Garbage monitoring systems based on Internet-of-Things application

N. A. Ali, A.R. Syafeeza, A. S. Ja’afar, Norihan Abdul Hamid, M. Ridzuan

Machine Learning and Signal Processing (MLSP) Research Group
Centre for Telecommunication Research & Innovation (CeTRI)
Faculty of Electronics and Computer Engineering (FKEKK), Universiti Teknikal Malaysia Melaka (UTeM), Hang Tuah Jaya, Durian Tunggal, 76100, Melaka,
alisa@utem.edu.my

Abstract. Garbage management is one of the primary problem faced by cleaners in terms of the duration of the cleaning process. The design of a smart green environment of garbage monitoring systems is developed based on an IoT (Internet of Things) application is believed to overcome this waste issue. The main contribution of this project is demonstrated by a system based on IoT that allows the waste management to monitor based on the garbage depth inside the dustbin and also the notification of its full condition by using a mobile phone and the Blynk apps. The proposed system consisted of the ultrasonic sensor, which measures the garbage level inside the dustbin. The system shows the status of the garbage through LCD, and a WiFi module (ESP8266) used to send the information to the smartphone. Thus, it is expected that this system can build a greener environment by monitoring and controlling the collection of garbage smartly through an IoT application.

1. Introduction

This paper focuses on designing and developing a low-cost yet clean and eco-friendly environment of dustbin monitoring system controlled by the Arduino Microcontroller. Nowadays, the communities need the IoT (Internet of Things) in their system. Thus, this smart dustbin is containing the IoT through the dustbin. This dustbin contains the Arduino Uno as the microcontroller. The main project is to detect the level of the garbage and then notify the cleaner when the dustbin is full.

The problem that the cleaner face nowadays such as plastic bag always wasted when the cleaner need to clean up the dustbin although the dustbin is not full. Besides, when the dustbin is full, the user still throws the garbage at the dustbin. The cleaner cannot monitor the current level of garbage in the dustbin, and this may take longer time in monitoring, although the lack of real-time information resulting in an unsuccessful collection of waste would happen.

The ultrasonic sensor is used in this project as the main component to detect the distance of the garbage inside the dustbin. This device will capture the level of garbage. Sound reflection concept is applied in capturing the level of the garbage. An ultrasonic sensor emits the sound, and it reflected back when it blocks by something which is garbage in the dustbin. The level of the garbage is detected when the garbage distance is near to the ultrasonic sensor. The ESP8266 is used to act as the WiFi module. This device can connect to the Arduino by near WiFi. Then the LCD display is used to show the reading of the garbage inside the dustbin. Finally, the Blynk applications (apps) is used to notify the cleaner through the smartphone.
The remainder of this paper is organized as follows. Section 2 is about the theory related to smart dustbin. In Section 3, the methodology of the project is discussed. The Experimental Result and Conclusion are discussed in Section 4 and 5, respectively.

2. Related works
The similar project [1] combines 8051 microcontrollers, IR sensor, RF module, Intel Galileo Gen2. In this projected system, it proposed the low-cost embedded system to make the truck located the dustbin through the city or Campus. The dustbin also has a unique ID that makes it easy to identify when the garbage is full. The detail can be access by the concern authorities from their place by using the Internet, and they can give the immediate response to clean the dustbin.

The dustbins interfaced with microcontroller ARM (LPC2148) based system and having IR wireless systems along with central system presented in [2] showing the status of garbage, on a mobile web browser with HTML page by Wi-Fi. This project also used the combination of a weight sensor and IR sensor to detect the amount of garbage in the dustbin and to give the information about the dustbin status. Hence the status will be updated on the HTML page.

The researchers [3-5] described the project combining the Arduino Uno Board as the microcontroller and the IR sensor for the detection of garbage. For the receiver part, this project has used the TSOP1738. The output of this TSOP1738 is connected to the Arduino UNO Board. The GSM is used for the transmitter section compare to the ZigBee.

The project by researcher [6] is about the system to schedule the trucks by finding the shortest path between the almost filled waste bins and which bins that have smelly gases and give a route for collection. The smart dustbin will transmit information about the status and smelly gas level. This system also provides estimation dates for collection of waste, real-time bin status, expected to fill updates and the shortest path for waste collection. This project used the combination of the Arduino Uno Board, HC – SR04 level sensor, MQ – 4 Gas Quality sensor to build the dustbin.

Previous studies [6,7] showed monitoring the garbage status by using the ultrasonic sensor to detect the level of the garbage and the Wi-Fi module. The webpage is used to monitor the status of the dustbin inside the campus. The WiFi module will send the data to the nearest router, and the router will send the information to the user.

3. Methodology
The project consists of 4 main components which are Arduino UNO, ultrasonic sensor, ESP8266 WiFi module and the LCD display. The notification will be sent to the smartphone through the Blynk apps.

3.1. Block and sketch diagram
The Arduino Uno will be used as the main brain of the controlling the LCD display, ESP8266 and ultrasonic sensor. The ultrasonic sensor used to control the distance inside the dustbin and the ESP8266 is acting as a WiFi module that is to connect the Arduino to the smartphone.

![Figure 1. Block diagram of the proposed system.](image-url)
3.2. Flowchart of part A
As shown in Figure 2, the first part of the proposed system consists of the ultrasonic sensor, an Arduino microcontroller and a WiFi module. ESP8266 Wi-Fi module is used for connecting the Arduino through the web server into Blynk Apps.

![Flowchart of part A](image)

**Figure 2.** Flowchart of part A.

The ultrasonic sensor used in this project is for detecting whether the dustbin is filled with garbage or not. When the distance measured by the ultrasonic sensors is less than the threshold value programmed in microcontroller; which is less than 5cm from the top lid, depicts that the bin is filled-up and displayed on the LCD.

The same is intimated to the smartphone via WiFi module (IoT) through Blynk apps by displaying the message as “Dustbin is Full-100%”.

If the distance of waste/garbage from the top lid more than the threshold value set, then the message on LCD is displayed as either “Dustbin is Not Full-0%” or “Dustbin is Not Full-50%” for empty or half-filled condition respectively.

Once the level distance measure less than 5% from the top of the dustbin lid, the notification will then be sent to the cleaner or user via Blynk app in smartphone and displayed the status as ‘FULL’ condition.

3.3. Flowchart of part B
Figure 3 shows the configuration of Blynk App and account creation. In order to connect to the internet, a prebuilt platform called Blynk app is required. After the user/cleaner installs the Blynk app on the smartphone, an account needed to be created in the app to access its services. The services are enabled for the signed users. A unique authentication code is used by the code to communicate with the project. The Blynk apps need to be running in the background for the user to get real-time notifications on any smartphone device.
3.4. Component structure

The connection of the component to the microcontroller Arduino UNO can be separated into 3 parts. There is the connection of LCD display, the connection of the ultrasonic sensor and the connection of the ESP 8266. For the notification to the smartphone, the Blynk apps is used in order to get the notification when the dustbin is full.

Table 1 depicts the connection of the LCD display to the Arduino UNO. The LCD function is to show the status of the dustbin to the user. For the displaying the LCD display will show 3 types of reading when the dustbin is empty (1), when the dustbin reaches half of the dustbin (2), and when the dustbin is full (3).

Table 2 shows the connection of the ultrasonic sensor. The ultrasonic sensor will emit the signal, and the signal will reflect when the signal block by the target object. The sensor calculates the exact distance between the sensor and the target object by computing the time that the signal travelled, at the speed of sound, between emission and detection.

While Table 3 represents the connection of the ESP 8266 to the Arduino pins. ESP8266 is the component that programs to be a WiFi shield, so it is used to connect with surrounding WiFi connection. This component also needs the name of WiFi and its password inside the coding for the ESP8266 connected to the WiFi. The ESP8266 contain 8 pins, but we only used 5 of the pin. The pins used in this project are Rx, Tx, 3.3V, En, and Gnd. The ESP8266 only function at 3.3V so to archived that the ESP 8266 will connect to the 5V Arduino and through the voltage regulator. The voltage regulator function is to reduce the voltage and maintain it to the 3.3V only. Besides, the capacitor 470µF also used as a precaution if the voltage went high, so it will not damage the voltage regulator and the ESP8266.
Table 1. LCD connection.

| Arduino Uno Pin | LCD Display Pin |
|-----------------|-----------------|
| Ground          | VSS             |
| 5V              | VDD             |
| 1               | RS              |
| 2               | E               |
| 5               | D5              |
| 6               | D6              |
| 7               | D7              |
| 5V              | A (Anode)       |
| Ground          | K (Cathode)     |

Table 2. Connection of ultrasonic sensor.

| Ultrasonic Sensor Pin | Arduino pin |
|-----------------------|-------------|
| VCC                   | 5V          |
| Echo                  | 10          |
| Trig                  | 9           |
| GRD                   | Ground      |

Table 3. Connection of ESP 8622.

| ESP 8266 pin | Arduino Pin |
|--------------|-------------|
| Rx           | 12          |
| Tx           | 11          |
| Gnd          | Ground      |

As shown in Figure 4, the sketch diagrams demonstrate how the components are supposed to be connected together using the breadboard and the jumper wires.

![Diagram](image)

**Figure 4.** (a) Connection with ultrasonic sensor, (b) Connection with WiFi module, (c) Connection with LCD Display.

Blynk is the apps that can be download at the Google store for Android and Apple store for iPhone. This app contains many functions such as gauge, reading, notifying and much more.
For this project, the function used is notifying and email. The Blynk will notify the cleaner when the dustbin is full. This project will alert during of 3 minutes start from the dustbin is full. When the dustbin is cleared, the notified signal will stop sending the notification to the cleaner.

4. Experimental results

4.1. Component structure experiment ultrasonic sensor and LCD display
The ultrasonic sensor (Trig Pin) will transmit the signal into the dustbin, and the signal will reflect if the signal hit something solid, then the ultrasonic sensor (Echo Pin) will receive the reflected signal and with the reflected signal which shows the level of the dustbin, which is 25cm. There is a multi-distance of the dustbin, and the reading of the percentage of the dustbin will be shown on the LCD display. There are some distances that set in the coding for the ultrasonic to read for example when the distance is less than 5cm the LCD display will show “THE DUSTBIN IS FULL” and “100%”. Meanwhile, the other distance the LCD display will only show “DUSTBIN NOT FULL”. For this experiment, the distance has been set up for three reading of distance there are when the dustbin is empty when it’s medium level and when it full.

Figure 5 shows the empty dustbin and the reading of the dustbin at the LCD display (0%). While Figure 6 shows the garbage is half of the dustbin and the LCD display show the reading of the dustbin (50%). The full dustbin, as shown in Figure 7 displayed the reading of 100% on LCD.

![Figure 5. Empty Dustbin with reading of 0%](image1)

![Figure 6. Half-filled garbage with reading of 50%](image2)

![Figure 7. Full Dustbin with reading of 100%](image3)

The LCD display will show the status of the garbage based on the distance of the garbage from the ultrasonic sensor. The distance has been set in the Arduino coding. These figures show the reading of the garbage from the ultrasonic sensor and the displaying at the LCD display.

4.2. Configured testing on WiFi module ESP8266 with smartphone
ESP8266 is one of the devices used in this project. The function of the ESP8266 is to connect the Arduino Uno to the smartphone. In this process, the smartphone must open the hotspot so the ESP8266
can be connected to the smartphone. This process also used the WiFi connection but cannot be monitored by smartphone either it has connected to the WiFi or not.

The smartphone is open the hotspot as the WiFi; thus, the ESP8266 can connect to the hotspot’s smartphone, as shown in Figure 8. Figure 9 shows the ESP8266 are connecting to the WiFi of the smartphone. This thing will appear at the serial monitor at Arduino IDE. If the connection fails, it will show at the serial monitor.

Figure 8. ESP8266 is connected with smartphone.

Figure 9. ESP8266 is connected with WiFi.

4.3. Configured testing on Blynk apps

The Blynk apps is used to notify the user (cleaner) when the dustbin is full. This app is also easy to get, and it is free at the Google PlayStore (Android) and at AppStore (iPhone). There are many functions at the Blynk apps. One of the functions used in this project is to notify the user (cleaner). Figure 10 illustrates the Blynk apps used in this project; there is the notification through the smartphone and the email notifications. While Figure 11 illustrates the notification send through the smartphone. When the dustbin is full, this notification will appear at the smartphone screen.

Figure 10. Blynk Apps application.

Figure 11. Notification on smartphone.

Table 4 shows that when the dustbin is full, the Blynk apps only notifying the user when the dustbin is reached at 100% garbage. As for other status condition of garbage level, the Blynk apps will not notify the user.
Table 4. Notification smartphone and LCD.

| Distance (cm) | LCD Display          | Blynk Notification |
|--------------|----------------------|-------------------|
| <5           | DUSTBIN IS FULL      | Yes               |
| >=5 && <10   | DUSTBIN NOT FULL     | No                |
| >=10         | DUSTBIN NOT FULL     | No                |

5. Conclusions and future enhancement

For this project, the smart garbage monitoring system (IoT-based) is produced to improve the garbage waste management system. This project is considered successful because it achieved the main objective. Besides, this smart dustbin can contribute to the hospitality and for the multilevel building. This project has implemented the smart dustbin that can reduce the humidity and time waste management system by using the smart dustbin that can monitor the level of the garbage, whether it is full or not. In this smart dustbin system, it can be accessed from anywhere and anytime by the cleaner.

This smart dustbin also can inform the user about the status of the garbage by the LCD display. At the end of this project, the smart dustbin is able to notify the cleaner when the dustbin is full. Besides, the user is also able to see the status of the garbage inside the dustbin. The result contains three types of status there is normally, 50%, and 100%. The dustbin only notifies the user when the garbage reaches 100% of the dustbin. The distance of the dustbin is based on the distance of the garbage from the ultrasonic sensor. The ultrasonic sensor is set-up in three conditions of garbage level that are FULL, HALF-FULL and EMPTY.

However, if there is a limited coverage or availability of the network, the WiFi module will not be working. Future development of better communication hardware needs to be considered. Moreover, the development of the system can be improved by designing a system that can identify different type of garbage by using image recognition to avoid throwing garbages to the wrong type of bins. By implementing this proposed system, it will reduce cost and man-power, thus improving the garbage monitoring and controlling system.

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