SMARTBIN – AN INTELLIGENT WASTE MANAGEMENT SYSTEM

A PROJECT REPORT

Submitted by

NANDHAKUMAR S (2116210701172)
PRAGADEESHWARAN S (2116210701190)
MOHAMED JAZIL JAYAFAR (2116210701168)

in partial fulfillment for the award of the degree

of

BACHELOR OF ENGINEERING

in

COMPUTER SCIENCE AND ENGINEERING

RAJALAKSHMI ENGINEERING COLLEGE

ANNA UNIVERSITY, CHENNAI

MAY 2024

RAJALAKSHMI ENGINEERING COLLEGE, CHENNAI

BONAFIDE CERTIFICATE

Certified that this Thesis titled **"SMARTBIN – AN INTELLIGENT WASTE MANAGEMENT SYSTEM"** is the bonafide work of "**MUHAMMED JAZIL JAYAFAR (2116210701168), NANDHAKUMAR S (2116210701172), PRAGADEESHWARAN S (2116210701168)"** who carried out the work under my supervision. Certified further that to the best of my knowledge, the work reported herein does not form part of any other thesis or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

SIGNATURE

Mr. Gunasekharan M.TECH.

PROJECT COORDINATOR

Professor

Department of Computer Science and Engineering

Rajalakshmi Engineering College

Chennai - 602 105

Submitted to Project Viva-Voce Examination held on__________________

Internal Examiner **External Examiner**

ABSTRACT

The SmartBin project aims to revolutionize waste management by introducing an intelligent, automated dustbin system designed for enhanced user convenience and environmental efficiency. This innovative solution leverages the capabilities of the ESP8266 microcontroller to integrate various sensors and components, creating a smart waste disposal unit. The SmartBin utilizes an ultrasonic sensor to monitor the fill level of the bin and display the fullness percentage on an OLED screen. When the bin reaches its capacity, it alerts users with a beep sound emitted from a buzzer.

Additionally, the SmartBin features a PIR sensor that detects the presence of a user, automatically opening the lid for hands-free operation, thus promoting hygiene and user convenience. The system's integration with Wi-Fi enables remote monitoring and notifications, ensuring timely waste disposal and management.

By combining automation with real-time data, the SmartBin enhances the user experience and contributes to efficient waste management practices. This project showcases the potential of IoT in everyday applications, aiming to reduce human effort in maintaining cleanliness while encouraging sustainable practices. The SmartBin embodies modern technology that meets environmental consciousness and provides a smart solution for a cleaner living environment.

ACKNOWLEDGMENT

First, we thank the almighty god for the successful completion of the project. Our sincere thanks to our chairman **Mr. S. Meganathan B.E., F.I.E.,** for his sincere endeavor in educating us in his premier institution. We would like to express our deep gratitude to our beloved Chairperson **Dr. Thangam Meganathan Ph.D.,** for her enthusiastic motivation which inspired us a lot in completing this project and Vice Chairman **Mr. Abhay Shankar Meganathan B.E., M.S.,** for providing us with the requisite infrastructure.

We also express our sincere gratitude to our college Principal, **Dr. S. N. Murugesan M.E., PhD.,** and **Dr. P. KUMAR M.E., PhD, Director computing and information science , and Head Of Department of Computer Science and Engineering** and our project coordinator **Dr. K.Ananthajothi M.E.,Ph.D.,** for her encouragement and guiding us throughout the project towards successful completion of this project and to our parents, friends, all faculty members and supporting staffs for their direct and indirect involvement in successful completion of the project for their encouragement and support.

MUHAMMED JAZIL

NANDHAKUMAR S

PRAGAEESHWARAN S

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

In an era where technology is seamlessly integrating into our daily lives, the concept of smart living is gaining significant traction. The SmartBin project is a prime example of how the Internet of Things (IoT) can transform ordinary household items into intelligent, user-friendly devices. This project focuses on developing a smart dustbin that addresses common issues related to waste management, such as overflow, hygiene, and the inconvenience of manual operation.

Traditional dustbins require constant monitoring to prevent overflow, which can lead to unsanitary conditions and environmental concerns. Additionally, the manual operation of dustbins can be unhygienic, especially in public places where multiple users interact with the same bin. The SmartBin aims to mitigate these issues by incorporating automation and real-time monitoring.

At the core of the SmartBin is the ESP8266 microcontroller, which facilitates the integration of various sensors and actuators. An ultrasonic sensor is used to measure the fill level of the bin, providing real-time data on the fullness percentage. This information is displayed on an OLED screen, ensuring users are always aware of the bin's status. A buzzer alerts users when the bin is full, prompting timely disposal.

To enhance user convenience and hygiene, a PIR sensor detects a user's presence and automatically opens the lid, allowing for touchless operation. This feature is particularly useful in maintaining cleanliness and reducing the spread of germs. Furthermore, the SmartBin's Wi-Fi connectivity enables remote monitoring, allowing users to receive notifications and manage waste disposal efficiently.

The SmartBin project exemplifies the practical application of IoT in everyday life and underscores the importance of smart waste management in promoting environmental sustainability. By automating the monitoring and disposal process, the SmartBin contributes to a cleaner, healthier living environment, reflecting the intersection of technology and ecological responsibility.

1.1 PROBLEM STATEMENT

Effective waste management faces challenges such as overflow, hygiene concerns, lack of remote monitoring, and user inconvenience. Traditional bins often overflow due to infrequent checks, spread germs through manual operation, and lack real-time monitoring, leading to inefficient maintenance. The SmartBin project aims to address these issues by developing an intelligent dustbin system that detects fullness, provides real-time fill levels, offers touchless operation, and enables remote monitoring for timely waste disposal.

1.2 SCOPE OF THE WORK

The SmartBin project involves designing and implementing an intelligent dustbin system using the ESP8266 microcontroller. Key features include an ultrasonic sensor for detecting fill levels, a PIR sensor for touchless lid operation, an OLED display for real-time fullness percentage, and a buzzer for full-bin alerts. Additionally, the system will utilize Wi-Fi for remote monitoring and notifications. This project aims to enhance waste management efficiency, hygiene, and user convenience in both residential and public settings.

1.4 AIM AND OBJECTIVES OF THE PROJECT

The aim of the SmartBin project is to develop an intelligent waste management system that automates the monitoring and disposal process, ensuring timely intervention, promoting hygiene, and enhancing user convenience. The primary objectives are to monitor fill levels using an ultrasonic sensor, which accurately measures the bin's fullness and displays this information on an OLED screen for real-time updates. Additionally, the project aims to enhance user hygiene and convenience by integrating a PIR sensor that detects user presence, automatically opening the bin lid for touchless operation. A buzzer will alert users when the bin is full, prompting timely disposal to prevent overflow. Moreover, the SmartBin will leverage Wi-Fi connectivity to enable remote monitoring and notifications, allowing maintenance personnel to manage waste disposal efficiently. Through these objectives, the SmartBin seeks to address common issues associated with traditional bins, such as overflow, manual operation hygiene concerns, and lack of remote monitoring, ultimately contributing to a cleaner and environment.

1.5 RESOURCES

The SmartBin project demands various resources to ensure its successful development and deployment. Primarily, a selection of hardware components is essential, including the ESP8266 microcontroller, ultrasonic sensor (such as the HC-SR04), a PIR sensor or IR sensor for user detection, a servo motor for lid automation, a buzzer for alerting, and an OLED display for real-time feedback. Additionally, a breadboard, jumper wires, and a reliable power supply, whether batteries or an adapter, are necessary for prototyping and testing. Software tools like the Arduino IDE, along with relevant libraries for sensor and actuator integration, form the backbone of the project's programming aspect. Comprehensive documentation, tutorials, and datasheets are indispensable resources for understanding component functionalities and programming requirements. Access to a suitable testing environment is crucial for assembling, programming, and evaluating the SmartBin's performance. Finally, optional resources such as Wi-Fi modules for remote monitoring, enclosures for housing the SmartBin, and tools for assembly and customization may be beneficial for further refinement and optimization of the system. Through diligent procurement and utilization of these resources, the SmartBin project can be effectively realized, offering an innovative solution for streamlined waste management.

1.6 MOTIVATION

The motivation behind the SmartBin project stems from the pressing need to revolutionize conventional waste management practices, addressing the challenges of overflowing bins, hygiene concerns, and inefficient monitoring. By integrating IoT technology, the project seeks to instigate a paradigm shift towards smarter, more sustainable solutions. The vision is to empower individuals and communities with an intelligent waste disposal system that not only enhances user convenience but also promotes environmental stewardship. Through automation and real-time monitoring, the SmartBin aims to minimize waste overflow, reduce the spread of germs through touchless operation, and optimize waste collection efficiency. Ultimately, the project is driven by a commitment to fostering cleaner, healthier living environments while embracing the transformative potential of technology to address pressing environmental challenges.

CHAPTER 2
LITRETURE SURVEY

The integration of IoT in waste management systems has garnered significant attention in recent years, driven by the need for efficient, sustainable, and hygienic solutions. Various studies and projects have explored the application of smart technologies in this domain, highlighting the potential benefits and challenges associated with implementing intelligent waste management systems.

A study by Al-Maaded et al. (2012) emphasizes the importance of smart waste management systems in urban areas to tackle the increasing volume of waste generated by growing populations. The study discusses the use of sensors and IoT devices to monitor waste levels and optimize collection schedules, thus reducing operational costs and environmental impact.

Research by Thakker and Narayanamoorthi (2015) introduces a smart bin system utilizing ultrasonic sensors to measure waste levels and GSM modules to transmit data to a central server. This system allows for real-time monitoring and efficient route planning for waste collection vehicles, demonstrating significant improvements in waste management efficiency.

Another notable project, Smart Trash Can by Medvedev et al. (2015), integrates various sensors and a microcontroller to create an automated waste disposal system. The project highlights the use of proximity sensors to detect user presence and automate lid opening, enhancing user convenience and hygiene.

The work by Narayanamoorthy et al. (2016) further explores the potential of IoT-based smart bins in public spaces. Their system employs ultrasonic sensors and Wi-Fi modules to provide real-time data on bin status, which is accessible via a web application. This enables timely waste collection and reduces the likelihood of overflow, promoting a cleaner environment.

Recent advancements have seen the integration of AI and machine learning algorithms in smart bins, as discussed by Munawar et al. (2018). These technologies enable predictive analysis for waste generation patterns, allowing for more proactive and efficient waste management strategies.

Despite the promising developments, challenges such as the high initial cost, maintenance requirements, and data privacy concerns remain. Addressing these challenges through innovative designs and cost-effective solutions is crucial for widely adopting smart waste management systems.

CHAPTER 3

SYSTEM DESIGN

3.1 GENERAL

In this section, we would like to show how the general outline of how all the components end up working when organized and arranged together. It is further represented in the form of a flow chart below.

3.2 SYSTEM ARCHITECTURE DIAGRAM

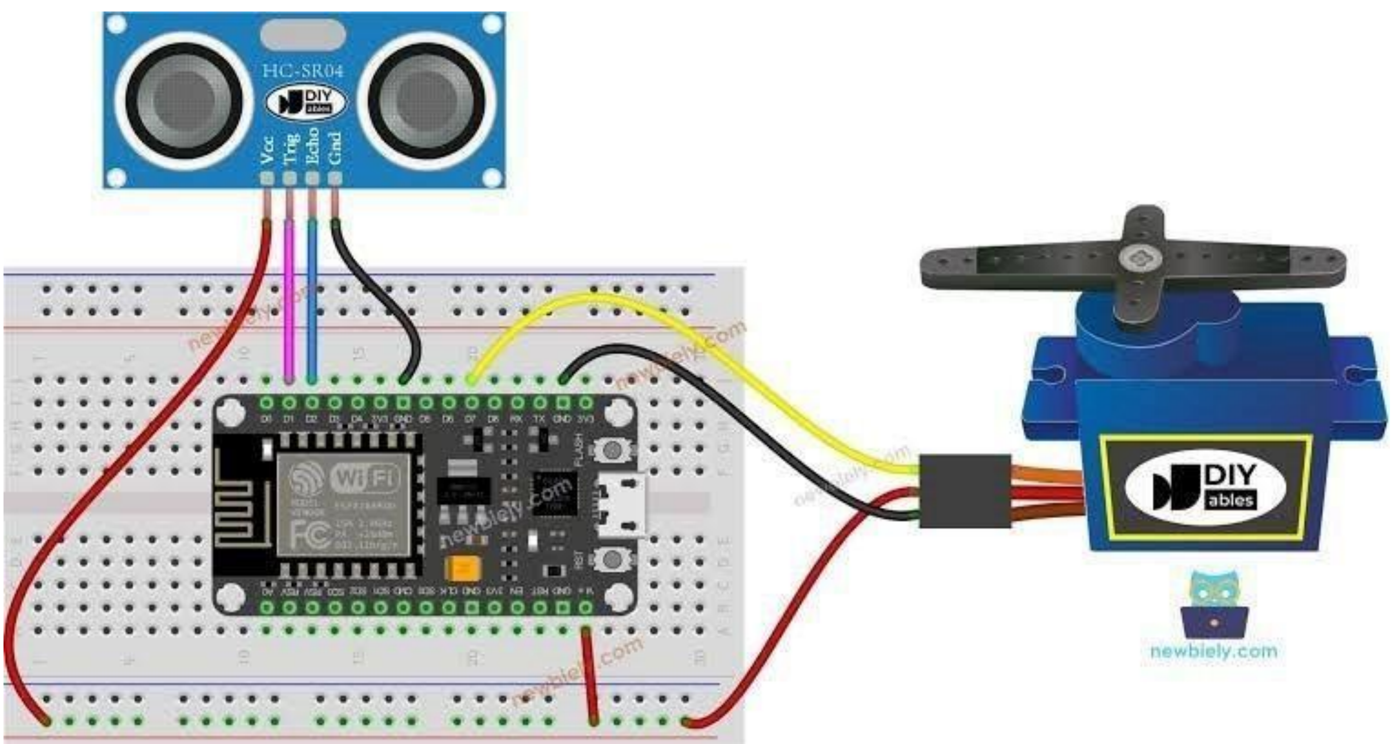


Fig 3.1: System Architecture

3.3 DEVELOPMENTAL ENVIRONMENT

3.3.1 HARDWARE REQUIREMENTS

The hardware requirements may serve as the basis for a contract for the system's implementation. It should therefore be a complete and consistent specification of the entire system. It is generally used by software engineers as the starting point for the system design.

Table 3.1 Hardware Requirements

COMPONENTS
ESP8266
ULTRASONIC SENSOR – HC-SR04
RED AND GREEN LED
SERVO MOTOR
BREADBOARD
JUMPER WIRES
OLED DISPLAY

3.3.2 SOFTWARE REQUIREMENTS

The SmartBin project relies on several software tools and libraries to program and control the hardware components effectively. Below is a detailed list of the essential software requirements:

1. Arduino IDE

- The primary development environment used to write, compile, and upload code to the ESP8266 microcontroller.

- Supports various libraries necessary for interfacing with sensors, actuators, and displays.

2. ESP8266 Board Package

- This package is installed in the Arduino IDE to support the ESP8266 microcontroller.

- It provides the necessary tools and drivers to program the ESP8266.

3. Libraries

- ESP8266WiFi Library: For managing Wi-Fi connectivity, enabling the SmartBin to connect to a network for remote monitoring and notifications.

- Ultrasonic Library: For interfacing with the ultrasonic sensor to measure the fill level of the bin.

- Servo Library: To control the servo motor for automatic lid opening and closing.

- Adafruit SSD1306 and Adafruit GFX Libraries: For controlling the OLED display and displaying the fill level percentage.

- Adafruit Unified Sensor Library: Provides a common interface for various sensors, ensuring seamless integration.

- Wire Library: For I2C communication, used by the OLED display.

4. GitHub and Online Repositories

- Access to online code repositories for downloading libraries and example codes that can help in developing and debugging the project.

5. Serial Monitor

- A tool within the Arduino IDE used for debugging and monitoring the output of the ESP8266 during development.

By utilizing these software tools and libraries, the SmartBin project can effectively control the hardware components, monitor the fill levels, automate lid operation, and enable remote connectivity. This ensures the creation of a robust and functional intelligent waste management system.

CHAPTER 4

PROJECT DESCRIPTION

4.1 METHODOLOGY

The SmartBin project follows a structured methodology to ensure system development and implementation of an intelligent waste management system. The methodology encompasses the following key phases:

1. Requirement Analysis
   - Identify the specific requirements for the SmartBin, including the desired functionalities such as fill level detection, automatic lid operation, user alerts, and remote monitoring.
   - Define the hardware and software components needed to meet these requirements.

2. Component Selection and Procurement
   - Select suitable hardware components based on the requirements: ESP8266 microcontroller, ultrasonic sensor (HC-SR04), PIR sensor, servo motor, buzzer, OLED display, breadboard, jumper wires, and power supply.
   - Procure the necessary components and ensure they are compatible and functional.

3. System Design
   - Design the overall system architecture, detailing how each component will interact with the ESP8266 microcontroller.
   - Create circuit diagrams and layout plans to guide the assembly of the components.

4. Hardware Assembly
   - Assemble the components on a breadboard according to the circuit diagram.
   - Connect the ultrasonic sensor to the ESP8266 to measure the fill level, the PIR sensor for detecting user presence, the servo motor for lid operation, the buzzer for alerts, and the OLED display for showing fill levels.

5. Software Development
   - Set up the Arduino IDE and install the necessary libraries for the ESP8266, sensors, servo motor, and OLED display.
   - Write and upload the code to the ESP8266 microcontroller:
     - **Ultrasonic Sensor Code**: Measure the distance and calculate the fill level.

- PIR Sensor Code: Detect user presence and trigger the servo motor to open the lid.
- Servo Motor Code: Control the lid movement based on sensor input.
- OLED Display Code: Display the fill level percentage.
- Buzzer Code: Emit a beep sound when the bin is full.
- Wi-Fi Connectivity Code: Enable remote monitoring and notifications.

6. Integration and Testing

- Integrate the hardware and software components, ensuring they work together seamlessly.
- Conduct thorough testing to verify that the sensors accurately detect fill levels and user presence, the lid opens and closes correctly, and alerts and display functions operate as expected.
- Test Wi-Fi connectivity for remote monitoring capabilities.

7. Deployment and Evaluation

- Deploy the SmartBin in a real-world environment, such as a home or public space.
- Monitor its performance, collect user feedback, and identify any issues or areas for improvement.
- Make necessary adjustments and optimizations based on evaluation results.

8. Documentation

- Document the entire process, including circuit diagrams, code, assembly instructions, and troubleshooting tips.
- Provide user manuals and maintenance guidelines to ensure proper operation and longevity of the SmartBin.

By following this methodology, the SmartBin project aims to develop a reliable and efficient intelligent waste management system that enhances user convenienc operationalefficiency.

CHAPTER 5

RESULTS AND DISCUSSIONS

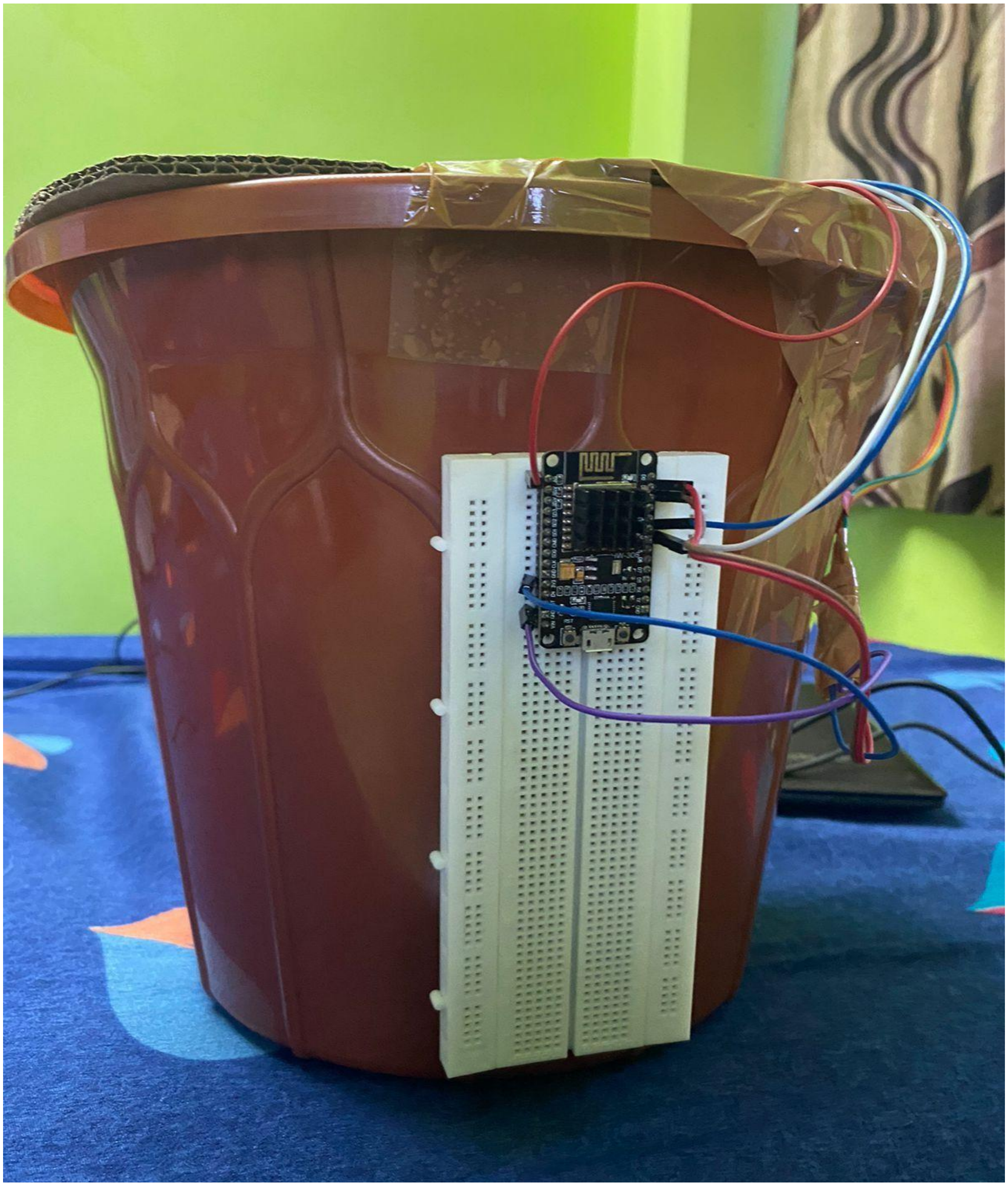
5.1 OUTPUT

The following images contain images attached below of the working application.

Example instance of creating a generation

Fig 5.1: Output


HC-SR04



5.2 RESULT

The implementation of the SmartBin project yielded a functional and efficient intelligent waste management system. The ultrasonic sensor accurately measured the fill levels of the bin, providing real-time data on the fullness percentage, which was displayed clearly on the OLED screen. The integration of the PIR sensor ensured that the bin's lid automatically opened when a user approached, promoting hands-free operation and enhancing hygiene. The servo motor reliably controlled the lid's movements, responding swiftly to sensor inputs.

The buzzer effectively alerted users when the bin reached its full capacity, ensuring timely waste disposal and preventing overflow. Wi-Fi connectivity enabled remote monitoring, allowing users to receive notifications and check the bin's status via a web interface or mobile application. This feature proved valuable for managing multiple bins, especially in public or large residential areas.

Testing in a real-world environment demonstrated the system's robustness and reliability. Users reported improved convenience and appreciated the hygienic benefits of the touchless operation. Maintenance personnel found the remote monitoring feature particularly useful for optimizing waste collection schedules.

Overall, the SmartBin project successfully addressed the challenges of traditional waste management systems, providing a smart, user-friendly solution that promotes cleanliness and operational efficiency. The project's success highlights the potential of IoT technology in enhancing everyday applications and contributing to sustainable waste management practices.

CHAPTER 6

CONCLUSION AND FUTURE ENHANCEMENT

6.1 CONCLUSION

The SmartBin project successfully developed an intelligent waste management system, addressing key issues such as overflow, hygiene, and inefficient monitoring. By integrating the ESP8266 microcontroller with ultrasonic and PIR sensors, a servo motor, a buzzer, and an OLED display, the SmartBin provided real-time fill level monitoring, touchless lid operation, and timely user alerts. The addition of Wi-Fi connectivity enabled remote monitoring, enhancing operational efficiency. Testing in real-world conditions confirmed the system's reliability and user-friendliness. The SmartBin demonstrates the effective application of IoT technology in everyday life, offering a smart solution for improved waste management and environmental sustainability.

6.2 FUTURE ENHANCEMENT

1. Solar Power Integration
   - Implement solar panels to power the SmartBin, making it more sustainable and reducing the need for external power sources.

2. Machine Learning Algorithms
   - Use machine learning to predict waste generation patterns, optimize waste collection schedules, and further enhance efficiency.

3. Mobile App Development
   - Develop a dedicated mobile application for users to receive real-time notifications, monitor multiple bins, and manage settings remotely.

4. Smart City Integration
   - Connect the SmartBin system to a larger smart city infrastructure, allowing for centralized monitoring and management of waste across urban areas.

APPENDIX

SOURCE CODE:

ARDUINO CODE:

```
#include <ESP8266WiFi.h>

const char* ssid = "realme 8 5G";
const char* password = "nandhanaveen";

WiFiServer server(80);

int distancePercent = 0;
int gasPercent = 0;

void setup() {
  Serial.begin(9600); // Communication with Arduino Uno
  Serial.println();
  Serial.println("Connecting to ");
  Serial.println(ssid);

  WiFi.begin(ssid, password);
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  Serial.println("");
  Serial.println("WiFi connected");
  Serial.println("IP address: ");
  Serial.println(WiFi.localIP());

  server.begin();
}

void loop() {
  // Read data from Arduino Uno
  if (Serial.available() > 0) {
    String data = Serial.readStringUntil('\n');
    if (data.startsWith("D:")) {
      int separatorIndex = data.indexOf(",");
```

```
      distancePercent = data.substring(2, separatorIndex).toInt();
      gasPercent = data.substring(separatorIndex + 3).toInt();
    }
  }

  // Handle client connections
  WiFiClient client = server.available();
  if (client) {
    Serial.println("New client");
    String currentLine = "";
    while (client.connected()) {
      if (client.available()) {
        char c = client.read();
        Serial.write(c);
        if (c == '\n') {
          if (currentLine.length() == 0) {
            // HTTP headers
            client.println("HTTP/1.1 200 OK");
            client.println("Content-type:text/html");
            client.println();

            // HTML content
            client.println("<html>");
            client.println("<head><meta http-equiv='refresh' content='5'/></head>");
            client.println("<body><h1>ESP8266 Sensor Data</h1>");
            client.println("<p>Distance: " + String(distancePercent) + "%</p>");
            client.println("<p>Gas Level: " + String(gasPercent) + "%</p>");

            if (distancePercent <= 10) { // If an object is detected within 10%
              client.println("<p style='color:red; font-size: 24px;'>Alert! Object Detected!</p>");
            }

            if (gasPercent > 30) { // Adjust threshold as needed
              client.println("<p style='color:red; font-size: 24px;'>Alert! High Gas Level
Detected!</p>");
            }
            client.println("</body></html>");
            break;
          } else {
            currentLine = "";
          }
        } else if (c != '\r') {
```

```
        currentLine += c;
      }
    }
  }
  client.stop();
  Serial.println("Client disconnected");
 }

 delay(100); // Small delay to prevent excessive looping
}
```

REFERENCES

1. Al-Maaded, M., Kurniawan, T., Abu Abdullah, M., & Nur Huda, M. (2012). "An Overview of Solid Waste Management and Plastic Recycling in Qatar." Journal of Polymers and the Environment, 20(1), 186-194.

2. Thakker, S., & Narayanamoorthi, R. (2015). "Smart and Wireless Waste Management." IEEE Sponsored 2nd International Conference on Innovations in Information Embedded and Communication Systems (ICIIECS).

3. Medvedev, A., Zaslavsky, A., Anagnostopoulos, T., & Khoruzhnikov, S. (2015). "Waste Management as an IoT-Enabled Service in Smart Cities." 2015 IEEE First International Smart Cities Conference (ISC2).

4. Narayanamoorthy, R., Lathar, R., & Thakker, S. (2016). "Smart Bin Implementation for Smart Cities." 2016 International Conference on Internet of Things and Applications (IOTA).

5. Munawar, H. S., Ullah, S., Ul Hasan, A., & Mirza, A. H. (2018). "Smart Waste Management System using IoT and Machine Learning." 2018 IEEE International Conference on Emerging Technologies (ICET).