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Smart Waste Management System

Using IOT

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Abstract: Waste collection and management are integrated parts of both city and village life. Lack of an optimized and efficient waste collection system vastly affects public health and costs more. The prevailing traditional waste collection system is neither optimized nor efficient. The Internet of Things (IoT) has been playing a great role in making human life easier by making systems smart, adequate, and self-sufficient. Thus, this paper proposes an IoT-based, efficient waste collection system with smart bins. India generates tons of waste annually. Conventional garbage collection is not efficient since the authorities are not notified until the waste bin is full, and this leads to an overflow of waste material. Efficient waste disposal and collection are essential for a sustainable and clean India. A smart waste management system uses an IoT-based waste bin for collection and monitoring the level of waste inside the bin. The system does real-time monitoring of the waste bins and determines which are to be emptied. The system is implemented using two ultrasonic sensors. One of the ultrasonic sensors detects the level of waste in the bin, and the other detects the person approaching the bin to dispose of the waste. This detection helps with the automatic opening and closing of the lid. A servo motor is connected to the lid, which serves the action of closing and opening the lid. In this system, the level of waste in the bin will be sent to the concerned authorities. Thus, it reduces fuel costs and human labor, making the system optimized and efficient by enabling real-time monitoring and enhanced navigation.

Key Word : Waste Collection, Internet of Things (IoT), Real time monitoring system, cost-effectiveness, Waste management, Sustainable, Real-time monitoring, Ultrasonic sensors, Servo motor, Automation, Fuel cost, Human labor, Optimization, Enhanced navigation, Smart bins, Public health, Efficiency.

1 I. Introduction

The amount of waste produced every day by industries and households is increasing at an appalling rate, and the major reason for this is the soaring use of packaged items such as textiles, paper, food, plastics, metals, glass, etc.; thus, the management of this refuse becomes a crucial part of our everyday lives. In most of the developed countries, there are many efficient techniques that are used for the proper management of this waste, but in some countries, especially the developing ones, the careless attitude of people towards maintaining clean surroundings, along with many issues such as no stringent laws for using biodegradable materials, no proper environmental policies, and no laws for sustainable development, are the seeds for the fatal results of waste management. Due to the increasing waste, the public bins that are used for collecting this waste are overflowing, and the locality is jumbled with trash, causing not only malodorous streets but also a negative impact on the health and environment.

II. Proposed System

The proposed system helps to collect garbage optimally from the dustbins, sends the data to the concerned authorities, and, by using algorithms, helps the authorities schedule the entire collection process based on the priority of the dustbins. The system includes an IR sensor, which is used to detect the person approaching the bin, and the lid of the bin opens with the help of a servo motor, which controls the opening and closing of the lid of the bin. After the person moves away from the bin, the

lid will close automatically. An ultrasonic sensor is used in order to measure the level of the bin. The board used is an ESP-32, which has a wi-fi module inside it, and the status of the bin is sent to the IoT server.

The IoT server displays the status of all the bins, and the authorities can view them. The IoT platform shows the accurate level of each of the bins with all the necessary data, i.e., the number of the bin, location, etc. To schedule the collection process, the Traveling Salesman Algorithm and Priority Scheduling Algorithm are used, and this helps the authorities optimally schedule the process. The priority scheduling algorithm filters the bins based on their level, i.e., it only shows the bins that are of top priority, i.e., the bins that are filled. The Traveling Salesman Algorithm helps to show the route based on the shortest distance so that the authorities can schedule accordingly and deploy only the required number of trucks, which helps to reduce resources such as fuel and time.

1. Proposed Model

Figure 1 : The Proposed Model

The major working components and connections of the Automated Water Quality Monitoring and Managing System are illustrated above. AT Mega acts as the main controller and brain of the system. Different sensors are used to sense different water parameters. The sensors include a temperature sensor to measure the temperature of the pond, a turbidity sensor to sense turbidity, a water level sensor to sense the water level, and a PH sensor to check whether the pond is acidic or basic in nature. Two solenoid valves are used to manage the acidic or basic nature, and the other water parameters are measured by the sensors and managed by the relay system.

2. Architecture

The IR sensor is responsible for the detection of people approaching the bin, and the servo motor controls the opening and closing of the lid. The proposed system has an ultrasonic sensor that monitors the level of waste inside the bin and a display monitor that shows the status of the bin to the

people so that they will use different bins. ESP32 microcontroller is used rather than Arduino as it has integrated Wi-Fi connectivity and sends the status of the bin to the IoT server monitored by the authorities. The IoT server shows the status of all the bins to the concerned authorities. The branch and bound algorithm is used 1 in order to help the authorities schedule the collection process based on the level of the bins, i.e., top priority bins are only focused on collection.

IR Sensor

Opening And Closing of Lid

Display Of Status of Bin

Branch and Bound Algorithm Calculates The Shortest Collection Route

Data Sent To IoT Server

Scheduling Of Collection Process

Figure 2 : The Proposed System Architecture

3. Schematic Diagram

Figure 3 : Schematic Representation

III. Working

The proposed system helps to collect garbage optimally from the dustbins, sends the data to the concerned authorities, and, by using algorithms, helps the authorities schedule the entire collection process based on the priority of the dustbins. The system includes an IR sensor, which is used to detect the person approaching the bin, and the lid of the bin opens with the help of a servo motor, which controls the opening and closing of the lid of the bin. After the person moves away from the bin, the lid will close automatically. An ultrasonic sensor is used in order to measure the level of the bin. The board used is an ESP-32, which has a wi-fi module inside it, and the status of the bin is sent to the IoT server.

The IoT server displays the status of all the bins, and the authorities can view them. The IoT platform shows the accurate level of each of the bins with all the necessary data, i.e., the number of the bin, location, etc. To schedule the collection process, the Traveling Salesman Algorithm and Priority Scheduling Algorithm are used, and this helps the authorities optimally schedule the process. The priority scheduling algorithm filters the bins based on their level, i.e., it only shows the bins that are of top priority, i.e., the bins that are filled. The Traveling Salesman Algorithm helps to show the route based on the shortest distance so that the authorities can schedule accordingly and deploy only the required number of trucks, which helps to reduce resources such as fuel and time.

IV. Implementation

1. Hardware implementation

The first step is to create a circuit consisting of all the required components. The circuit consists of the ESP 32 module, an ultrasonic sensor, an IR sensor, and a servo motor as the primary components. The fullness status of the bin is determined by calculating the distance between the lid of the bin and the trash using the ultrasonic sensor.A distance threshold will be set according to the bin dimensions. When the ultrasonic sensor indicates that the bin is full, the ESP 32 module will send a message to the IoT server. When the bin status is full, the lid will not open if a person approaches, but it can only be opened manually. The IoT server displays the status of the bins.

2. Code implementation

The code used is a crucial component of an automated waste management system utilizing an ESP32 microcontroller, various sensors, and actuators. The system is designed to efficiently monitor the level of waste in a bin and automatically open or close the lid based on certain conditions. Additionally, it incorporates features for displaying data on an LCD screen and transmitting information to a remote server for further analysis and management.

Setup and Initialization: The setup function begins by initializing serial communication for debugging purposes and configuring the I2C interface for communication with the LCD display. It also attaches the servo motor to the designated pin for controlling the lid movement. Furthermore, it sets up the pins for the IR sensor and ultrasonic sensor and initializes the lid in a closed position. Additionally, it attempts to establish a connection to a Wi-Fi network for remote communication.

The main components and functionalities of the code used are broken down and given below:

1. Libraries and Definitions:

The code includes several libraries for different functionalities, such as WiFi, servo motor control, HTTP requests, and interfacing with the LiquidCrystal I2C display.

WiFi credentials and other constants like pins, LCD parameters, and timeout values are defined.

2. Setup Function:

initializes serial communication, the LCD, and the servo motor.

sets up pins for IR and ultrasonic sensors.

- Connects to the WiFi network.

prints a setup completion message.

3. Loop Function:

measures the distance using an ultrasonic sensor (HC-SR04) to determine the level of content in a bin.

converts the measured distance to a percentage, representing the fill level of the bin.

checks if the IR sensor detects an object nearby and if the bin level is above a certain threshold.

If true, it opens the lid using a servo motor.

updates the LCD display with the current fill level and a message if the bin is full.

sends the fill level data to a ThingSpeak API endpoint using an HTTP POST request.

If the lid is closed, it clears the LCD display and prints the fill level. If the bin is full, it displays amessage on the LCD.

4. Additional Considerations:

- The lidServo. The attach() function attaches the servo motor to a specific pin for control.

The hcsr04() function is assumed to be a custom function for measuring the distance using the ultrasonic sensor.

The sendDataToAPI() function is assumed to handle sending data to the ThingSpeak API.

In summary, this code creates a smart bin system that monitors the fill level using ultrasonic and IR sensors, displays the fill level on an LCD screen, and sends the data to a cloud service (ThingSpeak) for further processing or monitoring. The servo motor controls the lid of the bin, opening it automatically when an object is detected nearby and the bin is not full.

3. Server Implementation

The server is a Django-based web application aimed at managing waste bins. The server includes functionalities for user authentication (login and registration), adding and deleting bins, and updating

bin contents. It also calculates optimal routes for waste collection. Authentication and authorization mechanisms are implemented to ensure that only authenticated users can access certain functionalities, like adding and updating bins. API end points serve as the communication interface between clients. They define the URLs that clients can interact with to perform various actions or retrieve data. The Update Bin Content Endpoint (/update-bing-content//)is used to update the contents of a specific waste bin identified by . Upon receiving the POST request sent to the endpoint, the server updates the content of the specified bin in the database accordingly.

V. Conclusion

The traditional methods of waste collection and management prevalent in both urban and rural areas of India have proven to be inefficient and costly, leading to detrimental effects on public health and the environment. Overflowing waste bins, inadequate monitoring, and inefficient collection processes contribute to unsanitary conditions, increased pollution, and unnecessary expenses. The current conventional garbage collection system suffers from a lack of timely notifications to authorities regarding bin capacities, leading to overflowing waste bins and subsequent environmental hazards. An efficient and sustainable waste disposal system is imperative for maintaining cleanliness and sustainability in India. The proposed smart waste management system utilizes IoT-based waste bins equipped with sensors for monitoring the level of waste inside each bin in real-time. By incorporating two ultrasonic sensors, one for detecting the waste level and another for detecting approaching individuals disposing of waste, the system enables automatic opening and closing of the bin lid. A servo motor connected to the lid facilitates this action, ensuring seamless operation without requiring manual intervention. One of the key benefits of this system is its ability to provide real-time data on waste levels to the relevant authorities. By transmitting this information, the system enables authorities to identify which bins require emptying, thereby optimizing waste collection routes and reducing fuel costs and human labor. In the future, the proposed model can be enhanced with some functionalities, like placing the bin above a composed pit so that bio-degradable waste can be

directly dumped into the pit when the bin reaches a certain level, with the help of some hardware updates to the bin. This will be really useful in order to prevent unpleasant smells that arise due to a mixture of excess biowaste.

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