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Smart garbage monitoring system using Wireless Sensor Network

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ABSTRACT

The present garbage monitoring system is a major trouble in the growing cities. As the population is growing, the garbage is also increasing. This chaotic collection of garbage is polluting the environment, leading to health problems. The present waste management methods are not effective to handle the increasing levels of garbage's that are being produced. This paper proposes IOT based smart device for dustbin which can detect the level of garbage at various part of the dustbin and also can detect methane gas concentration and send message to the server. If the detected value is above the threshold, the smart device will send the location of the filled dustbin to the server. The data from every such device is stored, processed and monitored in the cloud. The processed data is sent to the concerned authorities through email. The data can be viewed in the android app.

Keywords— *Nodemcu, Blynk, Arduino IDE, Ultrasonic sensor, Methane sensor*

1. INTRODUCTION

The population is increasing at an accelerating rate. Since the 21st century, many people are shifting from villages to the towns to get a better living opportunity. Due to the advancement in the technology lifestyle of the people has changed. As a result, the population is increased at an accelerated rate. The major problems it has created is the increasing levels of garbage collection. The present waste management methods are not sufficient to handle the growing levels of garbage that are being created. Due to this enormous amount of garbage's are collected at various parts of cities which causes bacteria and viruses to breed on this garbage. This results in the spread of many diseases. Ineffective garbage management methods have created this type of problems. In conventional waste management methods, workers are required to empty the bins at a particular time of the day. This method has many problems. Here the dustbin may have filled in completely so that it has space for filling garbage or the dustbin is filled completely a long ago and the garbage is overflown outside the dustbin. This overflow of garbage outside the dustbin produces various bacteria and viruses which causes various health problems. Thus, this waste management method is ineffective and there is a need for improvement.

It is required to develop IoT based waste management methods to turn the city environment to cleaner and healthier. For the implementation of this method, a new dustbin is designed, fitted with various sensors are proposed for real-time supervising of the garbage level in the bin. The rest of this paper is organized as follows: Section 2 discusses the literature survey and, proposed work is discussed in section 3. Section 4 discusses the design and implementation of the proposed model and, results are discussed in section 5. Finally, in section 6 conclusion and future works are discussed.

2. LITERATURE SURVEY

Garbage collectors are supported by sensor nodes that give information about the bin for allowing various sensors for communication. The module measures the garbage level and sends the measured value through the sensor node [1]. The limitation here is that it neither sends data to the local server nor to the client. In an isolated environment, bacterium turns organic compounds into methane gas with a process called fermentation. Methane sensor can be used for measuring biogas concentration [2].

Dustbin system contains two components: software and hardware. The hardware component is placed inside the dustbin which measures the level of garbage and sends the measured value to the cloud through a receiver-transmitter node. The main disadvantage here is that it uses raspberry pi which consumes more power. Here we can use Node MCU instead of raspberry pi so that proper power management can be done [3].

For garbage collection system internet-based platform will be effective, where it includes server, client and storage. Here in

the backend, it uses web server and database. Web server to process the collected data and database to store the garbage level information. The main disadvantage here is that it uses a web page to display the location. Here we can use the mobile application to display the location of the dustbins and to show the graph of data analysis [4].

IoT Based Smart Garbage and Waste Collection Bin system monitors the garbage collection and sends information to the cloud where it is stored and processed. The processed data is sent to the garbage collection vehicles. It uses an ultrasonic sensor to detect the level [5]. When the measured value is above the threshold it sends information to the office. The office sends concerned workers to empty the bins. The difference in the paper [6] is that it uses an IR sensor to detect the level of garbage in the dustbin. But it is quite expensive and much more than the requirement to the system, so node MCU becomes the best choice. By using an IR sensor, IR rays pass through objects that are. garbage's in the bin which would be a waste of detecting the level of waste. Hence the usage of ultrasonic sensor would be appropriate.

In garbage collection, it uses an ultrasonic sensor to measure the volume of garbage inside the dustbin. It also measures humidity and temperature [7]. The ultrasonic sensor is used for measurement of garbage level and servo motor is used for vibrating the dustbin [8]. When garbage level inside the dustbin is non-uniform it uses a servo motor to vibrate the dustbin and makes the garbage level uniform.

Using GSM technology, the waste garbage from the bins can be collected, but it is not effective when compared to Wi-Fi module where Wi-Fi module is of a much cheaper rate. For GSM we need to buy a SIM and recharge it. Sometimes GSM module will be disconnected which will be a wastage of energy and the authorities will not receive any messages or emails of the fully filled dustbin [9].

Usage of android application for garbage monitoring and data analysis. Using android application, it is easy to control and view the garbage collected data in the cities and also help the collector to reach the fully filled dustbin [10].

3. PROPOSED WORK

We proposed a smart garbage collection system on the basis of the level of garbage in the dustbins. The data obtained through sensors is sent over the Internet to a server provided for storage and further monitoring. We develop a smart device for dustbin which can detect the level of garbage at various part of the dustbin and also can detect methane gas concentration and send message to the server if the detected value is above the threshold value. Also, the device will send the location to the server. The data from every such device is stored, processed and monitored in the cloud. The processed data is sent to the concerned authorities through email. The data can be viewed in the android app. The main objective of this paper includes:

- To detect the concentration of the methane gas in the dustbin.
- To detect the level of garbage in the dustbin effectively.
- To determine statistics of the garbage collection in an area.

The outcome of this paper results in effective garbage level detection and dirty smell from the garbage is detected so that garbage can be disposed of as soon as possible which keeps the environment with fresh air. The garbage collection in an area can be monitored so that if needed extra dustbin can be added.The applications of this paper:

- Overflowing of waste garbage will be stopped as smart bins are operated at real-time.
- It will detect foul smell so that creating a clean and green environment is possible.
- Garbage collection data analysis at a particular region is possible.

The proposed idea can be represented in the form of three-block diagrams as shown in figure 1, figure 2 and figure 3. Figure 1 represents the front end which shows the hardware part, figure 2 represents back end which shows the interface of dustbins to the server where each dustbin has its own ID and figure 3 represents the graphical user interface in the mobile application which helps the user to view and monitor the dustbins easily.

3.1 Dustbin Side

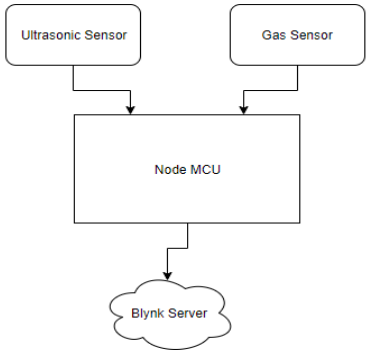

Fig. 1: Block diagram of the Dustbin module

Figure 1 show the NodeMCU integrated with the ultrasonic sensor and methane sensor. Later, NodeMCU is connected to the local server called blynk. It is shown only for a single dustbin system. Many of such dustbin systems can be interface together to form a network which is shown in figure 2.

3.2 Server/Cloud side

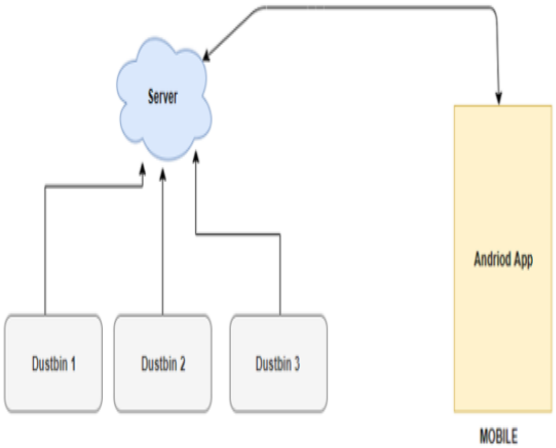

Fig. 2: Block diagram of Server/Cloud

Figure 2 represents the back end of the project where each dustbin hardware part shown in figure 1 is connected to the single node for controlling and processing of data. This is most software part which uses the blynk platform for the interconnection between the nodes. It can be operated by the mobile application.

3.3 Mobile App

Figure 3 shows the mobile app user interface to explore the various applications and implementations like:

- Dustbin level: Shows the level of garbage in the dustbin.
- Map: Shows the location of dustbins which reaches the threshold level.
- Graphical analysis: Shows the past data of dustbin levels on the hour and daily basis.
- Clear: This is a button to commence that the dustbins are emptied.

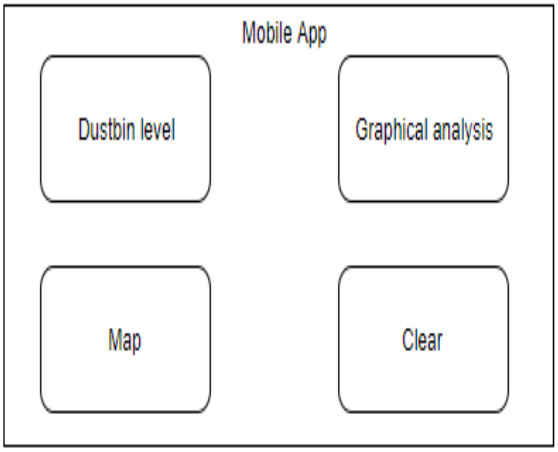

Fig. 3: Mobile App User Interface

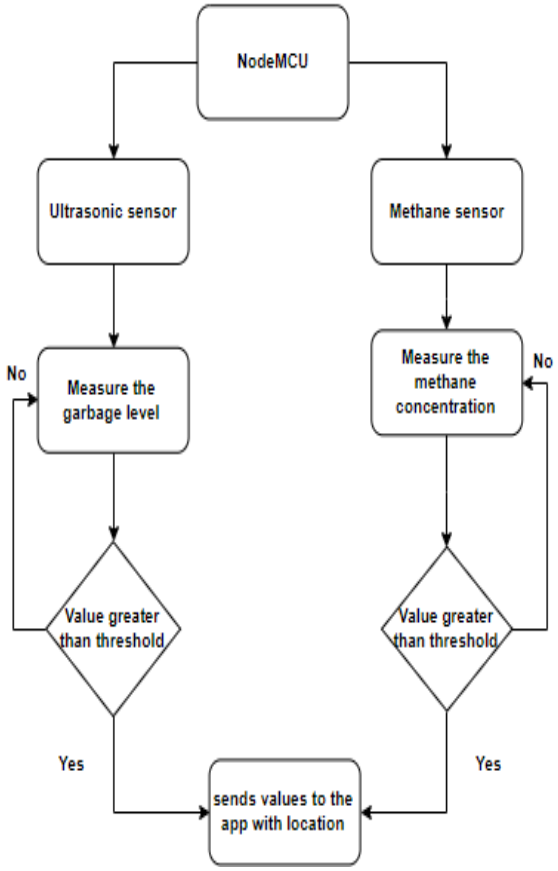

Fig. 4: Flow chart

The flow chart of working model shown in figure 4. Here ultrasonic sensor and Methane sensor are connected to Node MCU. An ultrasonic sensor measures the level of garbage in the dustbin. Methane sensor measures the concentration of foul gas in the dustbin. If the measured value is greater than the threshold value then, the values are sent to the app with its exact location. If the measured value less than the threshold value, the process will be repeated until the value becomes greater than the threshold value. The working algorithm is given as:

Algorithm: Working of Smart dustbin

Step 1: Connect to blynk server using Auth token.

Step 2: Set timer for 3 seconds.

Step 3: Node MCU measures level through ultrasonic sensor and gas concentration through methane sensor.

Step 4: Level and concentration is calculated

L ← Calculated level

C ← Calculated concentration

if L > Threshold value then

send values to the app with location

turn ON red LED

else if C > Threshold value then

send values to the app with location

turn ON red LED

else

repeat from step 3

turn ON green LED

end if

Step 5: View the location of dustbin on map using android app.

Step 6: After emptying all the dustbins press Clear button.

4. DESIGN AND IMPLEMENTATION

The dustbin system is designed and all the hardware components such as ultrasonic sensor, methane sensor, power regulator and Node MCU are integrated with the dustbin. In the android app, widgets are selected such as tabs, maps, super chart, email, button, and level display. The hardware device is connected to widgets using virtual pins. The data from the sensors are sent to the cloud which can be viewed in the android app.

4.1 Integration of hardware

Ultrasonic sensor and methane sensors are connected to the Node MCU using bread board and jumper wires. For the power supply, this module is connected to the power bank using a regulator. This power bank provides a constant supply of 5V and 1amps of current without any interruption so that the device does not get disconnected.

4.1.1 Integrating Ultrasonic sensor: Ultrasonic sensor is connected to the Node MCU to determine the level of the dustbin. It has both transmitter and receiver which transmits and receivers the signal. The output from the sensor is the decimal value in second. It is then multiplied with speed of sound and divided by 2 to get the distance between the ultra-sonic sensor and the reflecting surface. We require the level of dustbin that is level of dustbin filled up. It can be obtained by subtracting the obtained distance with the height of dustbin.

T= output from an ultrasonic sensor that is time taken for the echo of the trigger signal.

S = speed of sound

D = distance between the sensor and reflecting surface

D = T*S/2

H = the height of dustbin (distance between the dustbin bottom and the sensor)

L= level of garbage in dustbin = H- D

This L can be used to set the threshold value for the garbage level in the dustbin. It can be set to 5cm for practical purposes but in implementation, the relative size of dustbins is small so the level is set to 6cms

4.1.2 Integration of methane sensor: Methane sensor used to detect the concentration of the methane gas and other carbohydrate gases which produce foul smell in the dustbin due to decay matter and wet waste in the dustbin. The output of the sensor is the analog value which corresponds to the concentration of carbohydrate gases in PPM. No type of conversion or further calculation is required. The permissible levels are almost 1000ppm. Which can be set bas the threshold value for the sensor.

4.1.3 Integration of power regulator: Power regulator is used to regulating the power to the Node MCU. The power regulator is connected to the DC power socket of the power bank which gives out the 5V output power which is sufficient to drive the Node MCU and the other hardware parts integrated to it.

4.2 Widgets setup

Widgets are selected in the android app depending on the application. In the android app for selecting any widget, we need energy(coins). For every widget, a certain amount of energy is fixed. If energy is not sufficient then we need to purchase energy from the blynk. After selecting the widgets, they are connected to the sensors using virtual, analog or digital pins. Widgets that are used as follows.

4.2.1 Tabs: The purpose of the Tabs widget is to extend the project space. We can have up to 5 tabs. Also, we can drag widgets between tabs. Drag widget on the label of the required tab of tabs widget. Five tabs are added to show dustbin levels, locations, methane concentration, analysis charts, clear and mail buttons.

4.2.2 Maps: Map widget allows us to set points/pins on the map from the hardware side. This is a very useful widget in case we have multiple devices and we want to track their values on the map. We can send a point to map with regular virtual write command:

Blynk.virtualWrite (V2, pointIndex, lat, lon, "value");

The function takes the arguments like a virtual pin number, point index to the label at the location, latitude and longitude values of the location

4.2.3 Super Chart: Super Chart is used to display live and historical data. We can use it for sensor data, for binary event logging and more.

Email: Email widget allows us to send email from our hardware to any address.

Blynk.email("my_email@sjce.com", "Subject", "write message here");

Blynk email function takes three arguments which include the recipient's name, subject of the mail, mail body. It also contains to field. With this field, we may define a receiver of email in the app.

Blynk.email("Subject", "write message here");

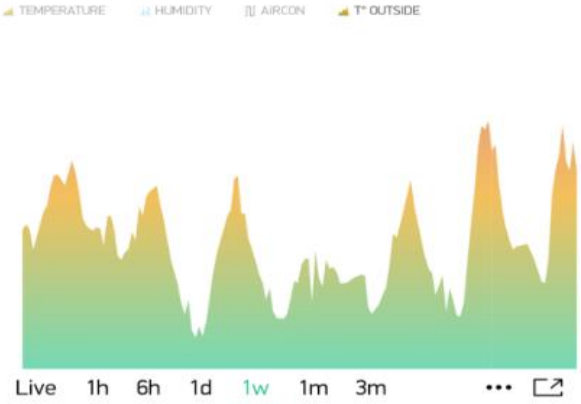

Fig. 5: Super chart widget

Fig. 6: Email widget

4.2.4 Button: Works on push or switch modes. Allow us to send ON and OFF values. The button sends 1 (HIGH) on press and sends 0 (LOW) on release.

Fig. 7: Button widget

4.2.4 Level Display: Level display is similar to the progress bar when we need to visualize a level between min or max value.

Blynk.virtualWrite(V1, level);

5. RESULT

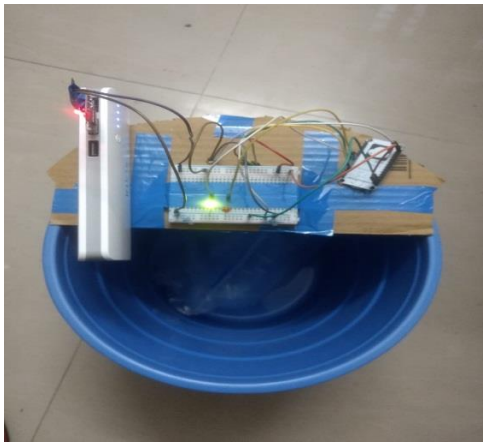

Fig. 8: Top view of dustbin integrated with hardware

Figure 8 shows the dustbin integrated with the hardware to detect the level of garbage and foul smell in the dustbin. It is connected to the power supply through the 5V regulator using

the power bank. It has two LEDs to indicate the garbage level. If the garbage level is below the threshold then the green LED turns ON and red LED turns OFF. We can observe that the green LED is ON and the red LED is OFF indicating that the garbage level in the dustbin didn't reach the threshold level and no decaying matter is emitting the foul smell.

Fig. 9: Full dustbin

If the garbage level is above the threshold then the red LED turns ON and the green LED turns OFF. In figure 9 we can observe that the dustbin is full. Green LED is OFF and the red LED is ON indicates that the garbage level reached the threshold level. In the mobile we can see that the location of the dustbin is displayed that is.., SJCE admin block.

The above dustbin is placed at SJCE admin block. Another dustbin same as above is made and placed at SJCE boys' hostel. In an Android application, we made 5 tabs. Tab 1 shows the exact simulation of dustbin1. Tab 2 shows the exact simulation of dustbin2. Tab 3 shows the map to display the dustbins location. Tab 4 shows the data analysis of dustbin1 and dustbin2. Tab 5 shows a clear button.

Fig. 10: Level simulation of dustbins D1 and D2

Tab 1 and tab 2 are combined as shown in figure 10 which display the simulation of dustbins. It shows the level of garbage in the dustbins graphically in the range calibrated from 1 to 20. As garbage level in the dustbin varies the simulated level also varies. It also shows the distance from the sensor and the concentration of methane gas in each dustbin.

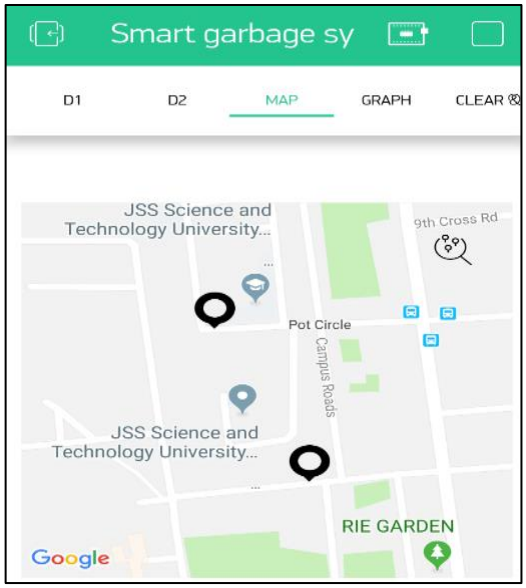

Fig. 11: Map showing the location of dustbins

Since the dustbins are static, we don't need the GPS module, instead, we can save the longitude and latitude of dustbin location in the module. Figure 11 shows the tab with the map. It shows locations of the filled dustbins in the map so it becomes easier for the municipality to locate the filled dustbins and empty them. Here one dustbin shows the location of SJCE admin block and other shows the location of SJCE boys' hostel.

Location of dustbin 1:
Longitude=76.613527
Latitude=12.311094
Location of dustbin 2:
Longitude=76.613010
Latitude=12.313203

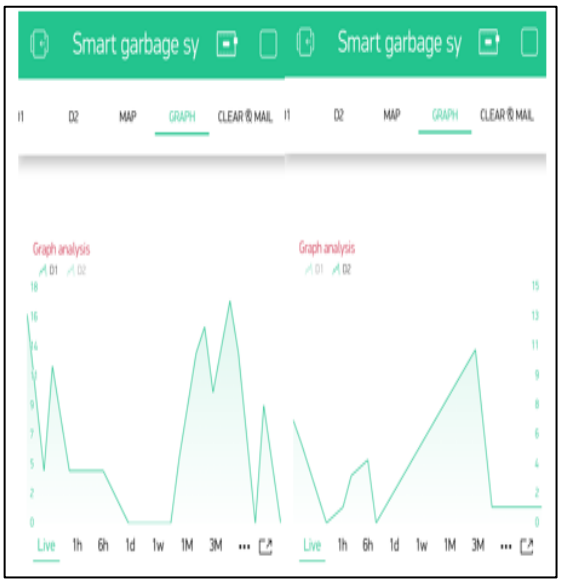

Fig. 12: Graphical analysis of garbage levels

Figure 12 shows the tab which includes a graph. The graph displays the data analysis of dustbin1 and dustbin2. It shows graphical analysis of the garbage level in the dustbins with y-axis represents the garbage level and x-axis representing the time. This time is the real-time simulation which can be selected live, hourly, daily, weekly, monthly and so on. The graph is connected to the virtual pin of the ultrasonic sensor.

Tab for clear button and mail widget is shown in figure 13, Clear button can be pressed after all dustbins are cleared. The mail button is to send both warning and acknowledgment mails.

Warning mail is sent when the dustbins are full and acknowledgment mail is sent once the dustbins are emptied.

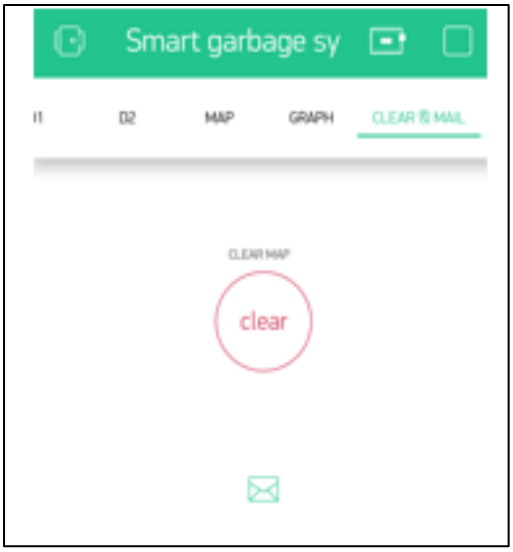

Fig. 13: Clear and mail buttons

6. CONCLUSION AND FUTURE WORK

We presented a smart garbage monitoring system. The system is based on IoT. It measures the waste level in the dustbins and sends this data to the server for storage and processing. The height of waste in the dustbin is calculated using the ultrasonic sensor and concentration of methane gas is calculated using the methane sensor which is placed in the dustbin. The server is built and all the data is sent to the server. The threshold level may vary from the dustbin to dustbin as it depends on the dimension of dustbin and height at which the sensor is placed. After calculating the garbage level and methane concentration, if the detected value is above the threshold then, the device will send the location to the server. The data from every such device is stored, processed and monitored in the cloud. The processed data is sent to the concerned authorities through email. The data can be viewed in the android app.

In the future, we would like to enhance the system for different kind of wastes, namely solid and liquid wastes. Solar panels can be fixed to the body of dustbin for power requirement. For connectivity, it can be integrated with the GSM module for connectivity at remote areas. The analytics data can be used to calculate the garbage collection in the city or region and proper waste management can be done.

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