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Smart Waste Management System

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Abstract: The majority of the roadside trash is currently piled high due to irregular rubbish collection. It makes the environment smell awful and makes people's living situations unclean. As a result, some fatal diseases and human illnesses spread. We intend to build a project named IOT-based rubbish Management system to address this issue. We'll be using a NODE MCU, an ultrasonic sensor, GPRS, and GPS in this system. Our project's goal is to create a clean environment in a clever way. Trash and bin overflow sensor with GSM and GPS The ULTRASONIC sensor is positioned within or on top of the litter box. A SMS message is delivered to the concerned party City/State Authority when The SENSOR hits the threshold value.

Keywords: Node MCU, GPS Module, GSM Module, LCD, Ultrasonic Sensor, Regulated Power Supply

1. Introduction

India is currently one of the nations that is developing the fastest. It is also making significant, aggressive efforts to control its garbage. The "Swachh Bharat" objective of the prime minister from 2014 to the "Hazardous and Other Wastes (Management and Transboundary Movement) Rules" (2016), the "Plastic Waste Management Rules" (PWM 2016), and many more. The government is making every effort to mechanise an efficient waste management system nationwide.[1], But is it really happening?

We frequently notice overflowing trash cans or dustbins in our city's public spaces. It puts people in unsanitary situations. Together with that, it makes the area ugly. Moreover, an unpleasant odour is spread at the same time. We are going to use GSM technology to create the Garbage Collection Bin Overflow Indicator project in order to prevent all such instances. In this project, a ULTRASONIC sensor will be mounted ABOVE the trash can. A text message will be sent to the appropriate Municipal / Government authority person when the SENSOR reaches the threshold value. When the trash cans or dustbins are full, that person can send the collection vehicle to pick them up.

Every individual would want everything that looks clean and beautiful, one of which is environmental cleanliness. There are still many individuals who tend to be less aware of the cleanliness of their environment. This is reflected in a large amount of garbage scattered on the streets and in city parks. This situation certainly creates unrest for public facility users. Dustbins that have been provided by the sanitation department are only a mute decoration on roads that are not maintained, are not attractive [2] , and are very dirty. Daily trash generation has significantly increased around the world. A minimum of 35% of the 1.9 billion tonnes of garbage that are produced each year are not processed safely. According to statistics, each person produces between 0.17 and 4.67 kg of garbage each day. [3]

We have seen that the municipal official or other government-authorized individual will keep an eye on the condition of the trash can. Or generally, we observe that they pick up these trash cans

or dustbins on a regular frequency. This schedule varies depending on the local population. It may occur once day, twice daily, or even once every two days in some circumstances. But, we see that whenever there is a festival or other event, the locals in that region produce a lot of trash. In such circumstances, the trash can fill up quickly and overflows, posing a number of issues. In addition, the municipality can be alerted when the bin is full or almost full, thus promoting dynamic scheduling and routing of the garbage collection. By comparing to the conventional static scheduling and routing, this dynamic scheduling and routing are said to allow operational cost reduction, by reducing the number of trucks, the manual labour cost and the transport mileage savings [4, 5, 6]. So, with the aid of our project, the government official can receive SMS right away in emergency situations.

As a result, they will receive an SMS prior to their routine visit to pick up the trash. After that, they can go get the trash cans. By delivering real-time information on the condition of trash cans, the smart waste management system put forth in this paper seeks to increase the effectiveness of waste management. The system uses Node MCU to communicate the data to a central server after employing ultrasonic sensors to measure the amount of trash in the bins. The time and expense connected with waste collection are decreased by analysing the data to determine the best waste collection routes. The suggested system tracks the whereabouts of trash cans and garbage trucks using GPS technology, enabling real-time monitoring of waste collection. Both waste collectors and citizens can use Android applications to examine the status of trash cans and plan rubbish collection accordingly.

2. Literature Review

Node MCU and ultrasonic sensors are used in the smart waste monitoring systems that several researchers have developed. For instance, Palaksha and Gowda (2019) suggested a smart waste monitoring system that measures the fill level of garbage bins using ultrasonic sensors. The data is transmitted to a central server by the system using Node MCU, where it is subsequently evaluated to improve the garbage collection procedure.

Andrei Brozdukhin and friends later proposed the new system with two working hands: software component and unique indicator equipment [7]. The distinctive indicator apparatus is fastened to the dustbin sides. There are two components to it: the sensor and the receiver-transmitter. The transmitter device, to which the sensor is linked, transmits the message "Dustbin is full, Please empty it" to the appropriate authorities. The sensor's purpose is to indicate the amount of trash in the trashcan. Artificial intelligence algorithms are now responsible for determining the quickest route and closest truck driver to the relevant trashcan and notifying them of the garbage pickup.

The IoT/AI based garbage waste intelligent management system has been prototyped around waste items, household dustbin, a garbage bag and a garbage collection vehicle [8]. The project begins with the flow of trash into the domestic bin and into the garbage can and ends with the garbage takeaway vehicles. An integrated container is where a fresh trash bag is put, according to RFID technology. All the drawbacks of small-scale use, low cost, low fuel consumption, and a clean environment have been overcome by Arduino with IOT processes.

Similar to this, Singh et al. (2020) suggested a smart garbage monitoring system that tracks the fill level of trash cans using an ultrasonic sensor and a Node MCU. Utilizing Wi-Fi, the system transmits the data to a central server, where it is analysed to improve the garbage collection procedure.

A smart garbage monitoring system that uses a Node MCU and ultrasonic sensors to track the amount of garbage bin fill was suggested by Prasad et al. (2021) in a different study. Using the MQTT protocol, the system transmits the data to a central server where it is evaluated to improve the rubbish collecting procedure.

Due to its capacity to precisely track the fill level of garbage cans and enhance the garbage pickup process, IoT-based smart garbage monitoring systems that use Node MCU and ultrasonic sensors are gaining popularity[9]. These systems have the potential to improve liability in cities and reduce the harmful effects of waste on the environment. It is possible to perform more research to enhance the precision and effectiveness of these systems as well as their integration with other IoT technologies like GPS and GSM.

3. Proposed System

The bin unit, the Node MCU module, and the monitoring centre are the three key parts of the proposed system. Each garbage can unit has an ultrasonic sensor that gauges the amount of waste within. The Node MCU module is in charge of gathering data from the sensors and transmitting it via a GSM module to the monitoring centre. The data is sent to the monitoring station, which then analyses it to calculate how much trash is in each bin. The recycling centre also utilises GPS to find the trash cans.

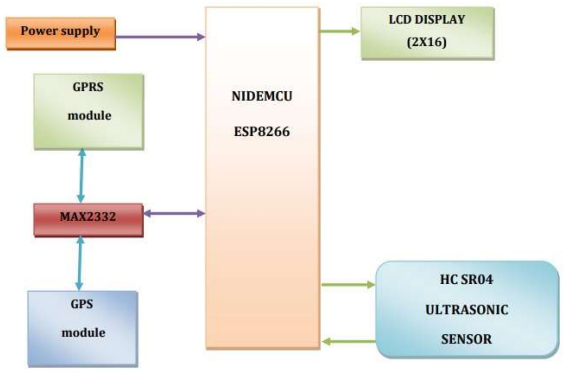

Figure. 1 Block Diagram

3.1 Node MCU

The ESP8266 System-on-a-Chip is the foundation of the open-source development board known as NodeMCU (SoC). It is the perfect option for IoT applications since it combines the capability of an IoT platform with a microcontroller. With a built-in Wi-Fi module and Lua scripting support, NodeMCU may be easily designed to connect to the internet and communicate with cloud services.

The 17 GPIO pins on the ESP8266 NodeMCU can be programmatically allocated to a variety of tasks, including I2C, I2S, UART, PWM, IR remote control, LED light, and button. Each GPIO with digital capability can be adjusted to high impedance, internal pull-up, or internal pull-down[10]. It can also be set to edge-trigger or level-trigger when setup as an input to produce CPU interrupts. Channel ADC an SAR ADC with 10-bit precision is built into the NodeMCU. ADC can be used to perform the two tasks, namely evaluating the input voltage at the TOUT pin and the power supply voltage at the VDD3P3 pin. These cannot, however, be put into action simultaneously.

A UART Pin Two UART ports, UART0 and UART1, on the ESP8266 NodeMCU enable asynchronous communication

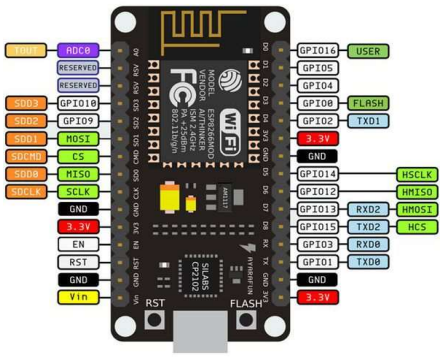

Figure. 2 Pin Diagram of Node MCU

3.2 GSM

The term "GSM" refers to the Global System for Mobile Communications, a digital cellular network standard for mobile phones and other portable electronics. The most common cellular technology in use today, GSM, uses the 900 MHz and 1800 MHz frequency bands for operation. To give numerous users concurrent access to a single radio frequency channel, it combines frequency division multiple access (FDMA) and temporal division multiple access (TDMA).

SIM (Subscriber Identity Module) cards are necessary for GSM networks to recognise and authenticate individual users. These cards have specific details about the user and the mobile device, such as the phone number and an encryption private key[11]. This enables customers to connect to the network from any GSM-compatible device and make or receive calls or messages.

A GSM network is made up of various functional entities with defined functions and interfaces. A generic GSM network's layout is depicted in Figure. The GSM network is comprised of three main divisions. Mobile Station is carried by the Subscriber. The radio link between the Base Station Subsystem and the Mobile Station is under control. The Network Subsystem handles call switching between mobile users and between mobile and fixed network users. Its principal component is the Mobile Services Switching Center (MSC). The mobility management functions are also handled by the MSC. The Operations Intention Center, which is in charge of making sure the network is configured and operated correctly, is not visible[12]. Communication between the Mobile Station and the Base Station Subsystem occurs

over the air, commonly referred to as the Um interface.

Figure. 3 GSM (Global System for Mobile Communication)

3.3 GPS

A network of satellites in orbit around the earth are used by the GPS (Global Positioning System) satellite-based navigation system to pinpoint the exact location of a device or object on the planet's surface. The US Department of Defense originally created GPS for military use, but it has subsequently found widespread use in civil applications like navigation, tracking, and mapping[13].

When a signal is sent from a GPS satellite to a GPS receiver on the ground, GPS technology measures the amount of time it takes for the signal to travel there. The GPS receiver can calculate the separation between itself and the satellite by measuring the signal's transit time. The signals from various satellites can then be used by GPS receivers to triangulate their position on the earth's surface.

GPS receivers passively receive satellite signals; they do not transmit. Global Positioning System satellites broadcast signals to equipment on the ground. GPS receivers require clear views of the terrain for the

They are only used outside because they operate poorly in densely forested areas or in close proximity to towering structures. A extremely precise time reference is necessary for GPS operations.

Figure. 4 GPS (Global Positioning System)

3.4 Ultrasonic sensor

A type of sensor called an ultrasonic sensor uses sound waves to find things or gauge distances. The Ultrasonic Sensor is utilized to gauge the separation with high precision and stable readings. It can gauge the good ways from 2 cm to 400 cm or from 1 inch to 13 feet.[14] It operates by releasing high-frequency sound waves, then timing how long it takes for the waves to return after colliding with an item. Based on how long it takes the sound waves to leave and return, the sensor can determine how far away the object is.

A transmitter and a receiver are the typical components of an ultrasonic sensor. High-frequency sound waves from the transmitter, which are typically between 20 and 200 kHz, bounce off of nearby objects. Following that, the receiver finds the reflected waves and calculates how long it takes for them to return. Based on how long it takes the waves to leave and return, the sensor can determine how far away an object is.

Figure. 5 Ultrasonic Sensor

Pin Number	Pin Name	Description
1	Vcc	The Vcc pin powers the sensor, typically with+5V
2	Trigger	Trigger pin is an Input pin. This pin has to be kept high for 10us to initialize measurement by sending Ultrasonic wave.
3	Echo	Echo pin is an Output pin. This pin goes high for a period of time which will be equal to the time taken for the Ultrasonic wave to return back to the sensor.
4	Ground	This pin is connected to the Ground.

Figure. 6 Pins of Ultrasonic Sensor

3.5 Liquid Crystal Display (LCD):

A liquid crystal solution is sandwiched between two sheets of polarising material to create LCD displays. The crystals align when an electric current is supplied through the liquid, blocking light from passing through. As a result, each crystal functions like a shutter, either letting light through or blocking it. An applied electric voltage can be used to control the liquid crystals, allowing or blocking light.

The LCD monitor is able to display images by meticulously regulating where and what wavelength (colour) of light is permitted to pass. Brightness on an LCD monitor is provided by its backlight.

Figure. 7 LCD Display

4 Implementation

Attach the GPS module's power and ground pins, respectively, to the 3.3V and GND pins of the NodeMCU board then attach the GPS module's TX and RX pins to the NodeMCU board's RX and TX pins, respectively. Thereafter, Install the GPS module and NodeMCU board's required libraries in the Arduino IDE.

Attach the ultrasonic sensor's power and ground pins to the NodeMCU board's 5V and GND pins, respectively. Then attach the ultrasonic sensor's trigger and echo pins to the D1 and D2 connectors on the NodeMCU board, respectively. Install the required libraries in the Arduino IDE for the NodeMCU board and ultrasonic sensor[15]. Attach the PSM module's power and ground pins, respectively, to the 3.3V and GND pins of the NodeMCU board.

Join the PSM module's control pin to the NodeMCU board's D3 pin. Install the PSM module and NodeMCU board's required libraries in the Arduino IDE. Attach the battery's positive and negative terminals to the NodeMCU board's Vin and GND pins, respectively[16]. Attach the battery's positive and negative terminals, respectively, to the Vin and GND pins of the PSM module.

Attach the Wi-Fi or SIM card to the NodeMCU board. To see if the NodeMCU board is online, upload some test code to it. Register for a cloud platform account. Make a new project, and then configure it as needed[17]. To save the rubbish level and location information, create a new database.
To notify the sanitation department when a bin is full, set up an alert system. To set up the GPS gadget and retrieve location information, write some code.

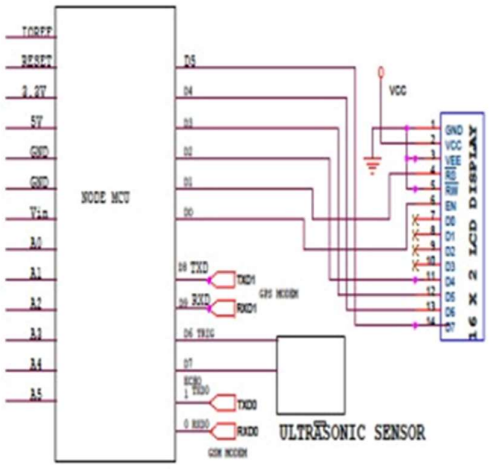

Figure. 8 Circuit Diagram

5. Results:

A microcontroller called the Node MCU has the necessary processing power to run the system. The GSM module transmits data to a central server for monitoring and analysis, while the GPS is used to track the location of the bins. The level of waste in the bins is determined using the ultrasonic sensor. It emits a high-frequency sound wave that reverberates off the trash's surface before returning to the sensor. The amount of trash in the bin is calculated based on how long it takes for the wave to return.

When a bin is full, the system can be set up to notify the waste management team, allowing them to arrange collections more effectively. As a result, collection expenses are decreased, and environmental outcomes are enhanced. A smart waste management system utilising Node MCU, GPS, GSM, and Ultrasonic Sensor can be a useful tool for controlling waste in an effective and sustainable manner.

6. Conclusion

To filter the waste as it moves through the city, a NodeMCU sensor-based automated trash checking system has been developed. As the trash turns out to be finished, the system becomes more and more convincing in informing the districts about the state of the rubbish at the trash container location. The primary feature developed in the project that increases the framework's dependability and effectiveness is estimating the level of the trash, informing the public and communities about its level, and recommending the driver to collect the trash. The ultrasonic sensor completes the movement identification system by detecting the proximity of an object to the garbage can while it is full.

The interface and programming can be adjusted and redeveloped by the prerequisite of the framework for various city municipals with further research to help its proficiency and execution. In spite of the fact that the advancement of the robotized trash observing framework is acceptable, there are things to be prescribed to chip away at it later on. Above all else, it is prescribed to add camera to the framework to catch the picture of the encompassing while the individuals attempt to drop the trash outside the canister which we will be utilized for punishment and to include smell sensor and dampness sensor to detect nature and receptacle dampness so it will have more productivity and straightforward ease of use.

Conflicts of Interest

There are no competing interests, according to the authors.

Author Contributions

Prof. Dhwaniket Kamble conceptualized this paper, Prof Santosh Rathod created the software simulation, checked the results, and Prof Alok Shah wrote the first draught. Syed Salik provided the oversight and final permission. Prasad Sakpal provided investigation, Prof RD Patil provided resources and Prof Archana Sukure provided data curation. Rohan Nikam has validated the project and checked project administration. Farhan palawkar has provided visualization and supervision.

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