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Development of Smart Trash- Collecting Robot System

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Abstract: Waste management is an important challenge in modern cities due to increasing population and garbage production. Manual waste collection requires more time, labor, and may expose workers to unhealthy conditions. This paper presents the development of a Smart Trash-Collecting Robot System designed to assist in automatic waste collection in public areas. The robot uses a microcontroller to control DC motors, a motor driver, and a trash-collecting mechanism. It can be operated through a Bluetooth module, allowing the user to control the robot wirelessly using a mobile device. A solar panel can also be integrated to provide additional power and improve energy efficiency. The robot moves to the waste location and collects trash into a storage bin, helping maintain cleanliness in the environment. The proposed system reduces human effort, improves waste management efficiency, and supports cleaner public spaces such as parks, streets, and campuses. The system is simple, cost-effective, and suitable for smart city applications.
Keywords: Smart Robot, Waste Management, Trash Collection, Arduino/PIC, Bluetooth Control.

I. INTRODUCTION

Waste management has become a major challenge in many cities due to the rapid increase in population and daily waste production. Improper disposal of trash can cause environmental pollution, unpleasant surroundings, and health problems for people. Traditional garbage collection methods mainly depend on manual labor, which requires more time, effort, and may expose workers to harmful waste. With the advancement of robotics and automation, smart technologies can be used to improve waste management systems. A Smart Trash-Collecting Robot System is designed to assist in collecting garbage from public places such as parks, streets, campuses, and residential areas. This robot can move around the environment and collect trash using a mechanical collecting mechanism. The system uses a microcontroller to control the robot's movement and operations. Components such as DC motors, motor drivers, and Bluetooth modules are used to enable wireless control and efficient movement. In addition, a solar panel can be used to provide an eco-friendly power source for longer operation. The main objective of this project is to develop a simple, cost-effective, and efficient robotic system that helps reduce human effort in waste collection and supports a cleaner and healthier environment.

II. OBJECTIVE

The main objective of this project is to design and develop a Smart Trash-Collecting Robot System that can assist in collecting garbage from public places efficiently. The system aims to reduce human effort involved in manual waste collection and improve cleanliness in the environment. The robot is designed to move around different areas and collect trash using a mechanical collecting mechanism. It can be controlled wirelessly using a Bluetooth module, making the operation simple and convenient. In addition, the use of a solar panel helps provide an eco-friendly power source and increases the operating time of the robot. Overall, this project focuses on creating a simple, low-cost, and effective solution for better waste management.

III. LITERATURE SURVEY

S.Kumar et al. (2019)– Design and Fabrication of Autonomous Waste Collecting Robot This study introduced an Arduino-based robot equipped with an ultrasonic sensor for obstacle detection and a servo-based mechanism for trash collection. The robot could move automatically, detect waste objects, and push them into a dustbin. It mainly focused on dry waste collection.

P.Gupta and R.Sharma (2020) – Smart Garbage Collector Using IoT the authors proposed an IoT-based garbage system where sensors detected the level of garbage in bins. The system was capable of sending alerts when bins were full. Though not fully mobile, the concept supported smart monitoring and efficient waste management.

A.Rahman et al. (2021)–Development of River Cleaning Robot This work presented a floating robot for collecting waste materials from water surfaces. The robot used a conveyor belt mechanism to lift and store trash. It demonstrated the importance of environmental cleaning robots in aquatic areas.

D.Patel et al. (2022)–Voice Controlled Trash Collecting Robot The researchers implemented a voice command system using Bluetooth and Arduino UNO to control the robot. This allowed users to navigate the robot manually using voice instructions. It was mainly designed for indoor and laboratory environments.

L.Wong et al. (2023)– AI-Based Object Detection in Waste Sorting Robots This recent study integrated camera and AI models (like YOLO) to identify recyclable and non-recyclable materials. This improved the robot's efficiency in sorting different types of trash automatically.

R.Sharma,P.Mehta(2019)–Solar-Powered Water Cleaning Machine Designed a solar-based system for cleaning floating waste using a net mechanism. It promoted energy efficiency but faced challenges during cloudy weather and lacked real-time obstacle detection.

IV. COMPONENTS OF VOICE CONTROLLER ROBOT

1. Arduino Uno

Arduino Uno is a microcontroller board and it having 14 output and input pins, in this 6 pins used as PWM output,6 analog input,1 UARTs 16 having USB, power jack ICSP button and reset button, Vin, Gnd, serial communication, external interrupts, led can simply connect to a computer and the supply AC to DC adapter or battery, operating voltage of this boards is 5 volt and the range of the input will 7 to 12 volts, length of the board is about 68.6 mm and the width is 53.4, the weight of this is 25 g, comparing to the Arduino Nano it having more space and more processing, programming of the Arduino Uno 16 can be done in pc with the c programming language and it can transfer to the Arduino by using USB cables.

Fig. 1 Arduino Board

2. Gear Motor

A gear motor is an all-in-one combination of an electric motor and a gearbox. This makes it a simple, cost-effective solution for high-torque, low-speed applications because it combines a motor with a gear reducer system.

Fig. 2 Gear Motor

3. L298N Motor Driver

L298N motor driver IC is very simple is to drive the two DC motors simultaneously. This IC works on the principle of Half H-Bridge. It controls the speed of the motor microcontroller sends the pulse signals to it accordingly. An L298N has four input pins, four output pins, 2 enable pins,VSS,VCC and GND.

Fig. 3 Motor driver

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4. Bluetooth Module HC – 12

The HC-12 module is a wireless communication device used to send and receive data between two electronic systems. It works using serial communication and can be connected to microcontrollers like Arduino or PIC. The module operates at 433 MHz frequency and can communicate over a long distance. In the Smart Trash-Collecting Robot System, the HC-12 module is used to control the robot wirelessly. It sends commands from the controller to the microcontroller, which then controls the motors and movement of the robot. The HC-12 module is low cost, easy to use, and suitable for robotic applications.

Fig. 4 Bluetooth Module HC05

5.Solar Panel

A solar panel is a device that converts sunlight into electrical energy. It uses solar cells to generate power from sunlight. The electricity produced can be used to power electronic devices or charge batteries. In the Smart Trash-Collecting Robot System, the solar panel is used to provide power to the robot and charge the battery. This helps increase the operating time of the robot and reduces the use of external electricity.

Fig. 5 Solar Panel

Solar energy is clean, renewable, and eco-friendly, making the system more efficient and environmentally friendly.

V. SOFTWARE

The software is used to control the operation of the Smart Trash-Collecting Robot System. The program is written using embedded programming and uploaded to the microcontroller. The software controls the movement of the robot, motor operation, and communication with the wireless module. The microcontroller receives commands from the Bluetooth or HC-12 module and processes them through the program. Based on the received command, the software controls the motors to move the robot in different directions such as forward, backward, left, and right. The software also manages the working of indicators like LED or buzzer.

VI. BLOCK DIAGRAM OF TRASH COLLECTING ROBOT

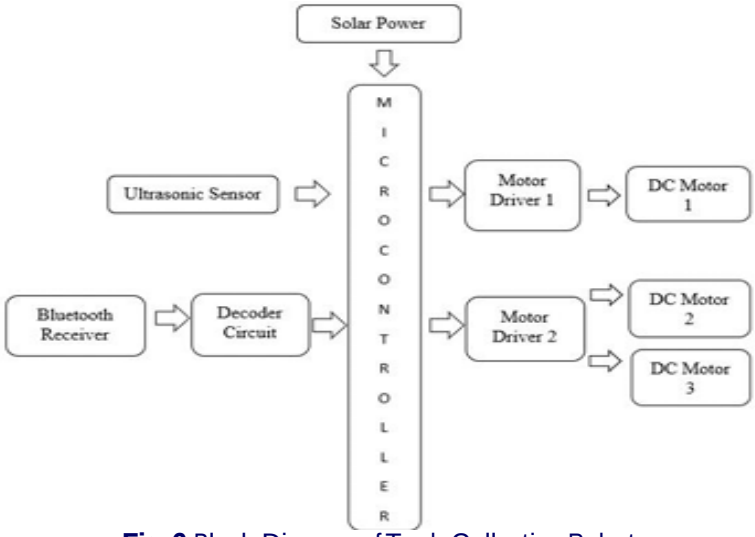
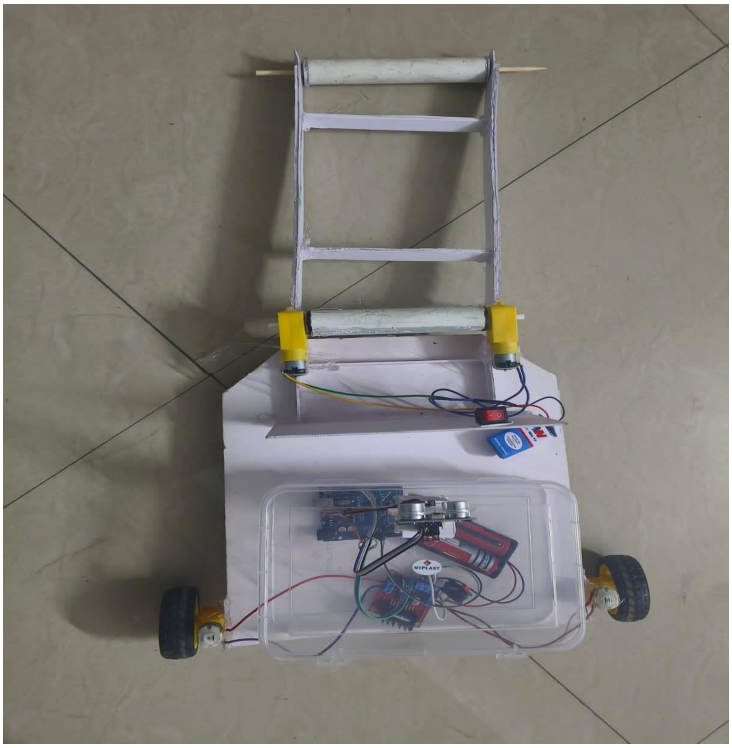


Fig. 6 Block Diagram of Trash Collecting Robot

The block diagram of the Trash Collecting Robot System shows the main components and their connections. The system is powered by a solar panel and battery, which provide the required electrical energy to the robot. A microcontroller acts as the main control unit and manages the operation of all components. The HC-12 or Bluetooth module is used for wireless communication to send control commands to the robot. These commands are processed by the microcontroller and sent to the motor driver (L298N), which controls the DC motors for robot movement. The motors allow the robot to move in different directions. A trash collecting mechanism is attached to the robot to pick up and store garbage in the bin.



VII. CONCLUSIONS

The Smart Trash-Collecting Robot System is developed to improve waste collection and maintain cleanliness in public areas. Traditional garbage collection methods require more human effort and time. The proposed system uses a microcontroller, motor driver, DC motors, wireless communication module, and a trash-collecting mechanism to collect garbage efficiently. The robot can be controlled wirelessly using a Bluetooth or HC-12 module, allowing the user to move the robot in different directions to collect waste. The integration of a solar panel provides an eco-friendly power source and helps increase the operating time of the robot. This system reduces human effort and improves waste management efficiency. It can be used in places such as parks, streets, and campuses to maintain a clean environment. In the future, additional sensors and automation features can be added to make the robot more intelligent and fully autonomous.

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