Real Time Smart Garbage Monitoring and Management System

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Abstract:
Urban waste management is a serious issue because of the high rate of waste generation and ineffective garbage collection practices. Conventional garbage collection is based on fixed timings, resulting in either full bins or redundant collection runs, resulting in higher operational expenses and pollution. To overcome these issues, this paper suggests a Real-Time Smart Garbage Monitoring and Management System based on IoT (Internet of Things) and Raspberry Pi. The system has been developed to track trash levels within bins through ultrasonic sensors, which scan the fill status of the bin continuously. The information is fed into a cloud database through Wi-Fi connectivity, facilitating real-time tracking. An HTML-based web interface is created with CSS and JavaScript to provide authorities with a view of the status of the bins in various locations. Automated notifications are sent when a bin reaches a specified level, and waste collection teams are triggered to act. The system can also offer analytical reports on garbage generation trends and assist in route planning and resource management for waste collection. By incorporating IoT-based automation, this system increases efficiency, cost savings, and sustainability in urban waste management. It minimizes manual intervention, avoids unsanitary conditions, and encourages environmentally friendly waste disposal practices. Future upgrades can involve the incorporation of machine learning for predictive analysis, solar-powered sensors, and smart segregation mechanisms to further enhance waste management operations.

INTRODUCTION:

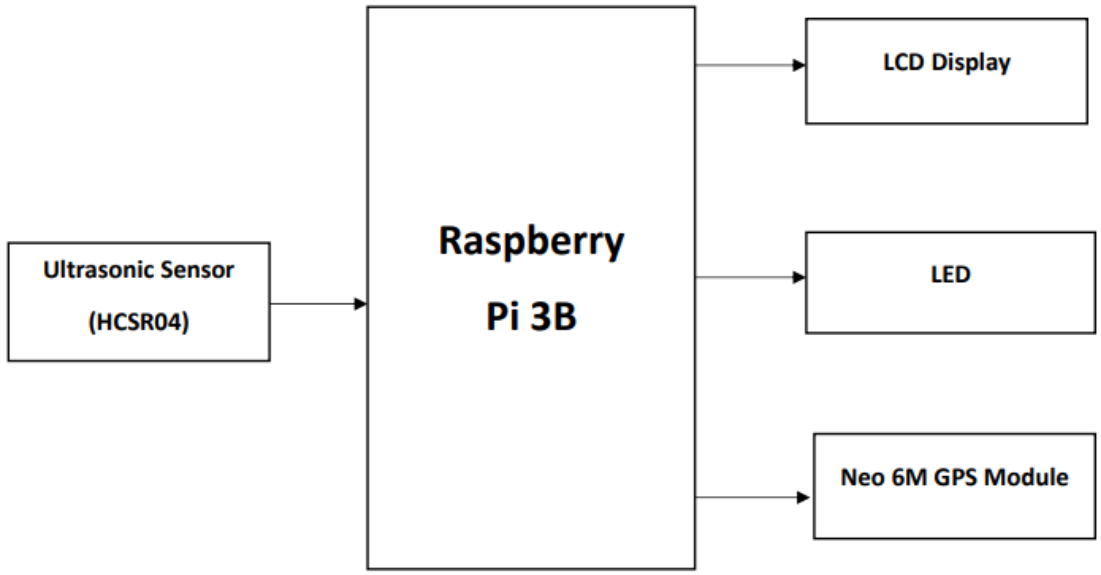
Using real-time garbage bin level monitoring, a Raspberry Pi based real-time garbage management and monitoring system is intended to optimize waste collection procedures. The system makes use of some sensors, including gas sensors to keep an eye on smells, temperature sensors to identify any fire threats, and ultrasonic sensors to gauge the fill level of bins. The processing unit, a Raspberry Pi, is connected to these sensors. The Raspberry Pi gathers data from the sensors continually and sends it wirelessly to a cloud-based platform. After processing the data, the cloud technology enables city officials to view a dashboard that displays the current state of every bin in real time. When bins are full or need quick care, the system might sound a warning. Using this information, the central management platform creates garbage collection routes that are optimized to avoid needless travel, save fuel, and enhance operational effective waste collection staff may access these optimal routes and receive real-time information via a smartphone application, ensuring timely collection and reducing the amount of overflowing bins in public areas. By using less fuel, this system promotes sustainability, reduces operating costs, and helps to create a cleaner atmosphere. Furthermore, it offers useful information for forecasting waste production trends, facilitating improved waste management planning in smart cities in the future. The Real-Time Smart Garbage Monitoring and Management System leverages IoT technology for real-time monitoring and efficient waste management, ensuring a cleaner urban environment.

LITERATURE REVIEW:

For a successful system, we should study about the research problem again and again. The question is "Is it possible to develop Smart dustbins which inform the municipality about the dustbins getting filled up?". In literature review we read various research papers to get knowledge about the work done so far. For garbage wastage detection, several research papers employ a weight sensor.

The weight sensor gives the weight of the garbage waste as an indicator to the concerned authorities for appropriate action. Andrei Brozdukhin later proposed the new system with two working hands: software component and unique indicator equipment [1].
The unique indicator equipment is attached on the dustbin walls. It is made up of two parts: one is the receiver-transmitter and the other is the sensor. The sensor is used for indicating the level of garbage in the dustbin and is attached to the transmitter device that sends the "Dustbin is full, Please empty it" signal to the concerned authorities. It is now the job of Artificial Intelligence algorithms to find the shortest path and nearest truck driver to the concerned dustbin and notifies them for the waste collection [2].
The IoT based garbage waste intelligent management system has been prototyped around waste items, household dustbin, a garbage bag and a garbage collection vehicle. The project starts with the flow of garbage in the garbage container and in the household bin and terminates at garbage takeaway vehicles [3].
Sharma et al. (2023) discuss the technical challenges in deploying IoT based waste management systems, such as ensuring reliable data transmission and maintaining sensor durability in harsh environments [4].
Rodriguez et al. (2022)present a detailed case study of Barcelona, where IoT-enabled waste management systems have led to optimized collection routes and reduced operational costs. They highlight the importance of stakeholder collaboration in successful implementation [5].

BLOCK DIAGRAM:



1.Raspberry pi 3
The Raspberry Pi 3 acts as the controller, processing data from input sensors and managing the output devices.

- Continuously reads sensor data.
- Processes and analyzes the collected information.
- Controls output devices based on predefined conditions.
- Connects to a database to store and display bin status

2. Input Component
(i) Ultrasonic Sensor (HC-SR04)

- The data is sent to the Raspberry Pi, which updates the monitoring system

3. Output Component

(i)LCD Display

- Displays critical information such as:

Waste level inside the bin.
Waste Status
Alerts when the bin is full.

- Helps waste management personnel monitor bin status directly from the device.

(ii)LED

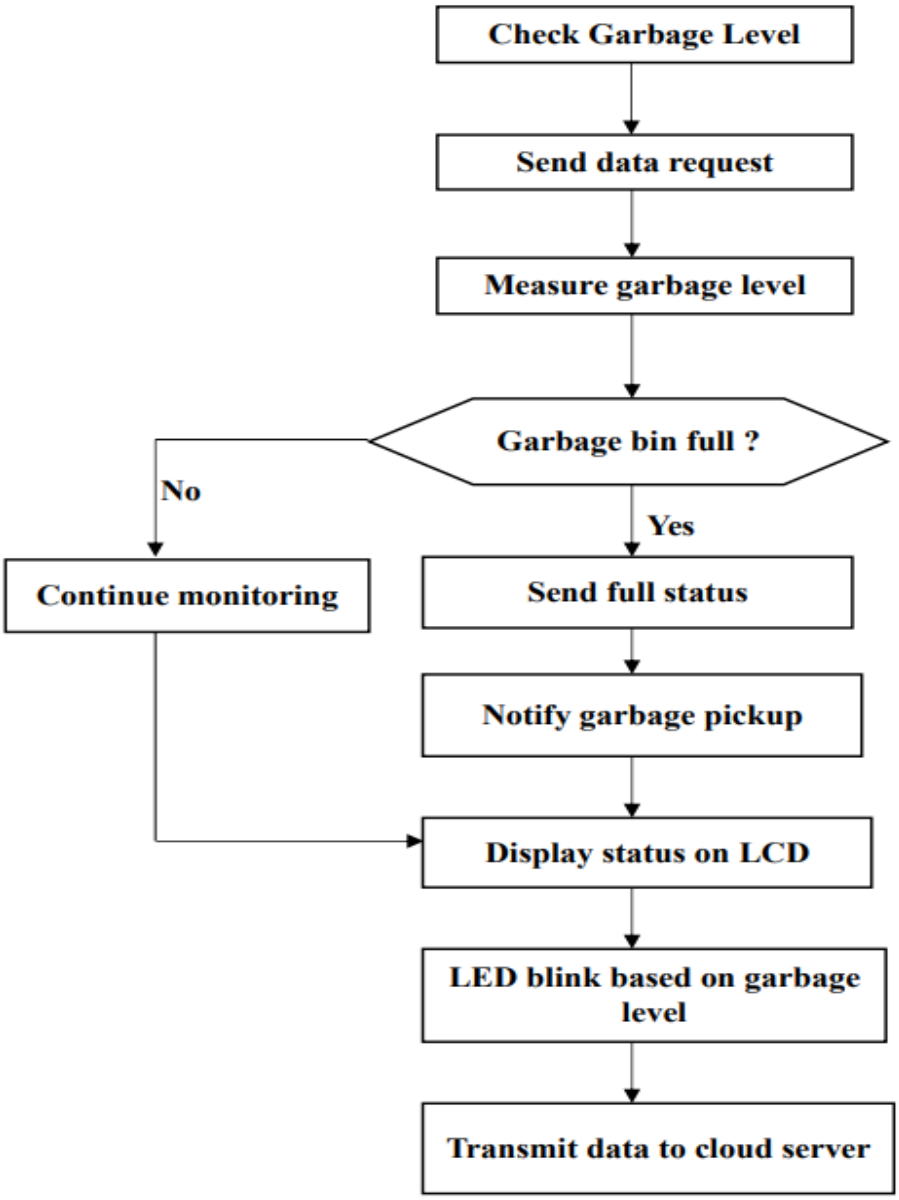
The LEDs on the system give a quick visual indication of the status of the garbage bin, such that waste management staff will know when to clear the bin. The LEDs are operated by the Raspberry Pi 3 depending on the fill level of the bin, as indicated by the ultrasonic sensor (HCSR04).

(iii) Neo 6M GPS Module

The Neo-6M GPS module provides real-time location tracking for smart garbage bins, enabling accurate bin positioning and efficient route planning. It integrates easily with Raspberry Pi to support location-based monitoring in the smart waste management system.

FLOWCHART:

This flowchart represents the working of the Real-Time Smart Garbage Monitoring and Management System. The process begins with checking the garbage level in the bin using an ultrasonic sensor, which sends a data request to measure the current fill level. The system then compares this measured value with a predefined threshold to determine if the bin is full. If not full, the system loops back and continues real-time monitoring. If the bin is full, the system updates the status, stores the data, and notifies the waste management authorities for prompt collection. Simultaneously, the LCD screen displays the fill status and location, while an LED blinks in green (empty), yellow (partial), or red (full) based on the garbage level. The status data, along with GPS coordinates from the Neo-6M module, is transmitted to a cloud server for remote access. Additional features include logging of historical bin data for analysis, predictive alerts based on past fill trends, and the possibility of route optimization for garbage trucks using GPS data. The system can also send notifications to mobile apps for real-time updates and is scalable to accommodate multiple bins across different locations. Automated system checks help ensure sensor and network health, and a manual override option allows maintenance teams to intervene when needed. This intelligent setup significantly reduces manual effort, enhances operational efficiency, and supports cleaner, smarter urban environments.

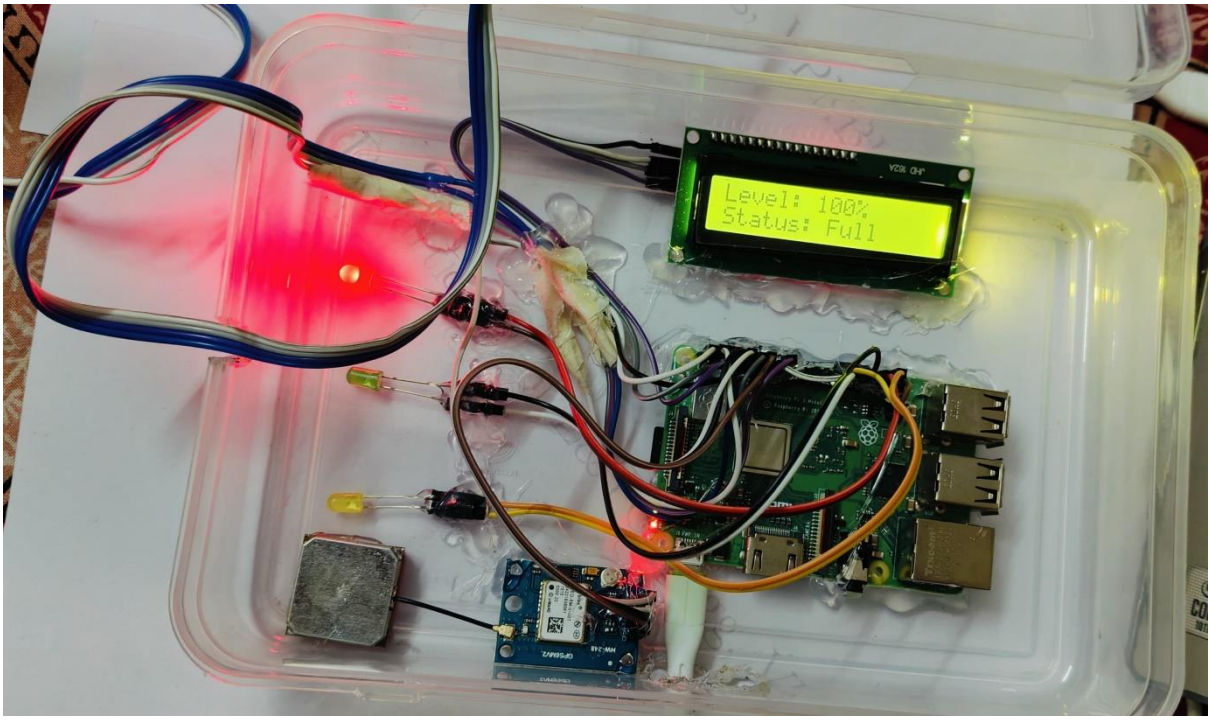


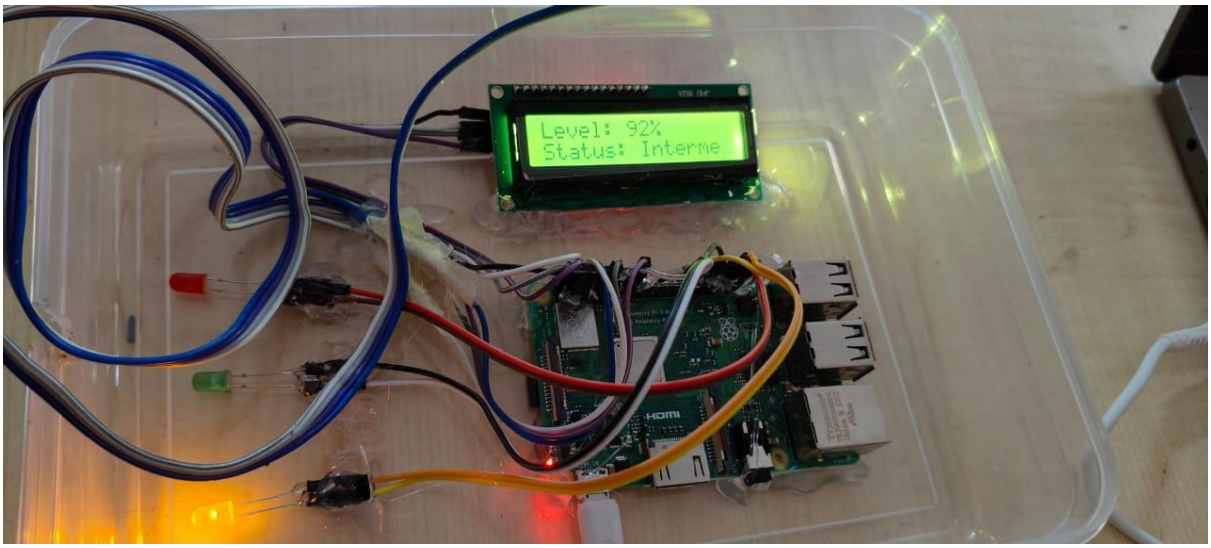
METHODOLOGY:

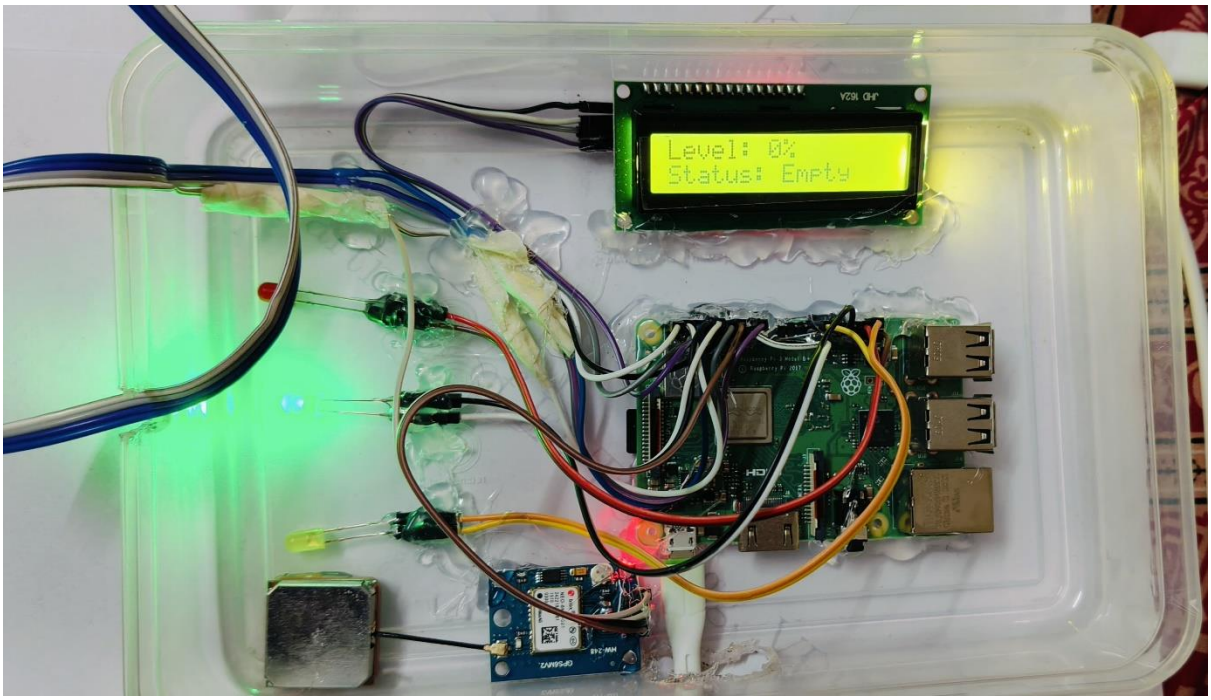
The development of the real-time smart garbage monitoring and management system involves the integration of hardware components, software programming, and communication technologies to enable automated waste level detection and remote monitoring. Initially, the system requirements were analyzed, and a suitable architecture was designed, incorporating essential components such as a Raspberry Pi, ultrasonic sensors (HC-SR04), LED indicators, an LCD display, and a stable power supply. The ultrasonic sensors are strategically mounted at the top inside surface of the garbage bin to measure the distance between the garbage level and the sensor, providing an estimate of how full the bin is. Based on the measured distance, threshold logic is implemented to classify the garbage levels. If the distance is less than 10 cm, the bin is considered full and the red LED is activated. A distance between 10 cm and 20 cm indicates a half-full bin, triggering the yellow LED, while a distance greater than 20 cm shows that the bin is empty, activating the green LED. The current garbage level is also displayed in real-time on an LCD screen connected to the Raspberry Pi.The Raspberry Pi is programmed using Python to handle sensor readings, LED and LCD control, and communication with the server. For real-time data transmission, the system sends the garbage bin status, along with a timestamp and bin ID, to an online server using HTTP requests. This data can then be accessed via a web interface or dashboard to monitor the status of multiple bins across different locations. Furthermore, the system integrates

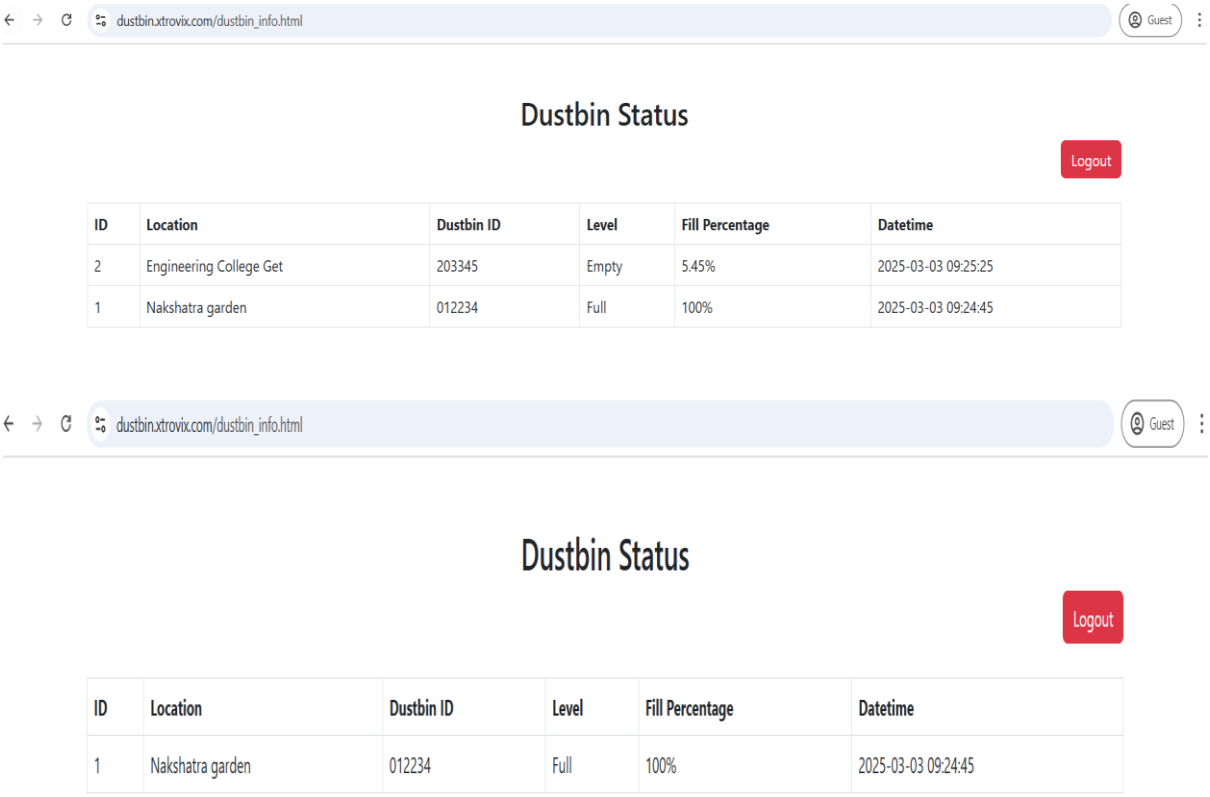
with the Telegram API to send instant alert messages to the concerned authority when a bin is detected as full, enabling prompt waste collection and management. The system is thoroughly tested and calibrated to ensure accurate distance measurements and reliable performance under varying conditions. Finally, it is deployed in selected locations for live monitoring, and continuous data collection is conducted to support further improvements in waste management efficiency.

RESULT:









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