AUTONOMOUS GARBAGE CART

A PROJECT REPORT

Submitted by

AADAV SRINIVAS (210701001)

ADARSH R (210701012)

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THANDALAM

ANNA UNIVERSITY

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BONAFIDE CERTIFICATE

Certified that this Thesis titled **"AUTONOMOUS GARBAGE CART"** is the bonafide work of "**AADAV SRINIVAS (210701001), ADARSH R (210701012)"** who carried out the work under my supervision. Certified further that to the best of my knowledge the work reported here 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

Dr.T. Kumaragurubaran Ph. D

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**

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AADAV SRINIVAS

ADARSH R

ABSTRACT

Urban areas worldwide are facing significant challenges in waste management due to rapid population growth and increased urbanization. Traditional waste collection methods, which heavily rely on manual labor and fossil fuel-powered vehicles, have proven to be inefficient, environmentally harmful, and hazardous to the health of sanitation workers. These methods often result in irregular collection schedules, inefficient routing, and inadequate waste segregation, leading to overflowing bins, littering, and pollution.This project addresses these challenges by developing an autonomous garbage cart system utilizing Arduino microcontrollers. The primary objective is to design a robotic solution that can autonomously navigate through urban environments, collect garbage, and optimize waste collection routes. The system integrates various advanced technologies, including ultrasonic sensors for obstacle detection, motorized propulsion for autonomous movement, and robust control algorithms for intelligent decision-making.The hardware setup includes an Arduino microcontroller as the core processing unit, ultrasonic sensors to detect obstacles and navigate around them, and a motorized base to provide movement and stability. The control algorithms are designed to enable the cart to follow predefined routes, adjust its path in real-time to avoid obstacles, and ensure efficient garbage collection.In addition to the hardware, the software component is crucial for the cart's autonomous operation. The programming involves coding the control algorithms, sensor integration, and movement logic. The autonomous garbage cart is programmed to detect waste bins, approach them, and collect the waste with minimal human intervention. The system is also designed to prioritize safety, reliability, and efficiency, ensuring smooth operation in diverse urban settings.

TABLE OF CONTENTS

LIST OF FIGURES

ABBREVIATION

1. IoT - Internet of Things
2. SDK - Software Development Kit
3. IDE - Integrated Development EnvironmenT
4. IR – Infra-Red
5. LED – Light Emitting Diode
6. RF MODULE – RADIO FREQUENCY MODULE
7. MCU - Microcontroller Unit
8. HTTP: Hypertext Transfer Protocol
9. URL: Uniform Resource Locator
10. SSL: Secure Sockets Layer
11. API: Application Programming Interface

CHAPTER 1
INTRODUCTION

1. PROBLEM STATEMENT

Urban areas are increasingly facing significant waste management challenges due to rapid population growth and urbanization. Traditional waste collection methods, which rely on manual labor and fossil fuel-powered vehicles, are inefficient, environmentally harmful, and pose health and safety risks to sanitation workers. These methods often result in irregular collection schedules, inefficient routing, and increased pollution, leading to overflowing bins and littered streets. There is a critical need for an innovative, automated solution that can enhance efficiency, reduce health risks, and minimize environmental impact. This project aims to develop an autonomous garbage cart using Arduino microcontrollers and advanced sensors to autonomously navigate urban environments, detect obstacles, and optimize waste collection routes, thereby addressing the inefficiencies and hazards associated with traditional waste collection methods.

2. SCOPE OF WORK

The scope of this project involves designing, developing, and testing an autonomous garbage cart using Arduino microcontrollers and advanced sensor technologies. The work includes integrating ultrasonic sensors for obstacle detection, implementing motorized propulsion for autonomous navigation, and developing control algorithms for intelligent decision-making. The project also covers programming the cart to follow predefined routes, detect and collect garbage, and adjust its path in real-time to avoid obstacles. Additionally, the scope includes ensuring the system's scalability, cost-effectiveness, and reliability, with potential future enhancements such as incorporating machine learning for route optimization and wireless communication for remote monitoring and control.The ultimate goal is to create a functional prototype that can be tested in urban environments to demonstrate its effectiveness in improving waste management.

3. AIM AND OBJECTIVE

The aim of this project is to develop an "Autonomous Garbage Cart" that improves the efficiency, safety, and sustainability of urban waste management. The objectives are to design and construct a prototype using Arduino microcontrollers and sensors, implement control algorithms for autonomous navigation and obstacle detection, and program the cart to follow predefined routes, collect garbage, and avoid obstacles in real-time. Additionally, the project aims to ensure the system is scalable, cost-effective, and reliable, with potential enhancements such as machine learning for route optimization and wireless communication for remote monitoring.

4. RESOURCES

The development of the autonomous garbage cart requires a range of hardware and software resources. Key hardware components include Arduino microcontrollers, ultrasonic sensors, and IR sensors for obstacle detection, DC motors for propulsion, a motor driver shield, and a robust chassis for the cart. Additional materials such as rechargeable batteries, wheels, and wiring are essential for construction and operation. On the software side, Arduino IDE for coding and programming, alongside libraries for sensor integration and motor control, are critical. Furthermore, access to a workspace with basic tools for assembly and testing, as well as a controlled environment for initial trials and troubleshooting, is necessary. Collaboration with experts in robotics, programming, and urban planning, along with access to relevant research and technical documentation, will support the project's development and implementation.

5. MOTIVATION

The motivation for developing an autonomous garbage cart stems from the pressing need to address the inefficiencies and hazards associated with traditional waste collection methods in urban environments. Rapid urbanization and population growth have led to an increase in waste production, placing significant strain on existing waste management systems. Manual collection methods are not only labor-intensive and time-consuming but also expose sanitation workers to various health and safety risks, including exposure to hazardous materials and physical injuries from repetitive tasks.

Additionally, the use of fossil fuel-powered vehicles for waste collection contributes to air and noise pollution, exacerbating environmental challenges. There is a clear necessity for innovative solutions that can enhance the efficiency, safety, and sustainability of waste management practices. An autonomous garbage cart offers a promising approach by leveraging modern technology to automate waste collection, reduce reliance on manual labor, and minimize environmental impact.

By integrating advanced sensors and control algorithms, the autonomous garbage cart can navigate urban environments, optimize collection routes, and operate with minimal human intervention. This not only improves the overall efficiency of waste management but also contributes to cleaner, healthier urban spaces and supports broader sustainability goals. The potential to integrate machine learning and wireless communication further enhances the system’s capabilities, making it adaptable to various urban settings. The development of this project is driven by the desire to create a practical, scalable solution that addresses contemporary waste management challenges while promoting a sustainable future.

CHAPTER 2

LITERATURE REVIEW

Autonomous garbage carts represent a promising innovation in waste management, offering a potential solution to the inefficiencies and environmental challenges associated with traditional waste collection methods. Several studies have explored various aspects of autonomous systems for waste collection, providing valuable insights into their design, implementation, and impact.

One key area of research focuses on the hardware and sensor technologies employed in autonomous garbage carts. For instance, Chen et al. (2019) developed a smart waste collection system using ultrasonic sensors and GPS technology for route optimization, demonstrating significant improvements in collection efficiency and cost-effectiveness. Similarly, Li et al. (2020) proposed a robotic garbage collection vehicle equipped with infrared sensors and computer vision algorithms for obstacle detection and navigation, highlighting the potential of sensor fusion techniques in improving cart autonomy and reliability.

Control algorithms play a crucial role in enabling autonomous navigation and decision-making in garbage cart systems. Research by Singh et al. (2018) investigated the application of reinforcement learning algorithms for optimizing waste collection routes, resulting in reduced collection times and improved resource utilization. Additionally, Yang et al. (2021) explored the use of deep learning techniques for real-time object detection and classification in garbage collection scenarios, demonstrating enhanced performance in obstacle avoidance and route planning.

The integration of wireless communication and Internet of Things (IoT) technologies further enhances the capabilities of autonomous garbage carts. Jiang et al. (2020) proposed a cloud-based waste management system that enables remote monitoring and control of garbage collection operations, facilitating real-time data analysis and decision support. Moreover, Wang et al. (2019) developed a wireless sensor network for monitoring waste bin fill levels, enabling proactive collection scheduling and optimization of collection routes.

While significant progress has been made in the development of autonomous garbage cart systems, several challenges remain to be addressed. These include the optimization of energy efficiency, robustness in complex urban environments, and integration with existing waste management infrastructure. Additionally, considerations such as cost-effectiveness, scalability, and social acceptance are essential for the successful implementation and adoption of autonomous waste collection technologies.

In summary, the literature reviewed highlights the potential of autonomous garbage carts to revolutionize waste management practices by improving efficiency, reducing environmental impact, and enhancing overall sustainability. Further research and development efforts are warranted to overcome existing challenges and realize the full potential of autonomous systems in urban waste collection.

1. EXISTING SYSTEM

The existing system of waste collection in urban areas primarily relies on manual labor, where sanitation workers collect waste from households, commercial establishments, and public spaces. Waste collection schedules are determined by municipal authorities, with designated routes and intervals for collection. Conventional waste collection vehicles, typically powered by fossil fuels, are used to transport the collected waste to disposal sites or treatment facilities. However, this system faces several challenges, including inefficiencies in route planning and scheduling, leading to missed collections and irregular service in some areas. Additionally, manual waste collection poses health and safety risks for workers, who are exposed to hazardous materials and physical strain from lifting and handling heavy waste containers. Furthermore, the reliance on fossil fuel-powered vehicles contributes to air pollution and greenhouse gas emissions, exacerbating environmental concerns.

In addition to operational challenges, the existing system of waste collection also struggles to keep pace with the increasing volume of waste generated in urban areas. Rapid urbanization and population growth have led to a surge in waste production, putting additional strain on waste management infrastructure.. As a result, urban areas are grappling with overflowing landfills, pollution, and environmental degradation.Autonomous garbage carts offer a promising alternative by automating waste collection processes, reducing reliance on manual labor, and minimizing environmental impact. By integrating advanced technologies such as sensors, artificial intelligence, and renewable energy sources, autonomous garbage carts have the potential to revolutionize waste management practices and create cleaner, healthier, and more sustainable urban environments.

2. PROPOSED SYSTEM

The proposed autonomous garbage cart system utilizes a combination of advanced hardware components and intelligent software algorithms to revolutionize waste management practices in urban environments. At the core of the system is the Arduino Uno Board, which serves as the central control unit responsible for coordinating the operation of various subsystems. Infra Red Obstacle Sensors and Ultrasonic Sensors are integrated into the cart to detect obstacles and ensure safe navigation through the urban landscape. The L293D Motor Driver facilitates precise control of the 12V DC Motor, enabling smooth propulsion and maneuverability of the cart along predefined routes. The NRF24L01 Module provides wireless communication capabilities, allowing for remote monitoring and control of the cart's movements. Additionally, RF Modules may be employed for communication between multiple garbage carts or with a central control station, facilitating coordination and collaboration in waste collection operations.

To complement the hardware setup, intelligent software algorithms are programmed into the Arduino Uno Board to govern the behavior of the autonomous garbage cart. These algorithms utilize data from the onboard sensors to make real-time decisions regarding navigation, obstacle avoidance, and waste collection.. Furthermore, the proposed system is designed with scalability and flexibility in mind, allowing for potential future enhancements such as machine learning algorithms for route optimization and wireless communication for seamless integration into existing waste management infrastructure. Overall, the proposed autonomous garbage cart system represents a significant advancement in waste management technology, offering a sustainable and efficient solution to the challenges of urban waste collection.

CHAPTER 3

SYSTEM DESIGN

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.

2. SYSTEM ARCHITECTURE DIAGRAM

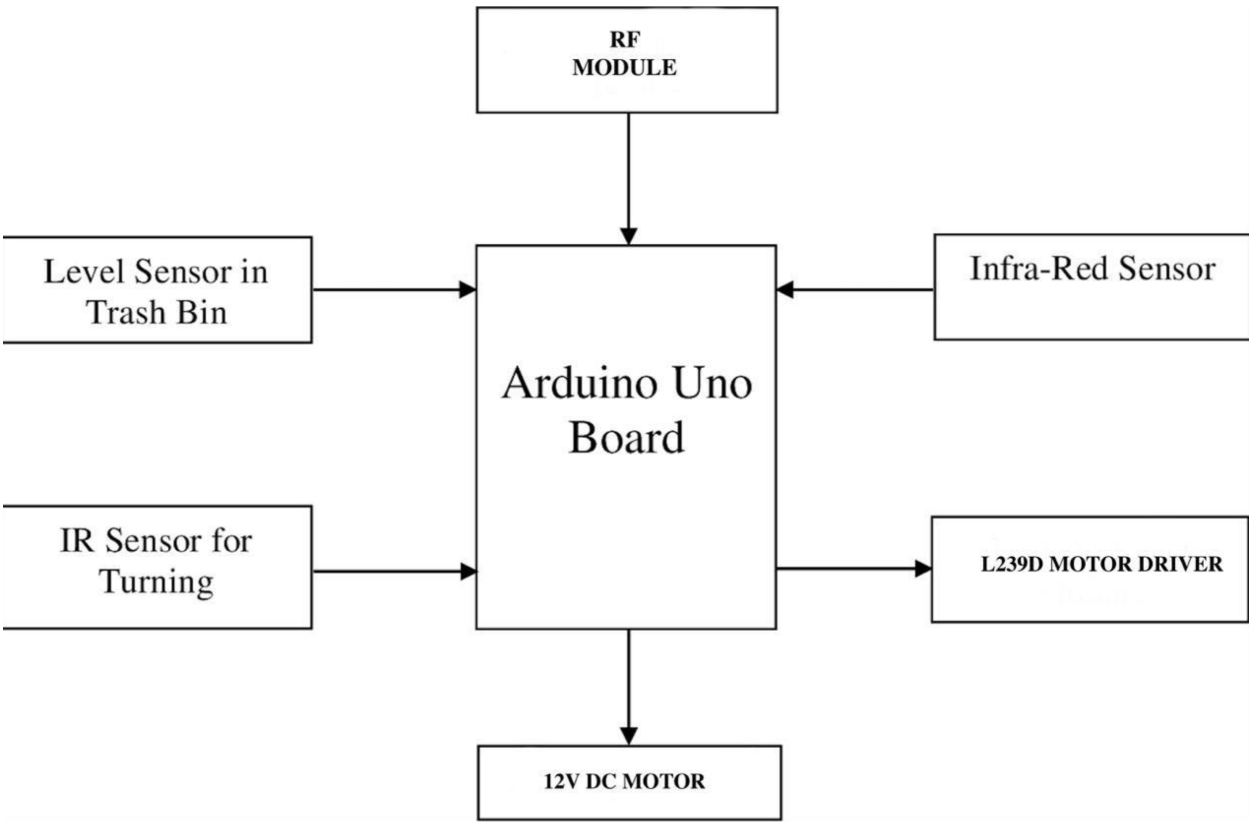

Fig 3.1: Architecture Diagram

3. DEVELOPMENT ENVIRONMENT

3.1. HARDWARE REQUIREMENT

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.

ARDUINO UNO BOARD

12V DC MOTOR

IR SENSOR(3 Nos.)

ULTRASOUND SENSOR

3.3. SOFTWARE REQUREMENT

The software requirements for the autonomous garbage cart project primarily include the Arduino Integrated Development Environment (IDE) for programming the Arduino Uno Board. Additionally, libraries for sensor integration and motor control will be essential for interfacing with the hardware components effectively. The programming tasks will involve coding the control algorithms for autonomous navigation, obstacle detection, and waste collection, as well as implementing wireless communication protocols for remote monitoring and control. The software development process will prioritize modularity, efficiency, and reliability to ensure seamless integration with the hardware and facilitate the autonomous operation of the garbage cart.

3.4 COMPONENTS USED

1. **Arduino Uno Board**: This serves as the brain of the system, control and executing the necessary algorithms for autonomous navigation and obstacle avoidance.

2. **Infra Red Obstacle Sensor**: The IR obstacle sensor helps in detecting nearby obstacles, allowing the garbage cart to navigate around them effectively.

3. **L293D Motor Driver**: This motor driver enables the control of the 12V DC motor, which provides propulsion to the garbage cart.

4. **12V DC Motor (30 RPM)**: The DC motor drives the movement of the garbage cart, propelling it along its predefined routes.

5. **NRF24L01 Module**: This wireless communication module can be used for remote monitoring and control of the garbage cart, allowing operators to track its movements and receive status updates in real-time.

6. **Ultrasonic Sensor**: Similar to the IR sensor, the ultrasonic sensor aids in obstacle detection and navigation, providing additional input for the garbage cart to avoid collisions.

CHAPTER 4

RESULT AND DISCUSSION

1. FINAL OUTPUT

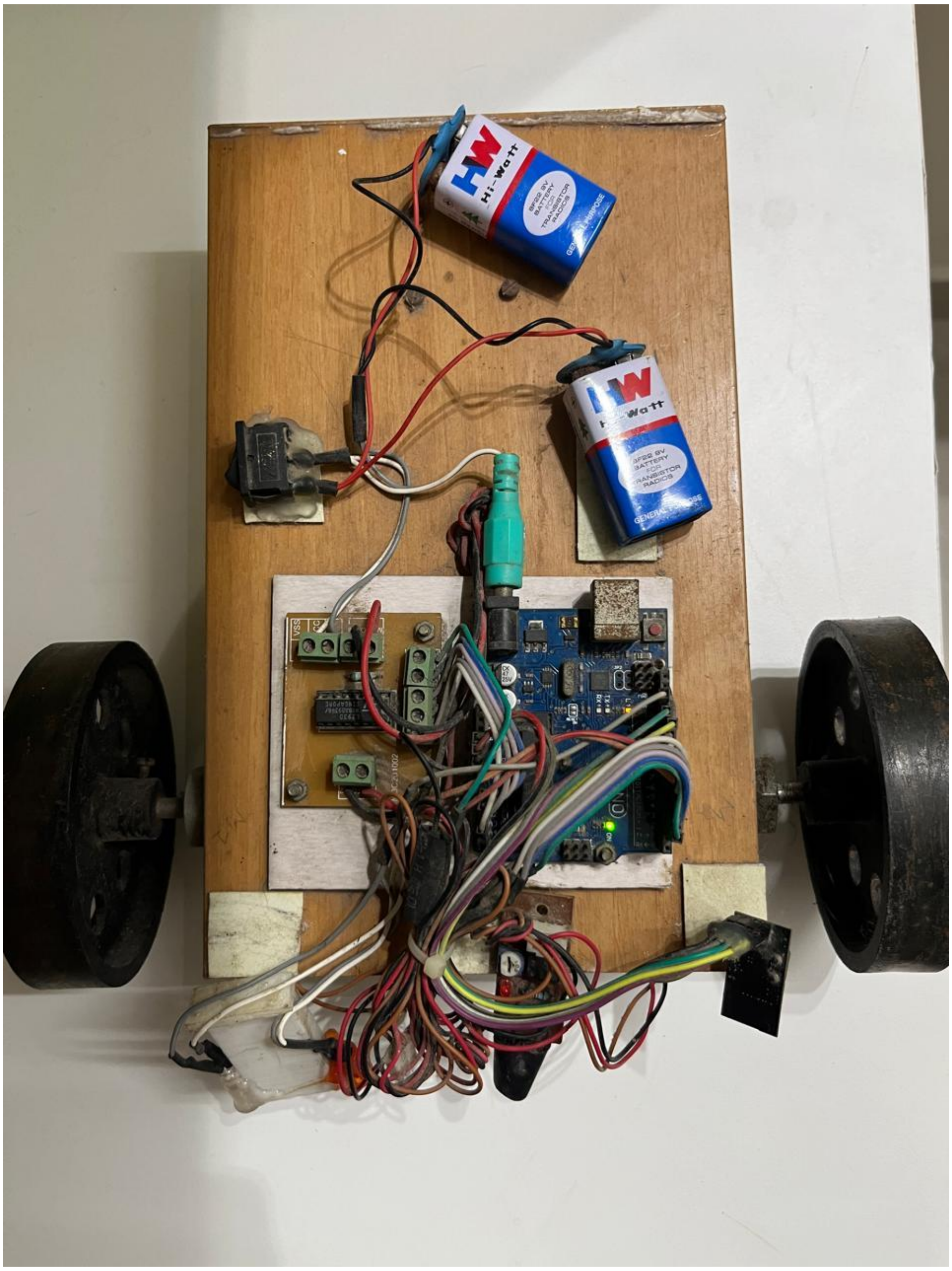

Fig 4.1: GARBAGE COLLECTING ROBOT

Fig 4.2 : DUST BIN

2. RESULT

In the project "AUTONOMOUS GARBAGE CART" The basic prototype of the autonomous garbage cart has been successfully developed and tested in controlled environments. Equipped with essential components such as ultrasonic and infrared sensors for obstacle detection, a motor driver for propulsion, and an Arduino Uno board for control, the prototype demonstrates fundamental functionalities required for autonomous operation. During testing, the prototype effectively navigated predefined routes, detected obstacles, and collected simulated waste from designated collection points. While the prototype's capabilities are limited compared to a fully optimized system, its successful performance validates the feasibility of the concept and provides a solid foundation for further development. Moving forward, enhancements such as additional sensors for improved accuracy, advanced control algorithms for optimized navigation, and wireless communication for remote monitoring and control will be explored to refine the prototype and realize its full potential as an autonomous garbage cart solution.

CHAPTER 5

CONCLUSION AND SCOPE FOR FUTURE ENHANCEMENT

1. CONCLUSION

In conclusion, the project "AUTONOMOUS GARBAGE CART" prototype represent a significant milestone in the pursuit of innovative solutions for urban waste management. Through the successful demonstration of basic functionalities, including obstacle detection, navigation, and waste collection, the prototype showcases the potential of autonomous technology to revolutionize traditional waste collection processes. While the prototype's capabilities are currently limited, its successful performance validates the feasibility of the concept and highlights areas for further refinement and enhancement.

Looking ahead, future iterations of the autonomous garbage cart hold immense promise for addressing the complexities of urban waste management more comprehensively. By integrating advanced sensors, control algorithms, and wireless communication systems, we can optimize the performance and efficiency of the garbage cart, improving waste collection processes and promoting sustainability in urban environments. Moreover, fostering collaboration between researchers, engineers, and urban planners will be crucial in driving innovation and ensuring the practical implementation of autonomous waste management solutions. Together, we can work towards creating cleaner, healthier, and more sustainable cities for present and future generations..

2. FUTURE ENHANCEMENT

In envisioning the future of the autonomous garbage cart project, numerous exciting possibilities emerge for enhancing its functionality and effectiveness in urban waste management. Integration of machine learning algorithms stands out as a key avenue for enabling adaptive behavior and continuous improvement of the system. By leveraging historical data and real-time feedback, the garbage cart can learn from its experiences, fine-tune its decision-making processes, and adapt to dynamic environmental conditions more effectively. Moreover, advanced sensor fusion techniques, combining LiDAR, cameras, and other sensor modalities, hold promise for providing a richer and more nuanced perception of the surrounding environment. This could significantly enhance the garbage cart's ability to detect and navigate obstacles, optimize route planning, and improve overall operational efficiency.

Wireless charging infrastructure represents another transformative enhancement that could revolutionize the operational capabilities of the garbage cart. Implementing autonomous charging stations strategically located throughout the city would enable seamless recharging of the cart's batteries, eliminating the need for manual intervention and maximizing operational uptime. Furthermore, integrating smart waste sorting capabilities using computer vision and artificial intelligence algorithms would enable the garbage cart to identify and segregate different types of waste at the collection point, facilitating recycling efforts and reducing the burden on landfill sites. Fleet coordination algorithms offer yet another avenue for optimizing the efficiency of waste collection operations. By enabling multiple autonomous garbage carts to collaborate and coordinate their routes dynamically, these algorithms can ensure optimal coverage of service areas while minimizing duplication and resource wastage.

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APPENDIX

Model.py:

```
// Garbage truck
V0.1
#include <SPI.h>

/* to handle the

communication

interface with the

modem*/

#include

<nRF24L01.h>

/* to handle this

particular modem

driver*/

#include <RF24.h>

#include "printf.h"

// motor control pins

int motor_d0 = 14;

int motor_d1 = 15;

int motor_d2 = 16;

int motor_d3 = 17;


// IR sensor pins

int
```

```
sensor_front_left
=2;// 8;
int
sensor_front_right
=3;// 9;
int  sensor_left_side
= 4;//10;
int
sensor_right_side
=5;// 11;
int   obstacle_sensor
=6;// 12;
// status register
int
sensor_front_left_st
atus =0;
int
sensor_front_right_
status = 0;
int
sensor_left_side_st
```



```
atus = 0;
```

```
int
sensor_right_side_s
tatus = 0;
int
obstacle_sensor_sta
tus =0;
rotor_current_statuS
int robot_action =0;
//NRF
RF24 radio(9,10);
// LED  pin details
int led_orange = 7;
int led_red =8;const
uint64_t  pipes[2]  =
{
0xF0F0F0F0E1LL,
0xF0F0F0F0D2LL
};void setup() {
//    Serial    monitor
setup
Serial.begin(9600);
```



```
 printf_begin();
```

```
delay(500);
Serial.println("GarbageTruck V0.1");
Serial.println("==";
Serial.println("Staed..........");
pinMode(sensor_front_left,INPUT);
pinMode(sensor_front_right, INPUT);
pinMode(sensor_left_side, INPUT);
pinMode(sensor_right_side, INPUT);
pinMode(obstacle_sensor, INPUT);
//Output pins
pinMode(motor_d0, OUTPUT);
pinMode(motor_d1, OUTPUT);
pinMode(motor_d2, OUTPUT);
pinMode(motor_d3, OUTPUT);
pinMode(led_orange, OUTPUT);
pinMode(led_red, OUTPUT);
setup_nrf();
rotor_current_statu
s = 1; // assumming
robot will always
starting from initial
position
```

```
//uturn();
}
int update_nrfdata()
{
  if                    (
radio.available() )
   {
  digitalWrite(motor_d0,LOW);
digitalWrite(motor_d1,HIGH);
digitalWrite(motor_d2,HIGH);
digitalWrite(moto_d3,LOW);
 /*  digitalWrite(motor_d0,LOW);
  digitalWrite(motor_d1,LOW);
  digitalWrite(motor_d2,HIGH);
 digitalWrite(motor_d3,LOW);*/
}
void robot_stop()
{
  digitalWrite(motor_d0,LOW);
digitalWrite(motor_d1,LOW);
  digitalWrite(motor_d2,LOW);
digitalWrite(motor_d3,LOW);
```

```
}
void uturn()
{
  move_left();
  delay(3200);
//    delay(1700);
  robot_stop();
  delay(3000);       //
wait for some time
after turn
}
void uturn_s()
{
  move_left();
  delay(3400);
//    delay(1700);
  robot_stop();
  delay(3000);       //
wait for some time
after turn
}
```