KLE Technological University
Creating Value, Leveraging Knowledge
Dr. M. S. Sheshgiri Campus, Belagavi

Department of
Electronics and Communication Engineering

Minor Project 1 Report

on

SMART GARBAGE MONITORING AND MANAGEMENT SYSTEM

By:

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

CERTIFICATE

This is to certify that project entitled **"SMART GARBAGE MONITORING AND MANAGEMENT SYSTEM "** is a bonafide work carried out by the student team of **" Divya Balekundri (02fe21bec030), Diya Bandi (02fe21bec031), Harsh D. Jadhav (02fe21bec036), Onkar Thorushe (02fe21bec056)"**. The project report has been approved as it satisfies the requirements with respect to the minor project 1 work prescribed by the university curriculum for B.E. (6th Semester) in Department of Electronics and Communication Engineering of KLE Technological University Dr. M. S. Sheshgiri CET Belagavi campus for the academic year 2023-2024.

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-The project team

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ABSTRACT

The smart Garbage Monitoring and Management System is an innovative solution designed to enhance the efficiency of waste management in various areas. By leveraging advanced sensor technology, this system continuously monitors the fill levels of garbage dumps in various localities. The real-time data collected is processed and analyzed to provide actionable insights, ensuring that waste collection is timely and efficient. This approach not only helps in maintaining cleanliness and hygiene but also optimizes the use of resources, reducing operational costs and environmental impact.

The system employs a network of smart sensors installed in garbage bins across different locations. These sensors detect the fill levels of the bins and transmit the data to a centralized platform. The platform is equipped with algorithms that analyze the incoming data and generate alerts when bins are nearing their full capacity. This real-time monitoring enables waste management authorities to plan and execute collection routes more effectively, preventing overflow and ensuring that garbage bins are emptied before they become a public nuisance.

By integrating smart technology into waste management, the system offers a proactive approach to handling urban waste. It not only facilitates timely collection but also helps in identifying patterns and trends in waste generation. This information can be crucial for city planners and policymakers in making informed decisions about waste management strategies and infrastructure development. Overall, the SMART Garbage Monitoring and Management System represents a significant step towards creating cleaner, more sustainable urban environments.

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Chapter 1

Introduction

In contemporary urban environments, efficient waste management is crucial to maintaining cleanliness, hygiene, and sustainability. Traditional waste collection methods often suffer from inefficiencies, leading to overflowing garbage bins, increased operational costs, and negative environmental impacts. Addressing these challenges, our project, the SMART Garbage Monitoring and Management System, provides an innovative, technology-driven solution to revolutionize waste management practices.

This system utilizes an ESP-8266 microcontroller as the core of our solution, integrating it with ultrasonic sensors to monitor the fill levels of garbage bins in real-time. The ultrasonic sensors accurately measure the waste level within each bin and relay this information to a central server. The system continuously tracks the status of each garbage bin, ensuring that the data is up-to-date and reliable.

When a garbage bin approaches its full capacity, the system automatically alerts the concerned authorities, enabling them to take timely action. This proactive approach not only prevents bins from overflowing but also allows waste management teams to optimize their collection routes and schedules. By strategically planning garbage collection based on actual data, the system enhances the efficiency of waste management operations, reduces unnecessary trips, and minimizes fuel consumption, contributing to a cleaner and more sustainable urban environment.

1.1 Motivation

Efficient waste management in urban areas is crucial due to the limitations of traditional methods, which often result in either overflowing garbage bins or unnecessary collection trips. These inefficiencies lead to unsanitary conditions, increased costs, and environmental concerns. The need for a smarter, more responsive system is evident.

The SMART Garbage Monitoring and Management System addresses these issues by using an ESP32-based solution with ultrasonic sensors to monitor waste levels in real time. This system alerts authorities when bins are nearing capacity, ensuring timely collection and preventing overflow. This improves public health, cleanliness, and resource utilization.

Additionally, optimizing collection routes based on real-time data reduces fuel consumption and greenhouse gas emissions, contributing to sustainability. The system also provides valuable data on waste generation patterns, supporting better urban planning and policy decisions. The SMART Garbage Monitoring and Management System exemplifies how technology can make waste management more efficient, cost-effective, and environmentally friendly.

1.2 Objectives

1. Implement an ESP-8266 based solution for efficient garbage collection.
2. Monitor waste levels in real-time using ultrasonic sensors.
3. Alert Authorities when bins are nearing capacity to ensure timely collection and prevent overflowing.

1.3 Literature survey

[1] Smart Dustbin Management System:

This paper proposes an IoT-based solution to improve urban waste management. The system employs ultrasonic sensors to monitor the fill levels of garbage bins and uses a microcontroller to send real-time data to a central server. When bins approach capacity, the system alerts waste management authorities, enabling timely collection. This method optimizes collection routes, reduces operational costs, and minimizes environmental impact by preventing bin overflow and unnecessary trips

[2] Smart E-dustbin:

The paper "Smart E-dustbin" by Chinmay Kolhatkar et al., presented at the 2018 International Conference on Smart City and Emerging Technology (ICSCET), introduces an intelligent waste management system. This system uses ultrasonic sensors to monitor the fill levels of bins and employs microcontrollers to transmit this data to a central server. When bins are nearly full, it alerts the relevant authorities to ensure timely collection. This approach optimizes waste collection routes, reduces operational costs, and mitigates environmental impacts by preventing bin overflow and unnecessary collection trips

[3] IoT Based Smart Dustbin:

This paper presents a smart waste management solution using IoT technology. The system features ultrasonic sensors to detect waste levels and a microcontroller to manage data transmission. The smart dustbin opens its lid automatically when waste is detected and sends notifications to a mobile device when the bin is full. This system aims to optimize waste collection, reduce manual monitoring, and improve efficiency and hygiene in urban areas by preventing bin overflow and ensuring timely waste disposal.

[4]Smart Waste Bin System:

The paper presents a comprehensive review of current smart waste bin technologies. It examines the effectiveness of these systems in improving waste management practices through the integration of IoT technologies. The review highlights various approaches and technologies used in smart bins, such as sensors for monitoring waste levels, and discusses their impact on enhancing waste collection efficiency. Additionally, the paper identifies gaps in existing research and suggests areas for future development to further optimize smart waste management systems.

1.4 Problem statement

Our project addresses the environmental threat posed by inefficient waste disposal through the development of a Smart Garbage Monitoring and Management System. By leveraging innovative technology and real-time data analysis, we aim to optimize waste collection processes, fostering cleaner and healthier environments.

1.5 Application in Societal Context

Our Smart Garbage Monitoring and Management System has significant applications that positively impact society. By integrating advanced technology to monitor and manage waste collection, the system addresses several critical societal issues:

1. Public Health and Hygiene: By ensuring timely collection of garbage, the system helps maintain cleaner urban environments. This reduces the risk of pest infestations and the spread of diseases, thereby improving public health.

2. Environmental Sustainability: Optimizing waste collection routes and schedules reduces fuel consumption and greenhouse gas emissions, contributing to environmental conservation. This also supports cities in achieving sustainability goals and reducing their carbon footprint.

3. Resource Efficiency: Real-time monitoring prevents unnecessary collection trips, thereby saving on labor and operational costs. This efficient use of resources can be redirected towards other community needs, enhancing overall urban management.

4. Data-Driven Planning: The system collects valuable data on waste generation patterns, which can inform better urban planning and policy-making. This data helps city authorities in making informed decisions about waste management infrastructure and services.

5. Quality of Life: Cleaner streets and timely waste removal contribute to a more pleasant living environment, enhancing the quality of life for residents. This can also have positive economic impacts, such as increased property values and attracting businesses and tourism.

1.6 Project Planning

1. Architecture Design

   Conceptual Design Develop high-level block diagrams. Choosing the arithmetic algorithms (e.g., Booth's algorithm for multiplication).

   Detailed Architecture Design Design the data path (multipliers, adders, accumulators). Define the control unit for managing data flow. Plan the pipelining strategy for maximizing throughput.

   Simulation and Modeling Create simulation models using software like MATLAB. Validate the design with test vectors and typical DSP algorithms.

2. Implementation

   Hardware Description Language (HDL) Coding Write the RTL code in Verilog or VHDL. Implement the pipeline and control logic.

   Optimization Optimize for speed, area, and power consumption.

   Verification Develop testbenches for functional verification. Perform simulation at the RTL level. Conduct timing analysis and check for setup/hold time violations.

3. Prototyping

   FPGA Prototyping Map the design onto an FPGA for prototyping. Perform hardware validation with real-world signals.

4. Testing and Validation

   Functional Testing Test the MAC unit with various DSP algorithms. Validate performance against specified metrics.

   Integration Testing Integrate the MAC unit with other system components. Ensure seamless data flow and communication

Chapter 2

System design

2.1 Functional block diagram

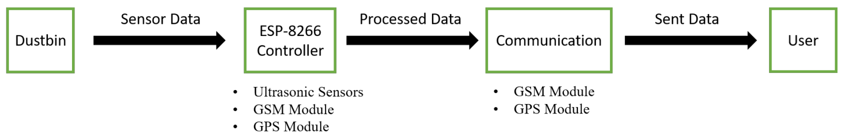

Figure 2.1: Functional block diagram

1. Dustbin: This is the starting point where garbage is deposited. The dustbin is equipped with sensors that gather data about the waste level.

2. Sensor Data: The sensors in the dustbin, specifically ultrasonic sensors, measure the fill level of the bin. This data is collected and sent to the ESP32 controller.

3. ESP-8266 Controller: This microcontroller processes the sensor data. It receives inputs from the ultrasonic sensors to determine the fill level and from the GPS module to track the location of the dustbin.

4. Processed Data: The ESP32 processes the incoming sensor data, converting raw measurements into meaningful information regarding the fill level and location of the dustbin.

5. Communication: The processed data is then transmitted through communication modules. The GPS module provides the location data, while the SMTP server facilitates sending notifications and alerts to the concerned authorities.

6. Sent Data: The data, including the fill level and location of the dustbin, is sent to the user. This ensures that the relevant information is accessible for monitoring and management purposes.

7. User: The end user, typically waste management authorities or personnel, receives the data. They can take necessary actions, such as dispatching collection teams to empty the bins that are full.

2.2 Design alternatives

1. Image Processing and Machine Learning

   Utilizing image processing and machine learning, the SMART Garbage Monitoring and Management System can classify and sort waste more efficiently. Cameras and computer vision algorithms can identify different types of waste materials, enhancing recycling efforts. Machine learning models can predict waste generation patterns, optimizing collection schedules and improving overall system performance by learning from historical data.

2. Weight Sensing System (ESP32, Arduino, or LPC1768)

   A weight sensing system integrated with ESP32, Arduino, or LPC1768 microcontrollers can accurately measure the fill level of garbage bins by determining the weight of the waste. This method complements ultrasonic sensors by providing an additional data point, ensuring more precise monitoring. The weight data can be transmitted to a central server for analysis, triggering alerts when bins reach their capacity and ensuring timely collection.

3. IR Sensor Monitoring System (ESP32, Arduino, or LPC1768)

   An IR sensor monitoring system using ESP32, Arduino, or LPC1768 microcontrollers can detect the presence of waste near the bin opening. IR sensors can be used to automatically open and close the bin lid, enhancing hygiene by minimizing physical contact. Additionally, these sensors can monitor the fill level, providing real-time data to the central management system and ensuring efficient waste collection.

4. Ultrasonic Monitoring System (ESP32, Arduino, or LPC1768)

   Ultrasonic sensors integrated with ESP32, Arduino, or LPC1768 microcontrollers measure the distance between the sensor and the waste surface, determining the fill level of garbage bins. This system provides real-time monitoring, with data transmitted to a central server. When bins are nearly full, alerts are sent to waste management authorities, ensuring timely collection. This approach prevents overflow, maintains cleanliness, and optimizes waste collection routes.

2.3 Final design

The Ultrasonic Monitoring System uses ultrasonic sensors integrated with ESP-8266 to measure the distance between the sensor and the waste surface in garbage bins and notify it.

1. Sensor Placement:
Ultrasonic sensors are mounted at the top of the garbage bins. These sensors emit ultrasonic waves that reflect off the surface of the waste.

2. Distance Measurement:
The sensor calculates the time taken for the emitted waves to bounce back from the waste surface. Using this time delay, the sensor computes the distance between itself and the waste.

3. Fill Level Determination:
ESP-8266 processes the distance data to determine the fill level of the bin. This information is continuously monitored to track the changing waste levels in real-time.

4. Data Transmission:
The fill level data is transmitted to a central server via wireless communication (e.g., Wi-Fi, GSM, or other networks supported by the microcontroller). The central server collects data from multiple bins for centralized monitoring and analysis.

5. Alert System:

When a bin approaches its full capacity, the system triggers alerts. Notifications are sent to waste management authorities through emails, SMS, or app notifications. This ensures that bins are emptied before they overflow, maintaining cleanliness and preventing littering.

6. Route Optimization:

Data from multiple bins can be analyzed to optimize waste collection routes. Bins that are nearly full are prioritized, reducing unnecessary trips and fuel consumption.

7. Benefits:

Real-Time Monitoring: Provides up-to-date information on bin status. Prevent Overflow: Ensures timely collection, preventing overflow and associated hygiene issues.

Operational Efficiency: Optimizes collection schedules and routes, saving time and resources.

Environmental Impact: Reduces fuel consumption and emissions by preventing unnecessary collection trips.

8. Scalability and Integration:

The system can be scaled to cover larger areas by adding more bins with sensors. It can be integrated with other smart city solutions for comprehensive urban management.

2.4 Flow Chart

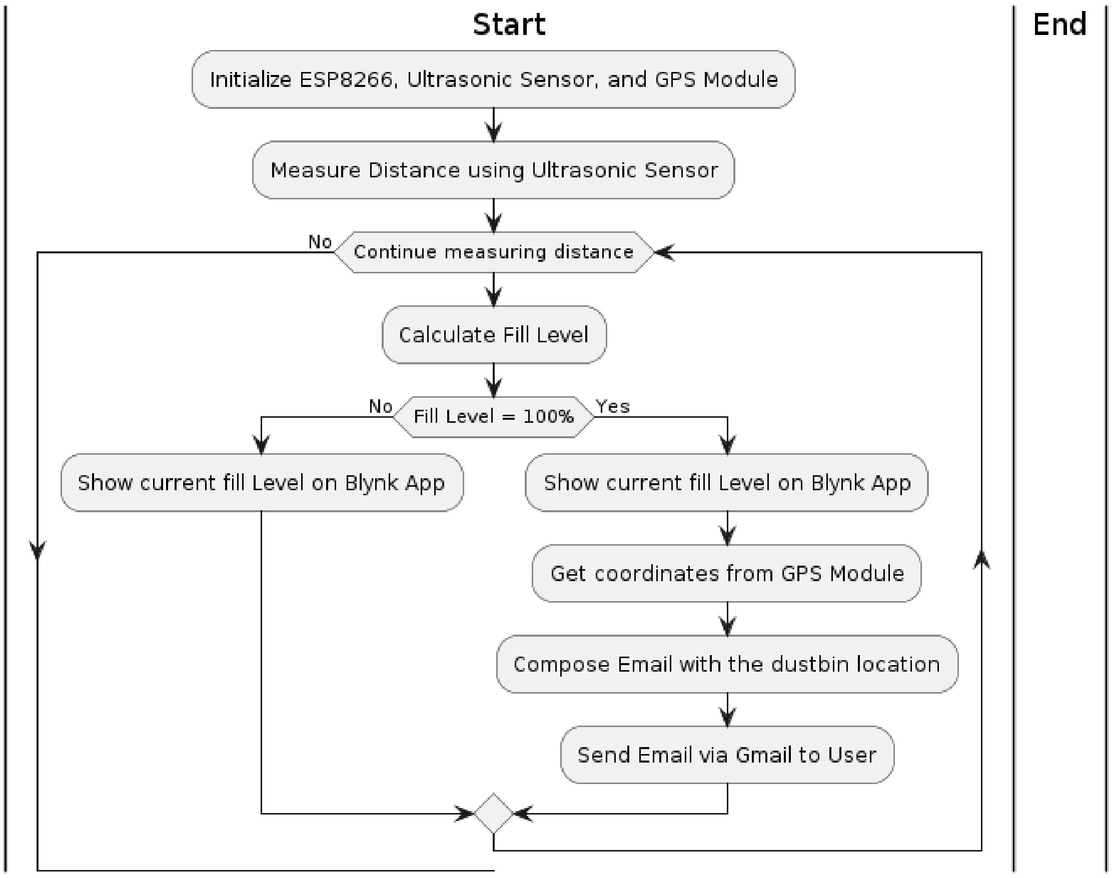

Figure 2.2: Flow Chart

Chapter 3

Implementation Details

3.1 Specifications and final system architecture

Specifications

1. Controller Unit: ESP-8266 A Wi-Fi-enabled microcontroller that handles data processing and communication.

2. Ultrasonic Sensor: HC-SR04 Measures the distance between the sensor and the waste surface to determine the fill level of the garbage bin.

3. GPS Module: NEO-6M with EEPROM Provides real-time location data of the garbage bins, allowing for precise tracking and efficient route planning.

4. IoT Application: Blynk Used for remote monitoring and management of the garbage bins. The application provides a user-friendly interface for real-time data visualization and alerts.

5. Notification System: Email Sends notifications and location links to waste management authorities when bins are nearly full, ensuring timely collection.

Final System Architecture

1. Garbage Bin with Sensors: Each garbage bin is equipped with an HC-SR04 ultrasonic sensor and a NEO-6M GPS module. The sensors continuously monitor the fill level and location of the bin.

2. ESP-8266 Microcontroller: The sensor data is sent to the ESP-8266 microcontroller. This microcontroller processes the fill level data from the ultrasonic sensor and the location data from the GPS module. The ESP-8266 is also responsible for connecting to the Wi-Fi network and transmitting data to the central server.

3. Data Transmission and Processing: Processed data, including the fill level and location of each bin, is transmitted over the Wi-Fi network to the central server. This data is then integrated into the Blynk IoT application for real-time monitoring.

4. Blynk IoT Application: The Blynk application provides a dashboard for waste management authorities to monitor the status of all garbage bins. It displays real-time fill levels, locations, and sends alerts when bins are nearly full.

5. Notification System: When a bin approaches its capacity, the system sends an email notification containing the fill level and a location link to the relevant authorities. This ensures that the bin is emptied before it overflows.

6. Central Server: The central server collects and stores data from all bins, enabling detailed analysis and reporting. It also helps optimize waste collection routes based on the fill levels and locations of the bins, thereby improving operational efficiency.

Chapter 4

Optimization

4.1 Intoduction to optimization

Optimization in waste management involves enhancing the efficiency and effectiveness of garbage collection processes to minimize costs, reduce environmental impact, and improve service quality. In the context of our SMART Garbage Monitoring and Management System, optimization plays a crucial role in several areas:

Route Optimization:

By using real-time data from ultrasonic sensors and GPS modules, the system can optimize waste collection routes. Bins that are nearly full are prioritized, ensuring that no bin overflows and reducing unnecessary trips. This leads to significant savings in fuel and time.

Resource Allocation:

Optimization ensures that waste collection resources (trucks, personnel) are allocated efficiently. By predicting waste generation patterns, the system can schedule collections at optimal times, reducing labor costs and improving service reliability.

Timely Notifications:

The system's ability to send timely notifications to waste management authorities ensures that bins are emptied before they overflow, maintaining cleanliness and hygiene in the locality. This proactive approach helps prevent public health issues and enhances community satisfaction.

Chapter 5

Results and discussions

5.1 Result Analysis

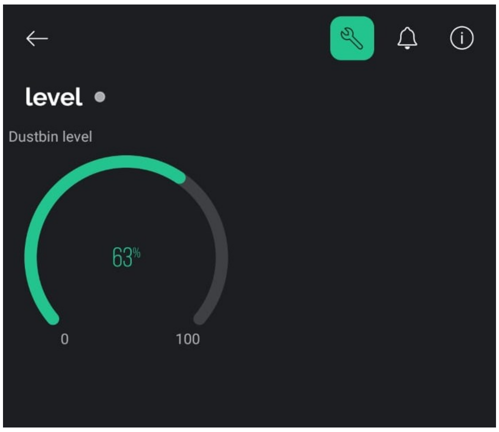

Figure 5.1: Blynl IOT App

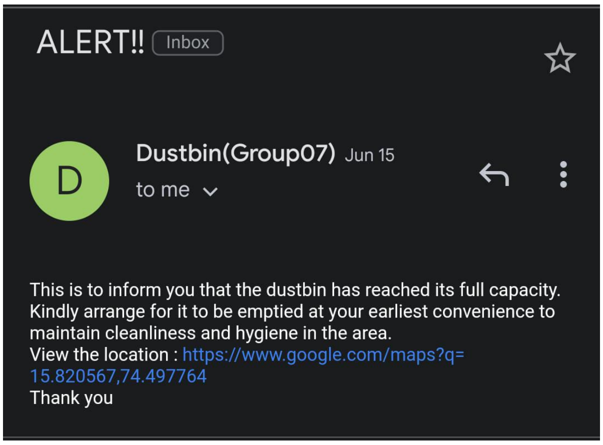

Figure 5.2: Location notification through Email

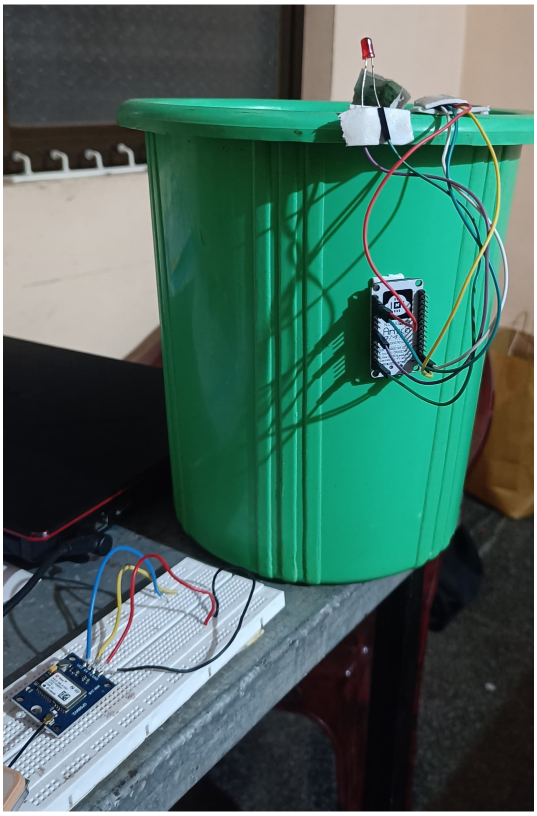

Figure 5.3: Implementation

The implementation shown above [Figure 5.3] is a prototype of the dustbins that are the part of our Smart Garbage Management System. It utilizes an ESP8266 microcontroller, ultrasonic sensor, and GPS module to monitor and manage the fill levels of dustbins in real-time. The system provides efficient waste collection by indicating fill levels via the Blynk IoT app [Figure 5.1] and sending location-based alerts via email when a dustbin requires emptying [Figure 5.2]. The fill level of the dustbin is continuously monitored on the app, and once the fill level reaches 100 percent, that is if the dustbin is completely filled, the user is notified through a mail including with the dustbin's location indicating it to empty it.

Chapter 6

Conclusions and future scope

6.1 Conclusion

The Smart Garbage Monitoring and Management System exemplifies the transformative power of technology in modern urban waste management. By leveraging an ESP-8266 based platform and ultrasonic sensors, the system provides real-time monitoring of garbage bin levels and ensures timely notifications for waste collection. This innovation not only prevents overflow and maintains cleanliness but also significantly optimizes waste collection routes, leading to reduced operational costs and lower environmental impact.

The system's ability to gather and analyze data on waste generation patterns offers valuable insights for urban planners and policymakers, facilitating informed decisions on infrastructure and service improvements. This data-driven approach contributes to more efficient and sustainable urban management practices.

Moreover, by reducing unnecessary collection trips and minimizing fuel consumption, the system supports environmental sustainability goals and helps cities reduce their carbon footprint. The enhanced efficiency and effectiveness of waste management services also lead to a higher quality of life for residents, promoting public health and creating more pleasant urban environments.

In conclusion, the Smart Garbage Monitoring and Management System is a significant step forward in addressing the challenges of urban waste management. Its implementation can lead to cleaner cities, more efficient use of resources, and a positive impact on the environment and public health, showcasing the potential of smart technologies in creating smarter, more sustainable urban spaces.

6.2 Future scope

Here's an exploration of the future scope of SMART GARBAGE MONITORING AND MANAGEMENT SYSTEM development in different applications:

The Smart Garbage Monitoring and Management System holds significant potential for future enhancements and expansions. One promising direction is integrating machine learning algorithms to predict waste generation patterns and optimize collection schedules dynamically. This would further enhance efficiency and resource utilization. Additionally, incorporating solar-powered sensors and IoT devices can make the system more sustainable and self-sufficient.

Expanding the system's capabilities to include recycling management by sorting waste at the source can also be explored. This would involve using sensors to distinguish between different types of waste, promoting better recycling practices and reducing landfill usage. Moreover, integrating the system with smart city platforms can enable more comprehensive urban management, linking waste management with other city services such as transportation and energy management.

Another avenue for expansion is developing mobile applications for residents to report issues, view collection schedules, and receive notifications about waste management activities in their area. This would increase community engagement and awareness, fostering a collaborative approach to maintaining cleanliness and sustainability.

Collaborations with municipalities and waste management companies can also help scale the system to cover larger areas, including rural regions, where waste management infrastructure may be lacking. This expansion could address broader environmental and public health challenges, making efficient waste management accessible to a wider population.

Overall, the further scope of the SMART Garbage Monitoring and Management System encompasses technological advancements, expanded functionalities, and increased community involvement, all aimed at creating more efficient, sustainable, and smart urban environments.

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