



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Issue 5, May 2024

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

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Enhanced Smart Robot with Object Recognition Capabilities

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ABSTRACT: Statistics indicate that a staggering 3.4 million tons of plastic are present in landfills, with only 30% being recycled. The remaining plastic is either incinerated or left to decompose, a process that can take thousands of years. The emissions released from burning plastic contain a cocktail of harmful carbon gasses like methane and ethylene, which, when inhaled over extended periods, can lead to health issues such as cancer, asthma, and irritation of the eyes and nose. Additionally, approximately 1 billion bottles are carelessly discarded during rallies and events. To address this issue and promote the efficient use of plastic, a robot has been developed. The primary aim is to introduce a way in which garbage could be collected and disposed efficiently. To design and develop a system for solving the problem. To test and maintain the implemented system. **METHOD:** Our project is divided into two main parts. We are designing a system that collects garbage automatically through object detection. For which we have used rocker-bogie mechanisms to travel on uneven surfaces. The machine can be controlled by software which will give commands to the robotic jaw to collect the stationary waste. **FINDINGS:** We have designed a semi-autonomous garbage collector robot which can do multiple functions. This robot has one robotic arm in which it can pick the garbage and dispense it in the main basket attached to the robot. The camera placed on the robot helps in detecting objects from far away. This robot has installed batteries in which there is no fuel or electricity required to complete the operation.

I. INTRODUCTION

In the past few years, disposing of plastic bottles has emerged as a major source of worry all across the globe. The ubiquitous presence of plastic waste in modern society has escalated environmental concerns and necessitated urgent action to address the challenges posed by plastic pollution. Plastic, renowned for its versatility and convenience, has permeated nearly every aspect of daily life, from packaging and transportation to consumer goods and infrastructure. However, the pervasive use of plastic bottles, in particular, has significantly contributed to the escalating crisis of plastic waste accumulation.

The rampant consumption and disposal of plastic bottles have precipitated a myriad of environmental and social ramifications, ranging from habitat degradation and wildlife entanglement to groundwater contamination and public health risks. With millions of tons of plastic bottles discarded annually, the scale of the problem has reached unprecedented levels, exerting immense pressure on ecosystems, municipal waste management systems, and global efforts to combat climate change. Moreover, the protracted decomposition time of plastic bottles, estimated to span several centuries, exacerbates the long-term environmental impact and necessitates sustainable alternatives for waste management



Figure : Thousands of plastic bottles thrown away in the environment

1.1 The rising problem of plastic waste in India

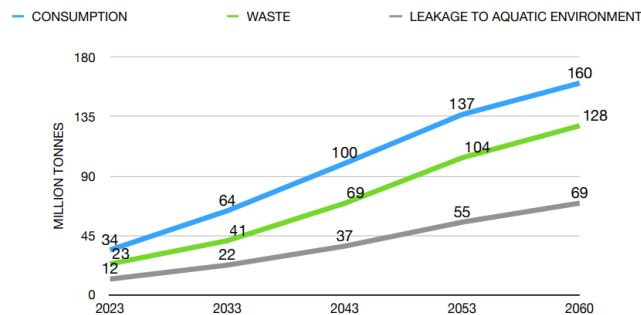


Figure: Threat of plastic waste in India

India's plastic consumption is expected to reach 20.89 million tons in 2021–24 and 64 million tons by 2033, so it is up to the industry to adopt circular economy principles in order to reduce waste and pollution while also creating new opportunities for growth and innovation. Waste that cannot be recycled and must instead be disposed of in landfills is frequently delivered to material recovery plants and recyclers in the waste management sector. Due to a lack of technology-enabled equipment and knowledge, the informal sector diverts most garbage to landfills, and waste materials gathered by the informal sector are not channeled transparently.

1.2 Challenges and Opportunities in Plastic Waste Management

India's waste management infrastructure is ill-equipped to cope with the escalating volume of plastic waste generated nationwide. Inadequate waste collection, segregation, and disposal systems contribute to the proliferation of plastic waste in urban and rural areas alike. This informal recycling sector faces numerous challenges, including limited access to technology-enabled equipment, insufficient knowledge of safe waste handling practices, and inadequate protective gear, placing workers at heightened risk of health hazards.

However, amidst these challenges lie opportunities for innovation and transformation in the plastic waste management sector. By embracing innovative technologies, such as robotics and automation, and fostering collaboration between the formal and informal sectors, India can unlock new opportunities for sustainable waste management practices. The Internet of Things (IoT) has emerged as a transformative technology with the potential to revolutionize various industries, including waste management.

IoT-based smart systems integrate sensors, actuators, and communication technologies to enable real-time monitoring and data exchange between physical objects and the digital world. IoT-based garbage monitoring can help reduce the risk of pest infestations, unpleasant odors, and other health hazards associated with overflowing garbage. Efficient waste management through IoT-based monitoring can reduce the amount of waste that ends up in landfills, helping to minimize environmental impact. With optimized waste collection routes, IoT-based garbage monitoring systems can help reduce labor, fuel, and equipment costs associated with traditional garbage collection methods.

II. LITERATURE SURVEY

1. J. S. A. Rongala et al., 2023 IOT based smart system for garbage detection and segregation

The research explores future prospects for expanding the application of IoT technology in sustainable waste management practices. It examines the feasibility of using IoT devices to monitor waste bins and optimize collection routes. The study evaluates the potential benefits of the smart system in enhancing efficiency and reducing environmental pollution. It discusses the challenges associated with implementing IoT-based solutions in waste management.

2. R. K. Kanna et al., 2023 - Smart Electronic Arm Module using Arduino Applications

The study explores designing and implementing a Smart Electronic Arm Module using Arduino applications. It focuses on the utilization of Arduino technology to develop an intelligent robotic arm module for various applications. It aims to address challenges associated with manual labor and repetitive tasks through the deployment of automation technology.

3. P. Randhavan et al., 2023 Development of Robotic Arm Prototype

The paper delves into the development of a prototype for a robotic arm. This prototype is envisioned to serve various purposes across industries, research, and education. By leveraging advanced technologies and engineering principles, the authors aim to create a versatile robotic arm capable of performing intricate tasks with precision and efficiency.

4. K. Yaswanth sai et al., 2022 - Garbage Segregation System with SMART Technology

The study likely focuses on implementing a garbage segregation system integrated with SMART (Self-Monitoring, Analysis, and Reporting Technology) technology. This system is designed to enhance the efficiency and accuracy of waste segregation processes, potentially revolutionizing waste management practices. Addressing the challenges associated with traditional waste management methods through innovative technological interventions.

5. Rupesh More et al., 2022 Smart Dustbin Using Arduino

The paper explores the development and implementation of a smart dustbin system leveraging Arduino technology. The system aims to enhance traditional waste management practices by integrating sensors, actuators, and microcontrollers to enable real-time monitoring and automation of waste disposal processes. By utilizing Arduino-based hardware and software solutions, the smart dustbin can detect the level of waste accumulation.

6. Said Achmad et al., 2022 Object Detection on Bottles Using the YOLO Algorithm

Through the utilization of deep learning techniques and computer vision algorithms, the authors aim to develop a robust system capable of accurately detecting and classifying bottles in diverse environments.

7. Abhilash V et al., 2018 IOT Based Wheeled Robotic Arm

The paper introduces an IoT-based wheeled robotic arm, aimed at enhancing automation and remote control capabilities in various applications. This innovative system integrates IoT technologies with a wheeled robotic arm, enabling remote monitoring, control, and manipulation of objects in real-time through wireless communication channels.

III. PROBLEM STATEMENT

Plastic pollution has become a pressing global issue, with millions of tons of plastic waste accumulating in landfills and the environment every year. Existing systems for managing this waste, such as landfilling, recycling, and incineration, are plagued by inefficiencies, low recycling rates, and harmful emissions. Manual collection of plastic waste, particularly in crowded events like rallies, poses safety risks for workers and often fails to adequately address the problem. To tackle these challenges, a new approach is needed. This paper proposes the development and implementation of a robotic system equipped with advanced technologies to autonomously identify and collect plastic waste, thereby enhancing efficiency, safety, and sustainability in plastic waste management.

3.1 Existing Systems

Existing systems for managing plastic waste, including landfilling, recycling, and incineration, face challenges such as limited recycling rates, harmful emissions, and health risks associated with plastic handling. Despite efforts, a significant amount of plastic remains untreated, contributing to environmental pollution and health hazards. In addition, the manual collection of plastic waste, especially in large gatherings like rallies and events, is inefficient and prone to safety risks for workers.

3.2 Proposed System

The proposed system aims to address these challenges by introducing a robotic solution equipped with advanced navigation and sensing capabilities. This system seeks to enhance efficiency and safety in plastic waste collection by autonomously identifying and collecting plastic bottles, thereby reducing reliance on manual labor and minimizing exposure to hazardous materials. By leveraging robotics technology, the proposed system aims to revolutionize plastic waste management, mitigating environmental pollution and promoting a safer and more sustainable approach to plastic recycling.

Key features of the proposed robot include:

- **Rocker bogie mechanism:** This design will ensure exceptional stability while navigating uneven terrain commonly encountered during outdoor events and gatherings.

- **High-resolution camera:** Equipped with advanced object recognition algorithms, the camera will accurately identify and locate discarded plastic bottles within the robot's environment.
- **Mechanized arm:** Designed for precise grasping and lifting, the arm will securely collect identified plastic bottles.
- **Storage unit:** Collected bottles will be deposited in a designated storage compartment within the robot for safe transportation to a recycling or processing facility.
- **By implementing this solution, the project aims to achieve the following objectives:**
- **Reduce environmental pollution:** Automated plastic bottle collection will significantly decrease the amount of plastic waste improperly disposed of, thereby minimizing the environmental impact.
- **Promote responsible waste management:** The robot will encourage responsible waste disposal practices by efficiently collecting discarded plastic bottles.
- **Create a more sustainable environment:** By diverting plastic waste from landfills and promoting recycling, this project will contribute to a more sustainable future.

IV. DATASET

The YOLO (You Only Look Once) dataset containing bottles and plastic images is a collection of annotated images specifically curated for training object detection models, particularly those based on the YOLO algorithm. This dataset typically includes a variety of images depicting scenes where bottles and plastic objects are present, such as in waste management facilities, recycling centers, or outdoor environments.

Each image in the dataset is annotated with bounding boxes around the bottles and plastic objects present, along with corresponding labels indicating their class (e.g., "bottle," "plastic"). These annotations serve as ground truth data for training the object detection model to accurately identify and localize bottles and plastic objects within images.

The YOLO dataset may vary in size and composition depending on the specific requirements of the object detection task and the intended application. It may contain images captured under different lighting conditions, camera angles, and environmental settings to ensure the model's robustness and generalization capabilities. Additionally, the dataset may be augmented with synthetic images or variations of existing images to further diversify the training data and improve the model's performance across different scenarios.

V. PROPOSED METHODOLOGY

Step 1 - Begin

Step 2 - Check Storage:

- 2.1. Determine if the storage unit is full.
- 2.2. If storage is not full, proceed to the next step.
- 2.3. If storage is full, go to step 7.

Step 3 - Check Ground Level:

- 3.1. If the ground is not steep, proceed to the next step.
- 3.2. If the ground is steep, go back to step 2.

Step 4 - Check Wall Presence:

- 4.1. Check if a wall is present.
- 4.2. If a wall is present and its height is less than 20, proceed to the next step.
- 4.3. If the wall height is more than or equal to 20, go back to step 2.

Step 5 -Scan Surroundings:

- 5.1. Utilize the camera to identify plastic bottles in the environment.
- 5.2. If a bottle is found, proceed to the next step.
- 5.3. If no bottle is found, go back to step 2.

Step 6 - Approach the Bottle:

- 6.1. Move the robot towards the identified bottle.

Step 7 - Grasp and Lift the Bottle:

- 7.1. Employ the mechanized arm to securely grasp and lift the bottle.

Step 8 -Deposit Bottle in Storage:

- 8.1. Place the collected bottle in the designated storage unit.

Step 9 -Loop back to Step 2

- 9.1. Repeat the process of checking storage and scanning the surroundings.

Step 10 -Stop:

10.1. Terminate the operation until the storage unit is emptied.

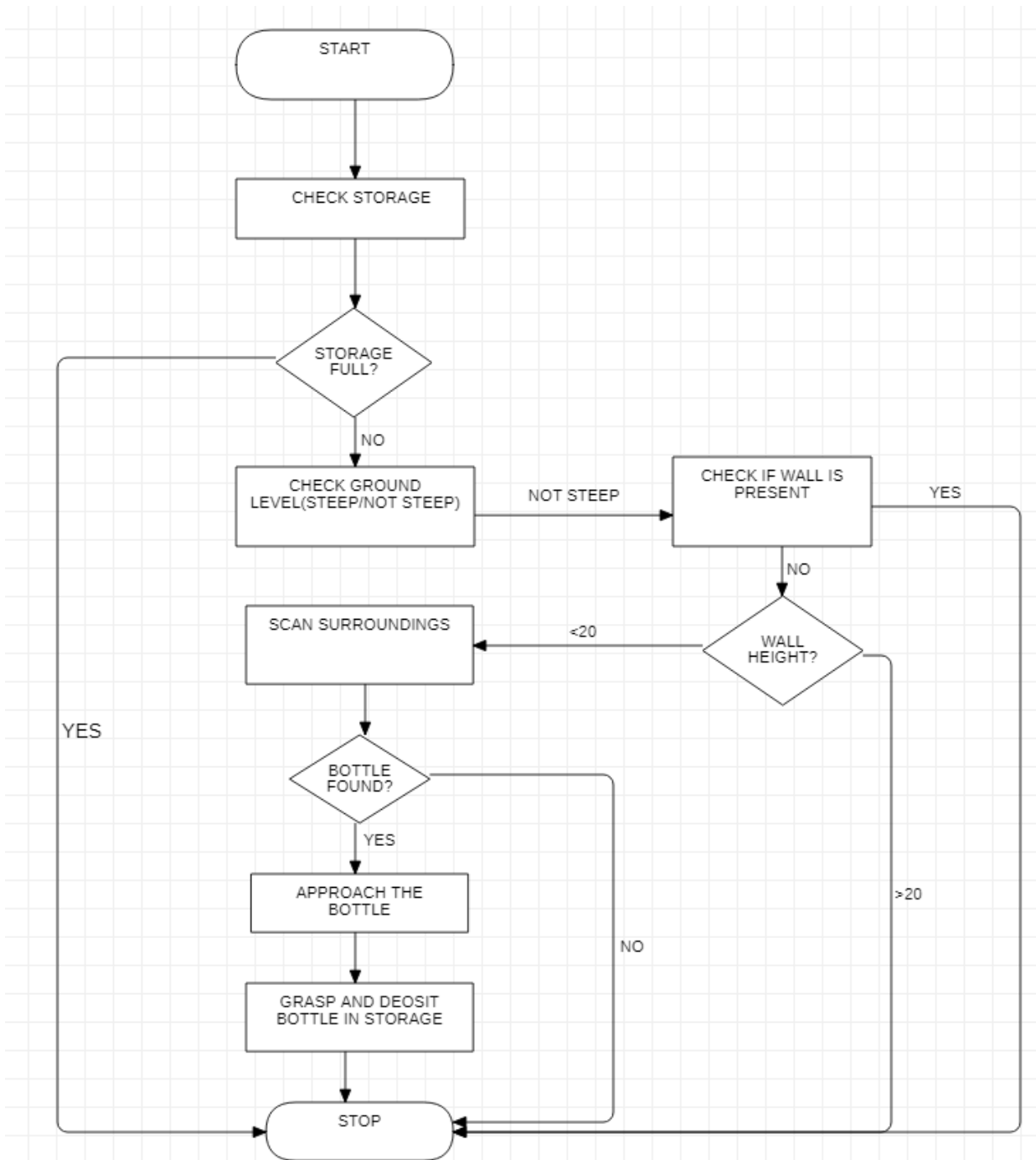


Figure : Data Flow Diagram

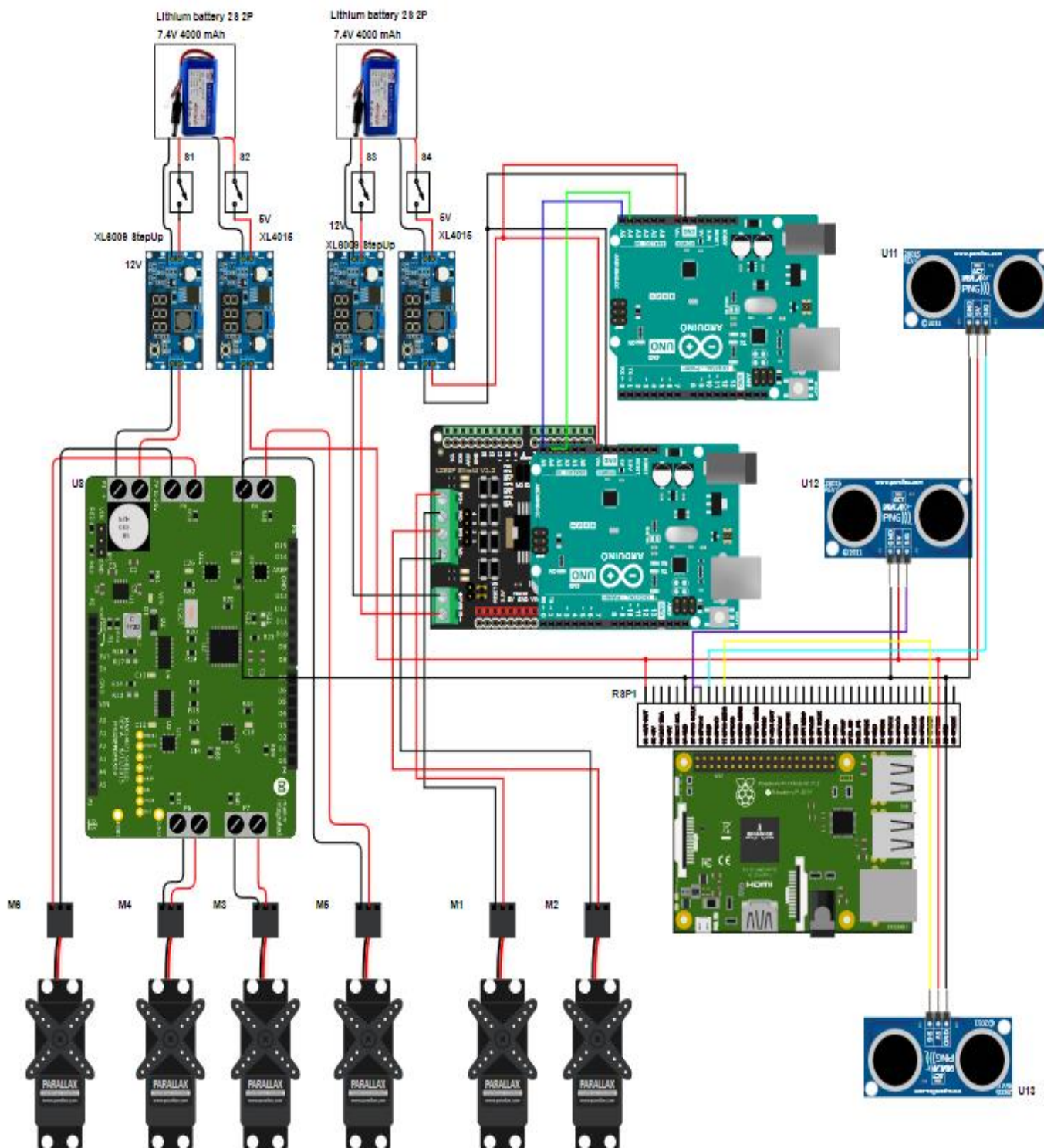
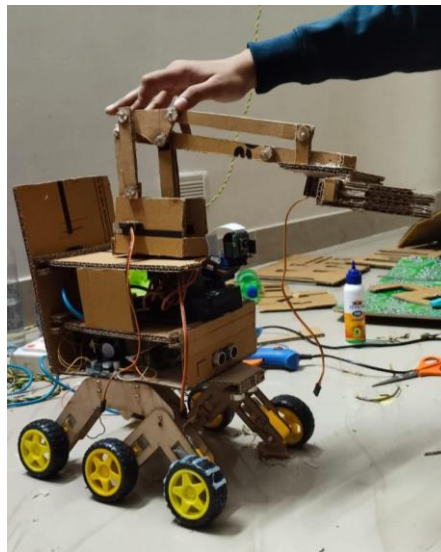


Figure : Circuit Diagram

VI. RESULTS

The implementation of the bottle detection system utilizing the YOLOv3 algorithm integrated with a Raspberry Pi and camera has yielded promising results. Upon deployment, the robot demonstrates efficient detection capabilities,

accurately identifying bottles within its designated range of 30 cm. The integration of the YOLOv3 algorithm enables real-time detection, allowing the robot to swiftly locate and approach bottles within its vicinity. Furthermore, the utilization of a manual control mechanism for the robot arm facilitates precise manipulation for bottle retrieval. By combining automated bottle detection with manual manipulation, the system achieves a balance between autonomy and human intervention, enhancing its versatility and usability in various scenarios. The incorporation of a rocker bogie mechanism enables the robot to navigate uneven terrains effectively, ensuring stability and maneuverability in challenging environments. This feature enhances the robot's adaptability, allowing it to operate in diverse settings with varying topographies. Overall, the bottle detection system demonstrates robust performance, effectively detecting and approaching bottles while offering manual control for manipulation and navigation on uneven terrains. These results validate the effectiveness and practicality of the integrated system in real-world applications, showcasing its potential for tasks such as automated bottle collection and environmental monitoring.



VII. CONCLUSION

The implementation of the bottle detection system signifies a notable advancement in robotics, particularly in autonomous object detection and retrieval. By integrating the YOLOv3 algorithm, Raspberry Pi, camera, and manual control mechanism, a versatile and precise robotic system has been created, capable of identifying and approaching bottles efficiently. The incorporation of a rocker bogie mechanism enhances the robot's mobility, enabling it to navigate challenging terrains effortlessly, thus expanding its potential applications from controlled environments to outdoor settings with uneven surfaces. Looking ahead, this system holds promise for environmental monitoring, waste management, and industrial automation, offering adaptability and versatility through autonomous detection and manual manipulation capabilities. This success highlights the potential of robotics to address real-world challenges effectively, with ongoing research and innovation poised to further enhance the capabilities and applications of autonomous robotic systems across various industries.

ACKNOWLEDGMENT

We want to express our deep-felt gratitude and sincere thanks to our guide Dr. A. Mallikarjuna Reddy, Associate Professor, Department of AI, Anurag University, for his skillful guidance, timely suggestions, and encouragement in completing this project. We want to express our profound gratitude to all for having helped us in achieving this dissertation. Finally, we would like to express our heartfelt thanks to our parents, who were very financially and mentally supportive and for their encouragement to achieve our goals.

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