

WASTE MONITORING AND MANAGEMENT SYSTEM USING IOT

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ABSTRACT: Waste disposal and monitoring are some of the major problems that the world is facing irrespective of their economic or social status. This is majorly seen when trash bins in busy towns and villages are overflowing with wastes which might lead to an unhealthy environment and maybe a reason for the spread of diseases. To avoid this condition and maintain public health and cleanliness. This paper proposes an idea that can interpret the real-time status of all bins situated in various parts of the city by sending an alert signal to the municipal workers for immediate cleaning of dustbin with proper verification based on the level of garbage filling, moisture, and temperature. It reduces the manual process of monitoring and verification.

KEYWORDS: Internet of Things (IoT), Moisture Sensor, Node MCU, Temperature Sensor, Ultrasonic Sensor.

I. INTRODUCTION

India comes under the category of developing nations. Separation of waste is crucial for apt disposal of a huge quantity of trash which is been produced in our daily routine from various sources. People became used to just throwing things away and never realize the consequences of their actions as seen in fig 1. Problems like health hazards, pollution, environmental disturbance can take place due to an appropriate system of management. Urban areas with developing economies face poor waste collection services and fail in the management of dump collection which worsens the problem. The waste collection method that is been implemented in many countries is a challenge and the majority struggle due to weak guidelines and rapid urbanization [8]. At present, the volume of municipal solid waste is increasing drastically with an increase in the rate of population, economic uprising, industrial development, change in consumption habits, and many other factors in the lifestyle of the urban population. It is alerted to the management company about the area that has to be visited to pick the overflowing or the bin that is nearing its saturation level so that the scavenger allotted may reach in prompt time and clear it.

The concept of the Internet of Things (IoT) is something in which surrounding things are connected using wired or wireless communication without manual intervention. Internet of Things as a technology performs sensing, activate, data assembly, storing, and processing by connecting devices to the Internet [1]. This paper aims to plan for a handy solution to the problem which most of the economies are facing today. The monitoring system enables the period by which the bin will be filled. Ultrasonic sensors will measure the distance between the lid and communicate it to the server and it can also be seen through mobile applications.



Fig 1. Current Situation

The proposed waste management system is based on a cluster of sensors and controllers. The ultrasonic sensor detects the height of the trash bin [4]. If the garbage container is about to fill a notification is sent to the respective authority. Wet and dry wastes are separated and collected in different containers. It is done using the moisture sensor and IR sensor if the moisture sensor detects the wetness in the waste only the wet container is opened. Once the garbage container is filled in a particular area, the garbage collector can locate the filled garbage container and can collect the wastes [6]. Two of the important features include checking the volume which the bin can hold and the other is interpreting the data and sending it to the cloud system for monitoring [5].

Wastes are majorly classified as recyclable waste, industrial waste, hospital waste, commercial waste, green waste, electronic waste, and nuclear waste and organic waste [16]. They are categorized based on the source that is producing the waste for instance industrial waste is categorized because of their origin from industries and so on. Many studies predict that the waste may grow to a tremendous amount around the year 2025 in which E-Waste may be major contributors because of the growing technologies and its uses may increase the rate of producing waste also. The current trend involves people used to dump out garbage usually in day to day basis without proper segregation. They dump though the bin is already overflowing. This leads to poor hygiene around the place becoming a source of vector. The government has deployed scavenger to clear the trash out of the garbage bin once a day, which is not sufficient in certain metropolitan cities like Chennai. The scavenger might not know the current scenario of one particular bin while they are looking on another bin simultaneously the previous bin may be filled and maybe overflowing also. So, the overall work for the scavenger becomes tedious and nerve-wracking during the rainy season. This is the time where the scavenger should take the utmost care. So, the proposed system would be beneficial to scavenger and also the person in charge of the cleaning process.

A real-time monitoring of the garbage bin is developed in such a way that dustbins are replaced once it gets filled [2]. This system uses the IoT application and sensors that ensure the clean environment and eases the work-load of the garbage collectors [8]. The purpose of this research is to develop a Smart system using IoT devices and sensors to monitor the garbage in real-time with greater efficiency and a cost-effective manner [10]. By implementing this system, we can reduce human efforts and ease the process of segregating wet and dry wastes [9]. All the real-time information will be get updated in the mobile application associated with Smart Bin [7]. This system provides an effective solution to the waste management problem and a better environment. For the waste management system in a future scale, it can be implemented using machine learning concepts and various modeling algorithms for better functionality than the proposed system based on the Internet of Things (IoT). There are certain systems developed using LoRa 32 TTL-100 at 433 MHz module which are advanced hardware components used along with machine learning.

The ideal principle to reduce the waste that is produced is on a day to day basis is by implementing the 3R principle that is Reduce, Reuse, and Recycle. The sustained development for the future will extend to good life and community to reserve the better hygiene of the people in all areas of life [15]. According to the government's guidelines as of India by both state and central government is to segregate the waste based on biodegradable and non-biodegradable. Biowaste can be composted using various ways and many valuable sources like biofuel etc. can be obtained from the biowaste. Many Non-Government Organizations help out to clear the waste in many innovative ways such as one of the NGOs known as EFI has launched a campaign to collect all the E-Waste all Chennai form various parts and many have volunteered for the same event for the E-Waste campaign. The main if the campaign is to protect the environment for better tomorrow that is a better environment for future generations.

Research work shows that few systems have been implemented with the PIR Sensor and ambient sensor with the I2C bus interface, which detects the presence of human and motor inclined with the lid opens up for people to throw the trash which has got some negative impacts too. Few other systems have been set up with GSM and GPS module for sending out notification based on location [17]. The proposed system is designed with minimal cost without the use of equipment like GPS and GSM modules. The principle of waste management is to confirm the proper collection and separation of waste at source and to ensure that it goes through various treatments for recovery. Every year urban India generates 62 million tons of municipal solid waste. The ongoing change in consumption patterns and rapid economic growth leads to an increase in the generation of waste to 165 million tons in 2030. The major problems affecting solid waste management are improper collection of waste, frequent manual checking for waste collection, and ethical problems [3]. This in turn leads to various impacts like environmental degradation, water pollution, soil pollution, and air pollution. This paper aims to reduce the problems faced in waste management. By implementing the concept stated in this paper problems like frequent

manual checking for waste, transportation, time consumption and inefficiency in the collection of waste can be avoided. Also, it helps to prevent the spread of hazardous diseases and pollution to the environment. In this way, it paves a way to an eco-friendly environment.

II. MATERIALS AND METHODOLOGY

To overcome the problem, a smart-bin is developed in such a way that the trash cans are monitored 24x7. The whole setup consists of Node MCU as the primary controller which is the main processing unit connected to the internetworking on the principles of the Internet of Things [1]. Along with it an ultrasonic sensor, moisture sensor, and temperature sensors are connected along with servo motor. The controller establishes a connection with the cloud and based on the output from various sensors the controller receives command over the cloud and can be controlled via mobile application as it is in fig.2 and the flowchart for the same is shown in fig 3.

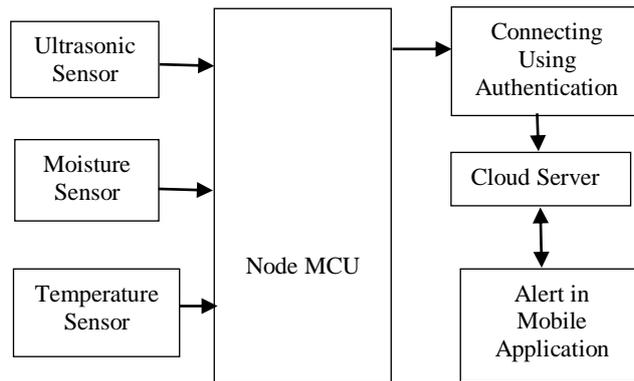


Fig.2 Block Diagram of Waste Management System

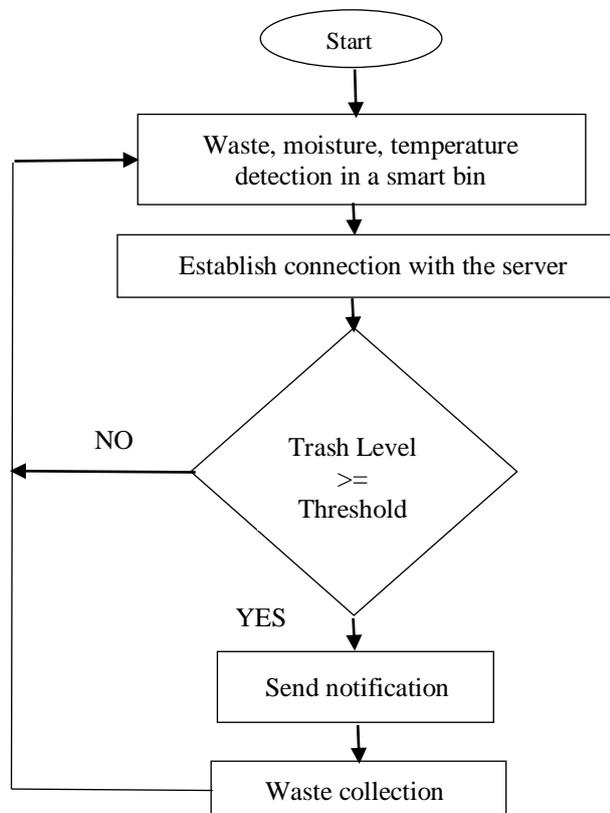


Fig 3. Flowchart of Waste Management System

Moisture sensor is placed at the mouth of the garbage container which is used to segregate the dry and wet wastes. The moisture sensor detects the moisture content in the wastes so that garbage container for wet waste disposal is only opened [11][12]. If no moisture is found in the waste the garbage container for dry waste disposal is opened. Hence dry and wet wastes are segregated. The ultrasonic sensor is placed at the bottom of the lid of the dry and wet garbage container. DC motor is responsible for the opening and closing of the container's lid. Ultrasonic sensors emit the sound waves towards the bottom of the garbage container and calculate the distance between the lid and the garbage level. When the distance between the lid and garbage falls below the threshold value, i.e. if the container is full an alert message will be sent to the respective authorities mobile. All those sensors are connected to the NODE-MCU (esp8266). Each garbage container is given a unique ID; hence the location of the particular bin can be identified. Hence the garbage is disposed of before it is overloaded and ensuring the cleanliness. The flow chart of the working process is shown in fig 3 and the algorithm for the waste management system is also inferred.

2.1 Algorithm

Step 1: Start

Step 2: Ultrasonic sensor detects the level of trash in the bin, moisture, and temperature sensor detects moisture level and the temperature respectively.

Step 3: A connection is established by the Node-MCU with the webserver.

Step 4: When the trash level or temperature is above the threshold level, an alert is sent to the concerned authorities via mobile application. If the garbage or temperature does not exceed the threshold level then the process gets repeated from Step 2 of the process. If moisture sensor detects moisture content beyond a threshold it sends notification else it starts again from Step 2 of the process.

Step 5: Then the trash in the bin at the specified location is cleaned by the local authorities as soon as possible.

Step 6: Jump to Step 2.

Step 7: Stop

2.2 Hardware Components

2.2.1 Ultrasonic Sensor:

Ultrasonic sensor is an electronic device used to measure the distance between the target object and the sensor by emitting ultrasonic sound waves and converts the sound waves into electronic signals [13]. To interpret the distance between the sensor and the target, the sensor will consider the time it takes for the sensor to emit the ultrasonic sound wave from the trigger probe and to receive the echo at the echo probe. The formula for this calculation is

$$D = \frac{1}{2} T \times C \text{ ----- (I)}$$

Where D is the distance, T is the time, and C is the speed of sound is 343 meters per second. Four pins of the sensor include Vcc- 5v power supply, TRIG- Trigger Pin, ECHO- Echo Pin, GND – Ground.

2.2.2 Moisture Sensor:

The Moisture Sensor measures the permittivity of the medium. In wet waste, dielectric permittivity is a function of the water content. The sensor produces a voltage based on the dielectric permittivity, and hence the water content of the material is obtained as the output. Thus, it helps differentiate between wet waste and dry waste.

2.2.3 Node-MCU:

The Node-MCU is a Wi-Fi enabled board developed to establish connectivity with the internet. The ESP8266 is capable of hosting an application as well as can connect to the Wi-Fi [14]. This Wi-Fi module can be integrated with the sensors and other applications to send and receive the data. The controller is connected to the server to enhance further possibilities of OTA updates for the controller in the system for better working for a longer period.

2.2.4 Mobile Application:

An Android application is developed to have remote control and track the level of various trash cans that need to be evacuated. Here the android application is used to monitor the level of the garbage bins. The mobile application is enabled two-way communication between the cloud.

3. Results and Discussion

The distance calculated from the ultrasonic sensor and the processing command sent by the controller is exchanged with cloud and mobile applications. The system consists of Node MCU, ultrasonic sensor, moisture sensor, temperature sensor, Wi-Fi module. To know about the presence of trash in the bin, many sensors can be used like weight sensors, IR sensors, etc. Whereas in the proposed method ultrasonic sensors are used which gives actual interpretation about the level of trash.



Fig 4. Experimental Setup of the bin

The sensor in fig. 4 pitches the ultrasonic sound waves on the trash present in the bin and calculates the distance yet to be filled and based on the result, it sends the notification to the mobile application as “ RANGE EXCEEDED” with particular bin ID which is hardcoded to the controller.

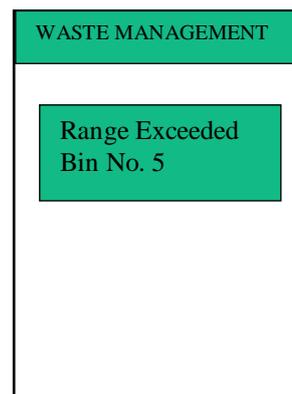


Fig 5. Mobile Application Developed Fig 6. Output of Mobile Application Smart Bin

The controller sends various information related to the bin regarding its distance which yet to be covered as in fig.5, if it exceeds the threshold value it pops out a notification as range exceeded and the bin to which the scavenger must first clear. The output from the mobile application prompting the personnel that bin number 5 has reached its maximum limit so that it has to be evacuated as soon as possible. The cloud-connected device sends and receives data to the mobile application connected by establishing two-way communication between the devices. The database stores all the information related to the bin and over a while, the system is designed in such a way to update the web API and keys for the Node-MCU for its proper working for a long while enabling less maintenance and making it cost-effective.

Ultrasonic sensor is preferable overweight sensors because weight sensors only interpret about the weight of the garbage, but does not report about the level of garbage in the bins. This sensor will work suitably and Node MCU will process the data from the sensor and then it will communicate the data with the cloud through Wi-Fi. The dashboard designed in the cloud platform will show the graphical level of the trash in the bin which can be accessed only by municipal authorities having access to the credentials. As the level of the trash is above the threshold level, the web page will generate an alert notification in the mobile application of the worker for that specific dustbin demanding cleaning process. Moisture sensor is used alongside an ultrasonic sensor so that it sends an alert notification when it detects moisture. This sensor helps to clear the trash if the level of garbage is not above the threshold level for two or more days which leads to several health hazards and foul smells to the surroundings. The temperature sensor sends a notification if the temperature is above the threshold level.

The model is developed in standard conditions for testing purposes. In our city, we can often see many of the garbage bins are overloaded. It creates an unhygienic condition to that place and leads to the spread of many diseases. It is proposed to develop an IoT based smart waste management system that effectively checks whether the garbage bins are full or not. By implementing this system, we can ensure the cleanliness of the area and can avoid the spread of diseases, and also, we can reduce the cost associated with garbage disposal. Various sensors have been used to implement in real-time. This system effectively monitors the garbage level of the dustbin.

IV. CONCLUSION

It is to help the local corporation in the waste management system, which is by monitoring the domestic wastage in and around the localities at regular intervals to avoid the damage to public health and environment. Which also minimizes the entire trip by garbage vehicles which ultimately reduces the expenditure. In the future, various types of sensors can be included to get the precise output. As this system reduces manual work and time consumption, it is a user-friendly product. This proposed product is an attempt to improve the current waste collection system in India and pave a path for an eco-friendly environment. This proposed system ensures the maintenance of garbage containers as and when the garbage level reaches its saturation level. This minimizes the frequent checking of garbage collection and hence reduces the overall expenditure associated with the garbage collection. It ultimately aims in maintaining cleanliness and productivity of the society. Therefore, the waste monitoring and management system makes the trash collection more efficient and effective.

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