of density of dust at multi places simultaneously.

Keywords : IoT, Internet of Thing, Dust Detector System

Introduction

At present, there is a lot of air pollution in the world, and it has a lot of health impacts on humans and not only on humans but any living things have been got these impacts, too. Air pollution, especially dust, can make harmful to health, especially to the lungs. It is necessary to have the devices in any place. In various places, some devices can measure and display the amount of particulate matter in the air such as dust, or micro dust at certain points.

However, some devices are expensive and need to pay to access the data and information on the system. Moreover, these devices are installed in far places that are not close to the user thus the user may not get real and accurate information. In addition, the existing device contains a high cost, approximately at least 3,000 (99$) per device and the server is required. The cost of the existing systems is not only the device, but include the cost of maintenance and operation that make the overall cost is high.

According to the above content, this is the beginning of an idea, why dust detectors cannot be created as the Do It Yourself (DIY) device? Because nowadays various types of sensors and IoT devices are affordable and available in the market. The device which can use to detect and measure pm 1.0, pm 10, and pm 2.5 (Particulate Matter) dust can be made easily and easy to install in a residential area or any place such as a school, office, or public area. Moreover, the data and information of the dust can be collected and displayed on various platforms such as instant platforms or DIY platforms. These platforms can be displayed on both mobile phones and dashboards in the web browser as well.

This paper presents to development of a low-cost DIY dust detector system that can detect and measure pm 1.0, pm 10, and pm 2.5. Moreover, this device can send the data to the internet via WiFi and require serverless. After that, the data can be processed and displayed as information. The related work is shown in next paragraph.

The CMU CCDC is proposed by Arduino (2022). This dust detector system contains devices and web applications. The details of the device are classified. There is this device in public, both hardware and software. no development of Only the information on measured dust is displayed on the website. The advantage of this system is there are a lot of installed devices around Thailand.

Yakkaw (2022) is an interesting dust-measured application. The details of the device are classified as CMU CDDC. Almost all of the devices are installed in the north of Thailand, especially in Chiang Rai. Moreover, the advantage of Yakkaw is Yakkaw has a mobile application to access information on measured dust. The android and IOS applications are developed. This makes the user easy to access the information of measured dust and necessary information. Figure 1 Shows application of Yakkaw.

Figure 1 Application of Yakkaw

However, the installed devices are in install in specific places or the priority places such as schools, hospitals, and some government places. Moreover, the requirement of people who live in the area is they want to know the exact value of density of dust, which is almost all close to them. This proposed system is developed to solve response this requirement. This development is based on the concept of low-cost, simple, and easy. The components of the device can be found in the general electronics shop or online shop. Moreover, the display system is free of the monthly charge. The details of the development of a low-cost DIY dust detector system are shown in next section.

Methodology

The low-cost DIY dust detector system which is presented in this project is designed under the concept of “low-cost, simple, and easy”. There are 2 subparts to this system. The first is the device part. In addition, the second is the display part. Figure 2 shows a block diagram of a low-cost DIY dust detector system for this paper.

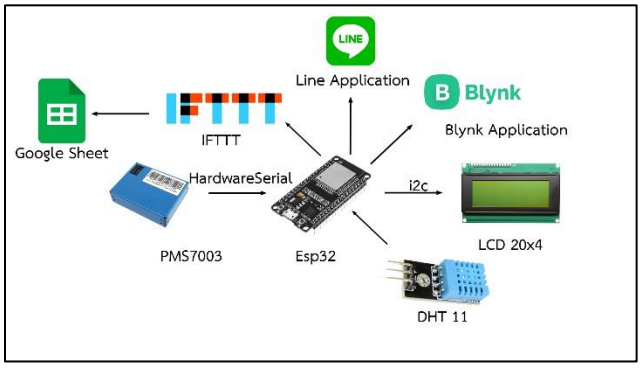

Figure 2 Block diagram of a low-cost DIY air dust detector system of this paper

1. Details of device part

Components that are used in the development of the dust meter are as follows:

- ESP32 is reported by Espressif Systems (2022) and is used as the main IoT board of this proposed device. This device has a compact size and is suitable for limited installation. The sleep mode with low energy consumption is the advantage of this device. The Wi-Fi connection (IEEE 802.11 b/g/n) is included. In this paper, Wi-Fi is used to send the data to the server.

- PMS7003 is the dust detected module and is reported by Plantonic (2022). Laser dust sensor technology is the main technology of this device. The particle size of dust that this device can detect are PM1.0, PM2.5, and PM10. The smallest detected particle size is 0.3 μm. The density of dust that PMS7003 can detect is in the 0-500 μg/m3 range.

- DHT11 is introduced by Mouser Electronics (2022). This device is used to measure temperature and humidity.

- LCD 20x4 is used to display the data. This LCD is connected with ESP32 via I2C communication.

- Multipurpose box 4x4 is used to contain the developed device.

2. Details of display part

The software used to develop this system are as follows:

- Arduino IDE is the open-source Arduino Software (IDE) that makes it easy to write code and upload it to the board. This software can be used with any Arduino board which is introduced by Arduino (2022). The Arduino IDE is used to develop the code of the proposed device. This Arduino IDE is free. The developer can download as much as you can. In addition, the IDE always has updates. There are a lot of useful updated libraries, new libraries, or new devices. This can help the developer improve their work.

- Blynk Application is a full suite of software required to prototype, deploy, and remotely manage connected electronic devices at any scale: from personal IoT projects to millions of commercial connected products. Blynk is introduced by Blynk (2022) and is used to display the information via the web application.

- IFTTT Platform is short for 'If This Then That', and is pronounced like 'Gift' without the 'G'. IFTTT is introduced by IFTTT (2022). This platform is a software platform that connects apps, devices, and services from different developers to trigger one or more automation involving those apps, devices, and services. IFTTT is used to connect the proposed device and Google Sheets. After that, the data visualization is applied to display the information on the graph. This service of IFTTT is free of the monthly charge.

- Notifications of the LINE application, the LINE notifications are integrated into this display part via LINE API. This notification can notify about dust information at that moment. This service of LINE is free of the monthly charge by LINE Corporation, (2022).

Results

The proposed device needs 5VDC via micro-USB of ESP32 to operate. The 5VDC is not only the power supply for ESP32. Moreover, this power source is used to feed the electrical energy for LCD and PMS7003.

The Hardware serial of ESP32 is used to connect with PMS7003 for the data transmission. The I2C which has 3 ports, SDA, SCL, and GND, respectively are used to connect with LCD for transmitting information from ESP32 to LCD. The virtual circuit of the proposed device includes ESP32, PMS7003, DHT11, and LCD 20x4 which is shown in Figure 3.

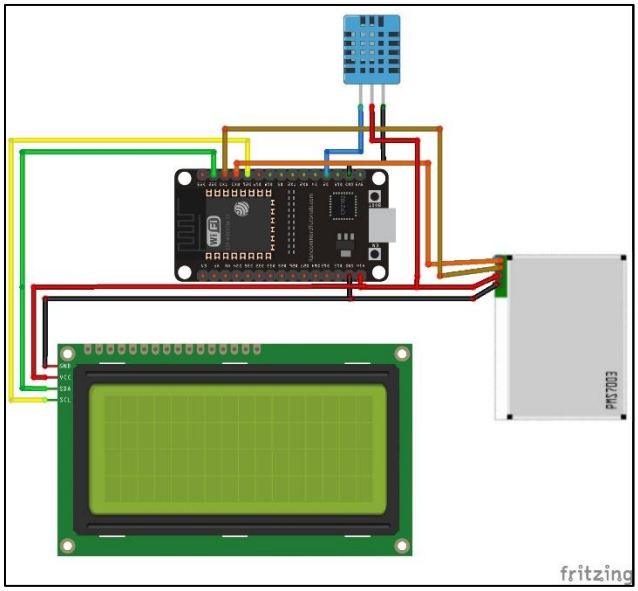

Figure 3 The virtual circuit of proposed device

The proposed device, while power is off, while power is on, are shown in Figure 4 And Figure 5, respectively. The side of the real device is shown in Figure 6 and Figure 7. And real circuit of the proposed device is shown Figure 8.

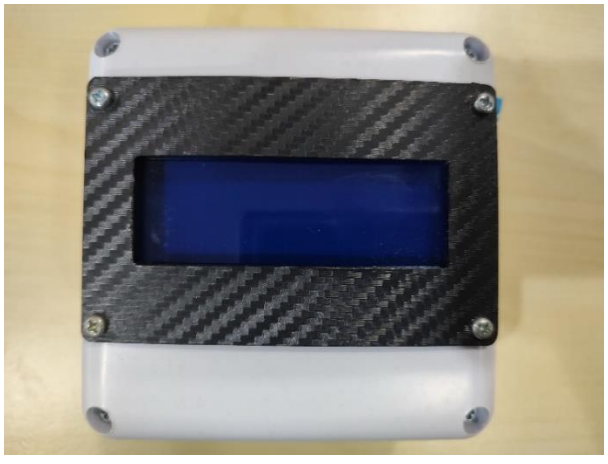

Figure 4 Proposed device while power is off

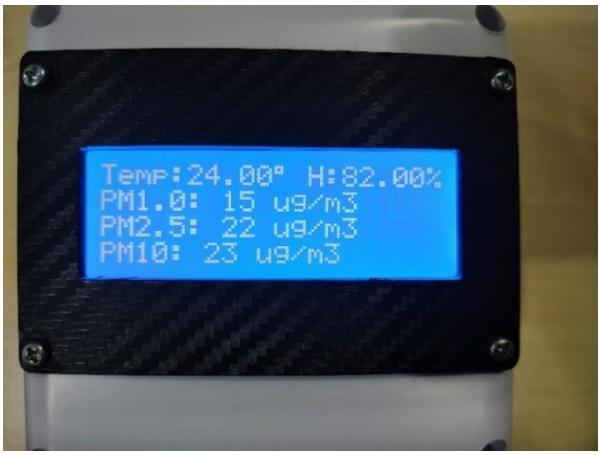

Figure 5 Proposed device while power is on

Figure 6 Side of real device with DHT11

Figure 7 Side of real device with air vent of PMS7003

Figure 8 Real circuit of proposed device

The current usage of the proposed device is in the range between 13.23-15.79 mA at 5 VDC. The electrical power usage can be calculated by equation P = VI. Thus, the electrical power usage is in the range of 66.15-78.95 mW when the device is activated to measure the density of dust, display the information on LCD, and sent the information of dust to the Blynk server.

The approximate maximum electrical power usage is 80 mW when the device is on standby mode. Figure 9 and 10 show the measuring of minimum current usage and maximum current usage, respectively.

Figure 9 The measuring of minimum current usage

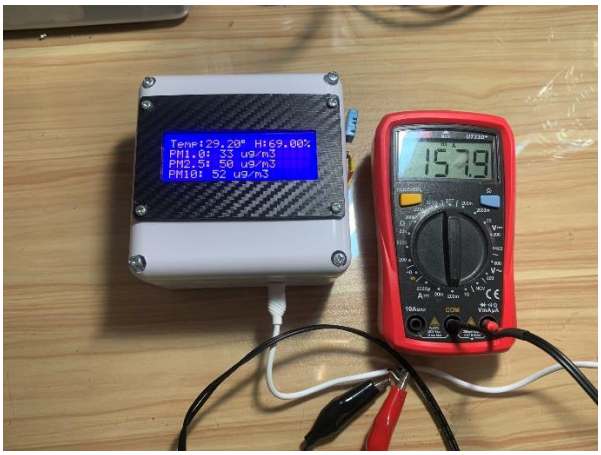

Figure 10 The measuring of maximum current usage

After ESP32 receives data from PM7003 and sends the information to LCD for displaying. The information is sent to the Blynk application for displaying via the internet. The dust data is transformed into dust information and can be displayed correctly on Blynk by comparing it with the information on LCD. Blynk application provides 2 types of display. First is the Blynk Mobile Application which is shown in Figure 11.

Figure 11 Blynk mobile application

The second is the Blynk Web Browser which is shown in Figure 12.

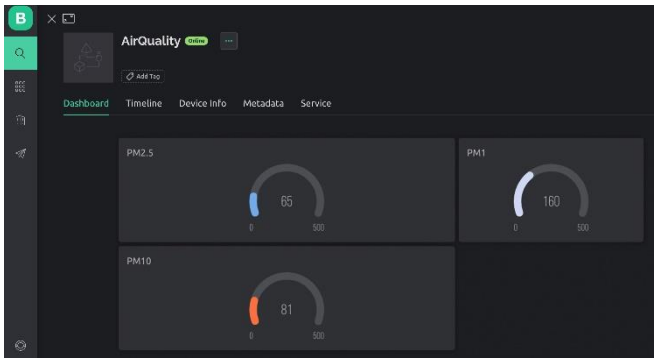

Figure 12 Blynk web browser application

Not only the information is sent to LCD and Blynk. In this paper, the working of the proposed system is set to 1 hour. The information is sent to Google Sheet via IFTTT. The Google Sheet with information is shown in Figure 13.

Time	Type 1	PM1	Type 2	PM2.5	Type 3	PM10
04:00 AM	PM1	22	PM2.5	24	PM10	30
05:00 AM	PM1	25	PM2.5	21	PM10	23
06:00 AM	PM1	22	PM2.5	20	PM10	19
07:00 AM	PM1	14	PM2.5	19	PM10	18
08:00 AM	PM1	29	PM2.5	39	PM10	34
09:00 AM	PM1	38	PM2.5	42	PM10	34
10:00 AM	PM1	28	PM2.5	40	PM10	32
11:00 AM	PM1	165	PM2.5	172	PM10	200
12:00 PM	PM1	40	PM2.5	60	PM10	70
13:00 PM	PM1	34	PM2.5	22	PM10	37
14:00 PM	PM1	18	PM2.5	15	PM10	12
15:00 PM	PM1	15	PM2.5	14	PM10	12
16:00 PM	PM1	17	PM2.5	18	PM10	10
17:00 PM	PM1	18	PM2.5	24	PM10	22
18:00 PM	PM1	22	PM2.5	17	PM10	13
19:00 PM	PM1	27	PM2.5	19	PM10	15
20:00 PM	PM1	32	PM2.5	32	PM10	45
21:00 PM	PM1	32	PM2.5	29	PM10	50
22:00 PM	PM1	267	PM2.5	270	PM10	320
23:00 PM	PM1	376	PM2.5	340	PM10	405
00:00 AM	PM1	187	PM2.5	122	PM10	202
01:00 AM	PM1	146	PM2.5	89	PM10	185
02:00 AM	PM1	78	PM2.5	62	PM10	100
03:00 AM	PM1	42	PM2.5	30	PM10	60
04:00 AM	PM1	35	PM2.5	23	PM10	46

Figure 13 Google Sheet with information

After the information is collected in Google sheet once an hour. However, the order of collecting can be adjusted for more or less. The data visualization is applied to transform the data numeric to graph visualization. Figure 14 shows the graph visualization of dust information.

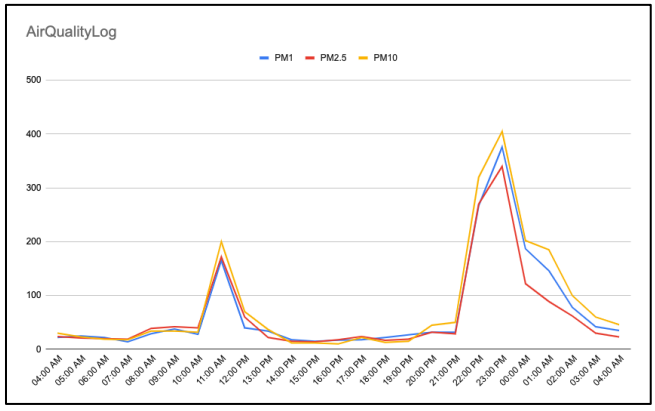

Figure 14 The graph visualization

According to section III, Notification of the LINE application is integrated into the display part. It does not only display the value of dust density. The threshold range is set to alert if the density of dust is over the threshold value. The levels of warning are

- Good if the density of dust is 0-50 µg/m3,
- Moderate if the density of dust is 50-150 µg/m3,
- Very Unhealthy if the density of dust is 150-300 µg/m3, and
- Hazards if the density of dust is over 300 µg/m3.

The notification via the LINE application is shown in Figure 15.

Figure 15 The notification via LINE application

The advantage of this proposed system is the user can access the display to view the information via the internet from everywhere with no service charge.

Discussion and Conclusion

This paper presents the development of a low-cost DIY dust detector system. The developed system is based on the concept “easy & simple, do it as you can”. The developer and user can adapt the function or code as they want such as the sleep time of the device or the UI of the display website. The maximum electrical power usage is 80mW approximately. This is mean the user will be charged a little bit of electricity bill per month. In addition, the overall cost is about 1,500 THB (45$) at the present. Moreover, this system can be developed as much as the developer can create and up to the next generation component that can improve the function and performance of the system. Due to the guideline of development, the users can increase the devices in the system to display the value of density of dust at multi places simultaneously.

Another guideline is the application of a map into the system which can help the user to view the value of density of dust point to point.

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