Project Report On

SMART GARBAGE SYSTEM

By

Khushwant Chauhan (4)

Samata Kadam (13)

Bhakti Lambate (15)

Department of
Electronics Engineering (VLSI Design & Technology)

Vidyavardhini's College of Engineering & Technology

University of Mumbai

2024-25

SMART GARBAGE SYSTEM

Submitted in partial fulfillment of the requirements
of degree of ***Bachelor of Engineering Mini Project 1B*** *in*
Electronics Engineering (VLSI Design & Technology)
by

Khushwant Chauhan (04)
Samata Kadam (13)
Bhakti Lambate (15)

Supervisor
Prof. : Dr. Ashish Vanmali

Department of
Electronics Engineering (VLSI Design & Technology)
Vidyavardhini's College of Engineering & Technology
University of Mumbai

2024-25

Project Report Approval for Bachelor of Engineering

This project report entitled

SMART GARBAGE SYSTEM

by

Khushwant Chauhan (04)
Samata Kadam (13)
Bhakti Lambate (15)

for the award of degree of ***Bachelor of Engineering Mini Project 1B in Electronics Engineering (VLSI Design & Technology)*** *by the University of Mumbai during the academic year 2024-25.*

Supervisor : Dr. Ashish Vanmali ( )

Internal Examiner : Dr. Ashish Vanmali ( )

External Examiner : ____________________ ( )

____________________ ____________________

Dr. Amrita Ruperee — HOD, EXTC

Dr. Rakesh Himte — Principal, VCET

Date: ____________

Place: ____________

Declaration

We declare that this written submission represents our ideas in our own words, and where others ideas or words have been included, we have adequately cited and referenced the sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated, or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources that have thus not been properly cited or from whom proper permission has not been taken when needed.

Khushwant Chauhan ( )

Samata Kadam ( )

Bhakti Lambate ( )

Date: ____________________

Acknowledgement

We are pleased to acknowledge our Guide Dr. Ashish Vanmali and Head of Department, Dr. Amrita Ruperee for their invaluable contribution and guidance during this Project work and for providing the facilities to accomplish this project. We would also like to thank our College Principal, Dr. Rakesh Himte. We thank our EXTC Department for giving us the opportunity to work on this project and for helping us.

Khushwant Chauhan (04)

Samata Kadam (13)

Bhakti Lambate (15)

Abstract

Smart waste management systems leverage technology and data to optimize waste management processes from collection to disposal, making them more efficient, sustainable, and cost-effective. This project presents a sensor-based automation system leveraging an Arduino microcontroller, an infrared (IR) sensor, and an electromechanical relay to control a servo motor. The system is engineered to detect object presence via the IR sensor, which sends a digital signal to the Arduino for processing. Based on the sensor input, the Arduino activates or deactivates the relay, which in turn switches the servo motor on or off. This architecture demonstrates a low-cost, efficient, and scalable solution for motion-controlled systems, smart home devices, security systems, and basic robotics. The design eliminates the need for complex wiring by integrating direct module connections without a breadboard, optimizing space, and improving reliability.

Content

List of Figures

List of Tables

Chapter 1

Introduction

As the world's population grows at an unprecedented rate, more garbage waste is being generated daily, and waste management with proper collection from garbage bins is becoming more and more challenging and important. This study investigates the implementation of an IR sensor-based control system that uses an Arduino microcontroller and an electromechanical relay to actuate a servo motor. The system architecture is constructed such that when the IR sensor detects an item, it sends a digital signal to the Arduino. The microprocessor interprets this input and then activates the relay module, which acts as an electrical switch to activate or deactivate the linked servo motor.

This configuration shows a real-world application of sensor-based automation, integrating real-time data processing, embedded system control, and electromechanical actuation to provide efficient and responsive operation. Smart trash systems reduce landfill waste by integrating automated waste sorting and recycling procedures. This preserves natural resources, lowers greenhouse gas emissions, and prevents contamination. AI-driven systems distinguish biodegradable waste, making composting and recycling easier. Intelligent garbage systems also promote community awareness through mobile applications and public displays.

Chapter 2
Literature Survey

2.1 Smart Garbage Monitoring System Based on IoT

The paper "Smart Waste Management System Based on IoT" explores the pressing problem of efficient waste management, which is becoming more difficult as the world's population and economy rise. According to Mustafa M.R1 [2], operational inefficiencies and environmental issues result from old waste management systems to handle the complexity of contemporary trash disposal. The study presents a novel waste management system that makes use of the Internet of Things (IoT) capabilities to address these drawbacks. Waste collection vehicles, IoT-enabled smart dustbins, and an administrative module intended for thorough system monitoring comprise the three main parts of this suggested system, each of which is essential to the waste management ecosystem.

To optimise collection routes and cut down on needless fuel usage, waste collection vehicles are equipped with GPS technology, which allows for real-time tracking of their position and movement. Sensors installed in smart dustbins track the weight and fill level of the rubbish that is collected, giving prompt notice when the bins need to be emptied. The administration module, a centralised platform that provides a visual depiction of truck whereabouts, bin status, and other pertinent statistics, receives this data after that. The technology seeks to improve garbage collection operations' efficiency, reduce operating costs, and foster cleaner, more sustainable urban environments by offering real-time information and facilitating data-driven decision-making. This comparative viewpoint helps to place the writers' contributions in the larger context of intelligent waste management technology.

2.2 Smart Garbage Monitoring for Waste Management

The "Smart Garbage Monitoring System for Waste Management" study focuses exclusively on the problems associated with waste management in residential complexes, especially in apartments and flats with shared waste disposal facilities and large population densities. Trash overflow, unhygienic conditions, and possible health risks might result from these settings' trash capacity restrictions and certain inhabitants' haphazard disposal methods [1]. The authors describe the creation of a smart garbage monitoring system that provides real-time waste level monitoring within the bins to solve these particular issues.

The Arduino Uno microcontroller, which acts as the system's central control unit, receives data from ultrasonic sensors that monitor the amount of trash in each bin. The system automatically creates warning messages and transmits them to the municipality using a GSM module when the garbage level hits certain threshold levels, allowing for prompt waste collection and action. The device not only notifies the authorities but also uses LED displays to provide homeowners with visual clues about the condition of the bin, encouraging proper garbage disposal techniques [3]. The suggested system is to decrease the frequency of overflowing bins, enhance the effectiveness of waste disposal management in residential areas, and lessen the related health and environmental hazards by providing continuous monitoring and early notifications.

Chapter 3
Problem Definition

Due to their limited dynamic capabilities and lack of real-time data, current waste management systems have a difficult time optimising their operations. Lack of accurate and timely information about garbage bin fill levels is a major problem that results in ineffective collection routes and needless fuel use when collection trucks service bins that are not yet full [2]. Additionally, this causes delays in responding to urgent situations when overflowing dumpsters provide immediate hazards to sanitation and public health. The issue is made worse in residential areas with a high population density, like those with flats, where different resident behaviours and shared waste infrastructure lead to localised capacity problems and raise the risk of unhygienic conditions [1].

It is challenging for conventional static collection schedules to maintain a clean and healthy environment in these situations due to the unpredictability of trash creation and disposal. As a result, there is an urgent need for workable and affordable solutions that use technology to offer real-time garbage level and collection truck position tracking [2]. Additionally, by enabling dynamic optimisation of collection logistics, such systems ought to facilitate effective resource allocation and route planning. These tools should also make it easier for waste management authorities to take proactive measures, allowing them to deal with problems as soon as they arise and stop garbage from building up and posing a risk to public health and the environment.

Chapter 4

Proposed Method/ Approach

4.1 Block Diagram of the Proposed Approach

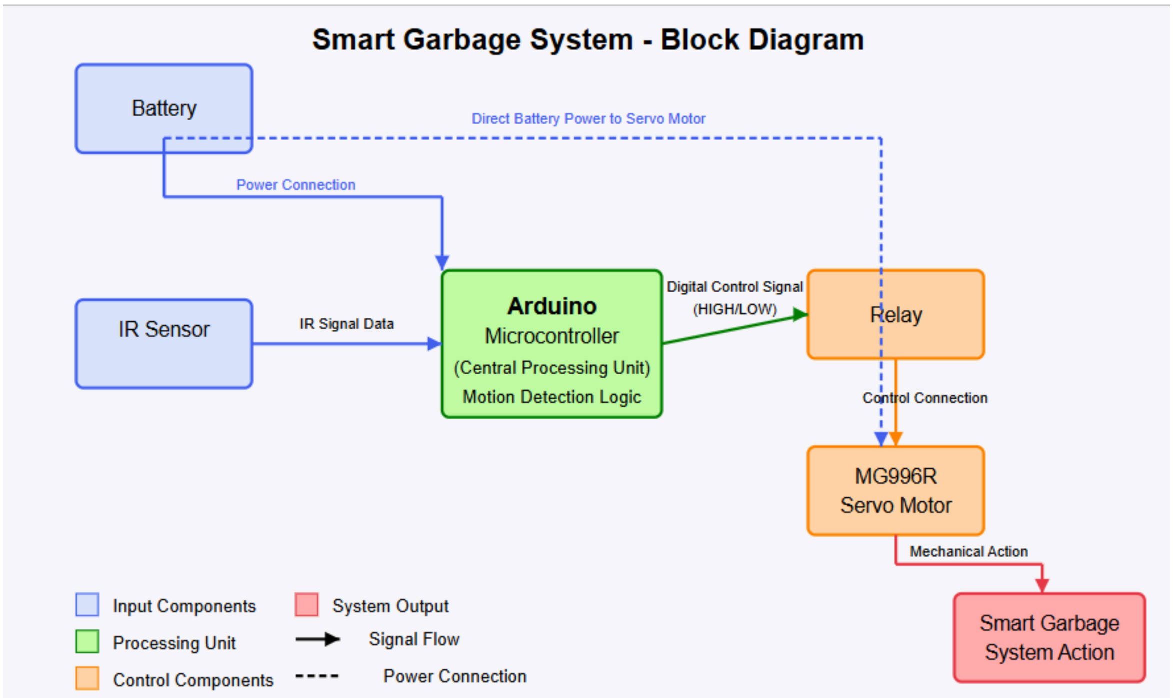

Fig 4.1: Block Diagram of Proposed Approach

The ultrasonic sensor detects sound waves and echoes, determining motion within a predefined threshold. The data is transmitted to the Arduino microcontroller, which serves as the central processing unit. The Arduino monitors these signals and defines a specific distance threshold. If the distance reading changes significantly or falls below the threshold, it interprets it as motion. The Arduino triggers the next stage of the system, which must be written and uploaded. The Arduino cannot directly power the MG996R servo motor, especially if powering it separately. Instead, it sends a control signal to a relay, typically a digital output from one of its digital pins, set to a HIGH or LOW state based on motion detection. This is often recommended for servos due to their potential current draw. The relay is configured to close when the Arduino detects motion and sends a HIGH signal to the control pin, completing a separate power circuit connected to the MG996R servo motor power source. The Arduino then sends Pulse Width Modulation (PWM) signals to the servo's control pin to dictate its position or initiate movement. When motion ceases, the Arduino changes its output signal to the relay, causing the relay's contacts to open and cutting off power to the motor. The Arduino can also stop sending PWM signals to the servo, ensuring the motor is only activated when the ultrasonic sensor detects motion.

4.2 Hardware & Software Requirements

4.2.1 Hardware Requirements:

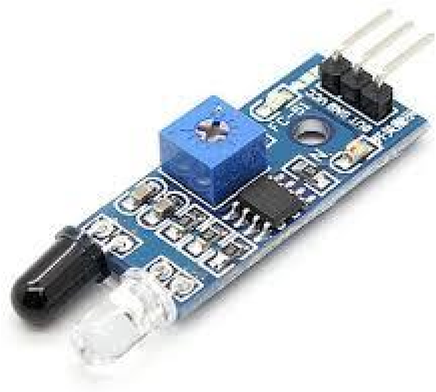

Fig 4.2: Arduino UNO Fig 4.3: Infrared Sensor

Fig 4.3: 5V- DC- Relay Fig 4.4: MG699R Servo Motor

The hardware components required for the smart dustbin project include an Arduino UNO, an Infrared Sensor, a 5V DC Relay, and an MG996R Servo Motor. The Arduino UNO serves as the central microcontroller, managing inputs and outputs for the system. The Infrared Sensor is used to detect the presence of a user near the dustbin, enabling touchless operation. The 5V DC Relay allows the Arduino to control higher-power components safely. Finally, the MG996R Servo Motor is responsible for opening and closing the dustbin lid based on the sensor input. Together, these components enable the automation and hands-free functionality of the smart dustbin.

4.2.2 Software Requirements:

- Arduino IDE

The Arduino code you've provided is designed to control a smart dustbin, likely one with an automated lid. It uses an infrared (IR) sensor to detect when an object (like a hand) is near. When an object is detected, the Arduino activates a servo motor to open the lid of the dustbin, and it also turns on a relay. The relay could trigger another action, such as activating an indicator light or a small compactor. After a one-second delay, the servo motor returns to its original position (closing the lid), and the relay is deactivated. The code continuously loops, checking the IR sensor and responding accordingly.

<u>Arduino IDE Code for the program:</u>

```
#include <Servo.h>
const int irSensorPin = 2;
const int relayPin = 3;
const int servoPin = 9;
Servo servoMotor;
void setup() {
 pinMode(irSensorPin, INPUT);
 pinMode(relayPin, OUTPUT);
 servoMotor.attach(servoPin);
 servoMotor.write(0); }
void loop() {
 int irSensorState = digitalRead(irSensorPin);
 if (irSensorState == HIGH) {
  digitalWrite(relayPin, HIGH);
  servoMotor.write(180);
  delay(1000);
 } else {
  digitalWrite(relayPin, LOW);
  servoMotor.write(0);
  delay(1000); }}
```

Chapter 5
Implementation

The Smart Garbage System utilizes a combination of sensors and a microcontroller to enable automated, touchless operation of a garbage bin. The primary objective is to enhance sanitation and operational convenience through motion-activated lid control. The system begins with the Infrared Sensor, which acts as an input module to detect the proximity of an object, such as a user's hand. Once detection occurs, the sensor transmits an IR signal to the Arduino Microcontroller, which functions as the central processing unit. The Arduino executes motion detection logic programmed within its firmware to determine the presence of an object and initiates a response accordingly.

Sr. No.:	Hardware Components	Pin Connection	Price/Component
01.	Infrared Sensor	VCC- 3.3V IN- Pin 02 GND- GND	Rs. 25
02.	5V- DC Relay	VCC- 5V OUT- Pin 03 GND- GND	Rs. 40
03.	Servo Motor	Signal- Pin 09 GND- GND VCC- 5V	Rs. 80
04.	Battery	(+) terminal -Servo Signal Pin (-) terminal -Arduino GND	Rs. 27
05.	Arduino	Connections as above	Rs. 150
06.	Jumper Wires	Male to Male Male to Female	Rs. 35 Rs. 35

Table I: Hardware Components & Connection

A Battery powers the entire system, delivering electrical energy to both the Arduino and the MG996R Servo Motor. However, the motor is indirectly controlled via a Relay Module, which serves as an electrically operated switch. Upon processing the sensor input, the Arduino generates a digital control signal (HIGH or LOW) and transmits it to the relay to activate or deactivate the motor circuit. When the relay receives a HIGH signal, it closes the circuit between the battery and the servo motor. This enables the MG996R Servo Motor to perform a mechanical operation, specifically, rotating to open or close the garbage bin lid. This mechanical actuation constitutes the system's output and is executed only when motion is detected within the sensor's predefined range. The relay ensures safe operation by isolating the low-power Arduino circuitry from the higher power demands of the servo motor.

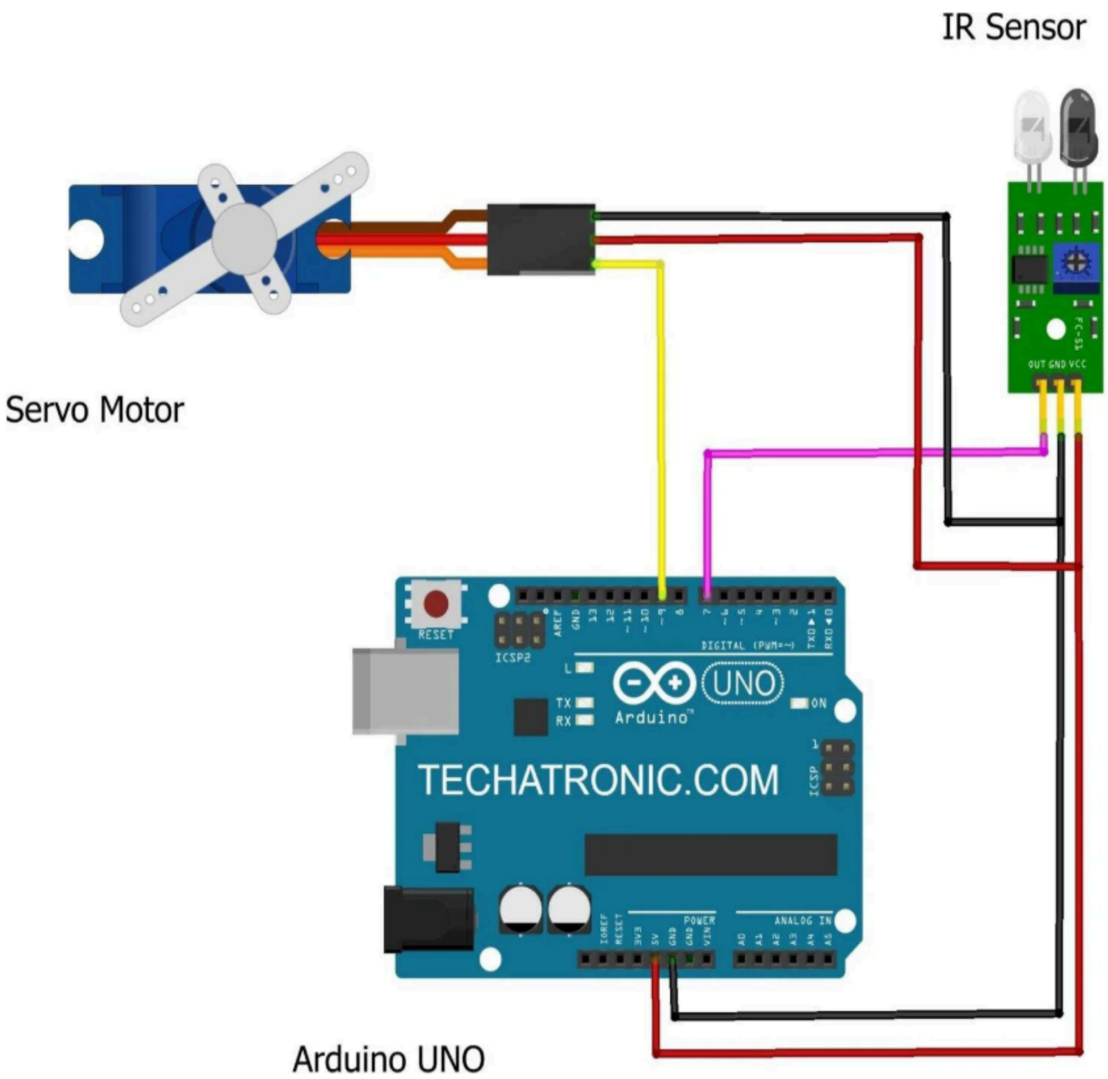

Fig 4.6: Interfacing of the project

This diagram illustrates a basic interactive system where an Arduino UNO controls a servo motor based on input from an IR sensor. The IR sensor, powered by the Arduino's 5V and GND, sends a digital signal to Arduino Digital Pin 2 indicating object detection. In response, the Arduino, also powering the servo motor, sends PWM signals from Digital Pin 9 to control the servo's angular position, enabling motion-activated or obstacle-avoidance functionalities. This setup demonstrates fundamental microcontroller interfacing for sensing and actuation.

Chapter 6

Results & Discussion

The Smart Garbage System was successfully implemented and tested under controlled conditions to validate its functionality. The system reliably detected the presence of a hand or object within the IR sensor’s proximity range, typically around 10–15 cm, and triggered the lid mechanism with minimal latency. The servo motor responded swiftly to the control signals from the Arduino, completing the open-close cycle within approximately 2 to 3 seconds, which was found to be sufficient for typical user interaction.

During testing, the system demonstrated consistent performance across multiple trials. The IR sensor exhibited high sensitivity and accuracy in detecting motion, and false positives were minimal when the sensor's range was properly aligned. The relay module effectively controlled the power supply to the MG996R servo motor without introducing noise or delays in actuation, indicating that the electronic isolation was functioning as intended. The motor itself delivered smooth and stable rotational motion, adequately lifting and lowering the lid without any mechanical jamming or over-rotation.

Power consumption was observed to be low during idle periods, with a slight increase only during active servo motor operation. This confirms the energy-efficient design of the system, as the relay ensures that the motor only draws power when necessary. The system also remained stable under continuous use, with no overheating or component failure observed over extended testing periods.

Overall, the results validate the operational reliability, responsiveness, and practicality of the Smart Garbage System in enabling contactless waste disposal. The system meets its design objectives by reducing manual interaction, enhancing hygiene, and automating a common public and household utility function using cost-effective and accessible hardware components.

Chapter 7
Conclusion & Future Work

7.1 Conclusion

The Smart Garbage System was successfully designed and implemented using an IR sensor, Arduino microcontroller, relay module, and MG996R servo motor. The system achieved its objective of enabling automatic, contactless operation of a garbage bin lid. Through efficient sensing, logical control, and mechanical actuation, the system provided a reliable and hygienic solution for waste disposal. The use of standard, low-cost components ensured accessibility and replicability, while the modular structure allowed for straightforward assembly and testing. Overall, the system functioned as intended, demonstrating quick response time, minimal power consumption, and consistent performance across various operating conditions.

7.2 Future Work

Although the current prototype fulfills its core functionality, several enhancements can be considered to improve its performance and usability. Incorporating ultrasonic sensors can provide more accurate distance measurement and minimize false triggers. Adding a load cell to monitor bin capacity could enable notifications for garbage collection. Integration with wireless communication modules such as Wi-Fi or GSM can allow for remote monitoring and alert systems, particularly useful for public or large-scale waste management [2],[5]. Additionally, incorporating solar power can enhance sustainability by reducing dependency on battery replacements. These improvements help transition the system from a prototype to a scalable smart waste management solution.

References

[1] Smart dustbin with automatic Open or close lid, Proceedings of UGC Care Journal, ISSN: 2249-6661, Nov.-Dec. 2021.

[2] Mustafa M.R1 "IoT-based smart garbage monitoring system & advanced disciplinary approach," Proceedings of International Journal of Scientific & Engineering Research, issue, 7th Mar. 2022.

[3] I. Sosunova and J. Porras, "IoT-Enabled Waste Management Systems for Smart Cities: A Systematic Review," IEEE Access, vol. 10, 2022.

[5] Mustafa M.R1 "Cloud-Based Smart Dustbin System," Proceedings of IEEE, 2017.

[6] Salsabil Meghazi Bakhouch Smart Waste Management System Based on IoT, Springer Nature Switzerland, Feb. 2024, pp. 322–331.