e-ISSN:2582-7219

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH IN SCIENCE, ENGINEERING AND TECHNOLOGY

Volume 7, Issue 1, April 2024

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.521

International Journal Of Multidisciplinary Research In Science, Engineering and Technology (IJMRSET)

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| | Monthly Peer Reviewed & Refereed Journal |

|| Volume 7, Issue 1, April 2024 ||

International Conference on Recent Development in Engineering and Technology – ICRDET 24

Organized by

Dhaanish Ahmed Institute of Technology, KG Chavadi, Coimbatore, Tamilnadu, India

Autonomous Litter Detection and Collection Robot

Razal Fayis V. S.[1] Ayush K. R.[1] Al Anzar A.[1] R. Chandraprakash[2]

UG Students, Dept. of Robotics and Automation, Dhaanish Ahmed Institute of Technology, Anna University, Coimbatore, India[1]

Assistant Professor, Dept. of Robotics and Automation, Dhaanish Ahmed Institute of Technology, Anna University, Coimbatore, India[2]

ABSTRACT: This project aims to develop an autonomous litter-picking robot designed to operate in indoor environments such as malls, bus stations, and cinema halls. The robot's primary objective is to detect and collect litter items while navigating through the space and avoiding obstacles. Leveraging a combination of sensors and image processing techniques, the robot can identify litter objects and adjust its path to pick them up without mistaking them for obstacles. By employing cost-effective hardware components and simplified algorithms, we aim to create a practical solution for addressing litter pollution in public spaces, demonstrating the potential of robotics technology in environmental sustainability efforts.

KEYWORDS: Raspberry Pi, Litter Detection, Object Recognition, Obstacle Avoidance, Node MCU, Robot, Arduino IDE

I.INTRODUCTION

This project focuses on developing an Autonomous Litter Detection and Collection Robot (ALDCR) capable of navigating indoor environments, detecting litter objects, and avoiding obstacles. The robot utilizes a combination of ultrasonic sensors, and a camera for litter detection mounted on a Raspberry Pi-controlled platform. We have integrated a custom litter detection model built using TensorFlow Lite which uses a 200 image datasetalong with OpenCV to analyze camera feed and identify litter items based on visual characteristics. When a litter object is detected, the robot adjusts its path to approach and pick up the object while avoiding obstacles detected by ultrasonic sensors. Through this approach, our project aims to address litter pollution in public spaces by providing an efficient and cost-effective solution that does not require complex hardware or algorithms. Adjustments and optimizations are made to the algorithms and sensor placements to ensure reliable performance and adaptability to different environments.

In this paper, we present a detailed overview of the design, implementation, and functionality of our Litter Picking Robot project. We describe the hardware components utilized, which include a Raspberry Pi as the central controller, ultrasonic sensor, servo motors, H-bridge motor driver, and NodeMCU for servo and motor control. Additionally, we discuss the software architecture, highlighting the machine learning model. programming languages, libraries, and protocols employed for object detection, servo control, motor control, and communication between the Raspberry Pi and NodeMCU. By developing this Litter Picking Robot, our goal is to address the issue of litter pollution in public spaces by providing an autonomous solution that can detect and pick up litter efficiently, thereby contributing to a cleaner and healthier environment.

Litter pollution is a significant environmental concern that affects public spaces worldwide, leading to detrimental effects on ecosystems, wildlife, and human health. Traditional methods of litter collection and disposal often rely on manual labour, which can be inefficient, time-consuming, and costly. To address these challenges, we have developed an innovative Litter Picking Robot capable of autonomously detecting and collecting litter in various environments, including malls, bus stations, and cinema halls. By leveraging the advancements in robotics, artificial intelligence, and

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| | Monthly Peer Reviewed & Refereed Journal |

|| Volume 7, Issue 1, April 2024 ||

International Conference on Recent Development in Engineering and Technology – ICRDET 24

Organized by

Dhaanish Ahmed Institute of Technology, KG Chavadi, Coimbatore, Tamilnadu, India

sensor technology, our project aims to provide a sustainable solution to the problem of litter pollution while promoting environmental conservation and cleanliness. Through this paper, we aim to provide insights into the design, development, and potential applications of our Litter Picking Robot, highlighting its role in addressing pressing environmental issues and contributing to a cleaner and more sustainable future.

II. LITERATURE REVIEW

In [1] the authors discuss the development of a small beach cleaning robot. The paper discusses two aspects of the robot the first one being the refuse collection mechanism and the second one being the autonomous navigation system. In order to enable effective collection of refuse from a sandy surface, they developed a mechanism that mimics cleaning of a floor using a broom and dustpan.

In [2] the paper proposes the development of an autonomous robot that identifies garbage and classifies it into biodegradable and non-biodegradable. The successfully developed robot is capable of collecting and segregating the garbage.

The next literature [3] discuss about the design and development of a similar robot system which primarily aims to introduce a way in which garbagecould be collected and disposed efficiently the scope of the paper also extendsto analyse the problemof garbagedisposal at a school, restaurant, office, hotel, production plant or other similar locations. The proposed system is divided into two sub systems the first system is designed to collect garbage by following a line over a predefined area. The second system is configured to collect the stationary waste.

The [4] paper discuss about the development of an autonomous robotic exploration algorithm using ultrasonic sensors. The authors state the key feature of the algorithm to be the acquisition of object location based on the sensor output, the sensor interface aids in intelligent decision making and proper identification of the object of interest, ignoring stray mobile objects or walls. One of the limitations of the algorithm is discussed to be when the object of interest in the corner of a room which increases the number of scans required to detect the object.

The [5] literature proposes, explains and discuss about implementing a concept of making a modular, scalable and cost-effective system for garbage collection. The authors talk about efficiently utilizing Internet of Things to maintain a constant connection between a central server and a network of garbage processing and collecting, independent autonomous robots.

III. EXPERIMENTAL WORK

The proposed system for the Autonomous Litter Detection and Collection Robot (ALDCR)consists of an autonomous litter-picking robot equipped with an ultrasonic sensor and image processing capabilities to navigate and detect litter in indoor environmentsThe litter picking system, comprised of two servo motors is responsible for optimal positioning the mechanism and a suction cup attached to the end of the mechanism which is controlled by a solenoid valve and vacuum pump to supply air, the servo motors, the solenoid valve and the vacuum pump is controlled by a PCA9685 module which communicates via I2Cto the NodeMCU all of these components work together to pick up litter items identified by the image processing system. Once the litter is securely picked up, the servos are reversed to deposit the litter into the mounted litter box. In the development of my litter-picking robot. The NodeMCU also controls the drive motors which are controlled by an LM2596 H-Bridge Driver module.

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| | Monthly Peer Reviewed & Refereed Journal |

|| Volume 7, Issue 1, April 2024 ||

International Conference on Recent Development in Engineering and Technology – ICRDET 24

Organized by

Dhaanish Ahmed Institute of Technology, KG Chavadi, Coimbatore, Tamilnadu, India

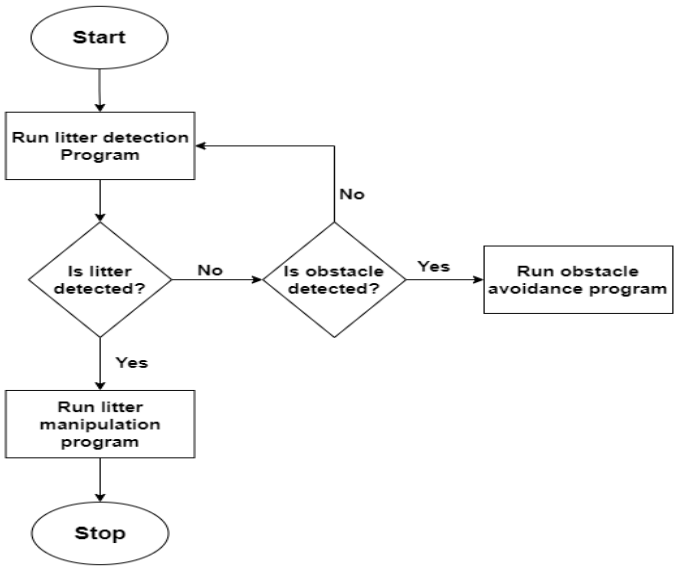

Fig.1. Process Flowchart

The NodeMCU serves as the central controller for the robot, coordinating the actions of the wheel motors, servo mechanism, suction pump, and solenoid valve. Upon detection of litter by the Raspberry Pi's custom object detection model built using TensorFlow Lite, which was trained using 200 litter images for object recognitionrunning on the Raspberry Pi using the Pi camera module, a signal is sent to the NodeMCU, prompting it to halt the movement of the robot and activate the litter collection system. The NodeMCU and Raspberry Pi communicate with each other through UART. This system, comprising the servo mechanism, suction pump, and solenoid valve, engages to collect the detected litter. In the absence of detected litter, the NodeMCU autonomously resumes control of the wheel motors, allowing the robot to continue its forward movement. This integration of Raspberry Pi detection and NodeMCU control ensures efficient and autonomous litter collection while optimizing the robot's operational capabilities.

The proposed ALDCR represents a significant advancement in waste management technology, particularly with the integration of the Raspberry Pi and NodeMCU. With the Raspberry Pi responsible for litter detection and decision-making, the system benefits from the Pi's powerful computational capabilities and AI algorithms. When litter is detected, the Raspberry Pi sends signals to the NodeMCU to initiate the appropriate actions, including stopping the wheel motors, activating the servo motors for litter collection, and controlling the suction pump and solenoid valve. This seamless communication between the Raspberry Pi and NodeMCU enables precise and timely execution of cleaning tasks, resulting in improved efficiency and effectiveness of litter collection. Additionally, the system's ability to operate autonomously in diverse environments enhances its adaptability and scalability, making it suitable for a wide range of applications. Overall, the integration of the Raspberry Pi and NodeMCU offers numerous advantages, including enhanced functionality, improved control, and greater flexibility in waste management operations.

IV. RESULTS

After the successful implementation of the system, several significant results were observed. Firstly, the integration of the Raspberry Pi and NodeMCU enabled seamless communication and coordination between the various components of the litter-picking robot. This allowed for efficient detection and collection of litter in both indoor and outdoor environments. Additionally, the use of the custom litter detection model on the Raspberry Pi facilitated accurate detection of litter items, minimizing false positives and optimizing the robot's performance. The system's ability to autonomously navigate and operate in diverse environments demonstrated its effectiveness and reliability in real-world applications. Furthermore, the successful execution of litter collection tasks, including stopping the wheel motors, activating the servo motors, and controlling the suction pump and solenoid valve, validated the robustness and

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| | Monthly Peer Reviewed & Refereed Journal |

|| Volume 7, Issue 1, April 2024 ||

International Conference on Recent Development in Engineering and Technology – ICRDET 24

Organized by

Dhaanish Ahmed Institute of Technology, KG Chavadi, Coimbatore, Tamilnadu, India

functionality of the system. Overall, the results of the successful implementation highlighted the system's capability to effectively address litter pollution challenges while showcasing its potential for broader deployment in waste management operations.

Fig.3. Robot side view

Fig.4. Robot top view

V. CONCLUSION AND FUTURE WORK

In conclusion, the successful development and implementation of the litter-picking robot represent a significant milestone in addressing litter pollution challenges. The system's integration of Raspberry Pi and NodeMCU, coupled with AI algorithms for litter detection, demonstrated its effectiveness in autonomously detecting and collecting litter in diverse environments. Moving forward, there are opportunities for further enhancement and refinement of the system. Introducing the capability for the robot to autonomously navigate towards detected litter when it's far away would indeed increase the complexity of the system, but it's a feasible extension. Additional navigation logic, integration with litter detection, adaptation of obstacle avoidance, sensor fusion, decision making, testing, and tuning would be necessary to realize this feature. Overall, adding autonomous navigation towards detected litter would make the system more sophisticated, enhancing its capabilities and utility in waste management operations. The complexity increase would depend on specific implementation details and the desired level of autonomy.

REFERENCES

[1] T. Ichimura and S. -i. Nakajima, "Development of an autonomous beach cleaning robot “Hirottaro”," 2016 IEEE International Conference on Mechatronics and Automation, Harbin, China, 2016, pp. 868-872, doi: 10.1109/ICMA.2016.7558676.

[2] Bhagyashree P Hegde, et al. “Garbage Collection Robot Using Image Processing." International Research Journal of Modernization in Engineering Technology and Science 4.6 (2022)

[3] Khan MA, Khan DMZ, Khan H, Hanzla M, Jamal M, Khalid T, Ullah N (2020) Garbage collector robot. Indian Journal of Science and Technology 13(20): 2065-2070. https://doi.org/10.17485/IJST/v13i20.212

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| | Monthly Peer Reviewed & Refereed Journal |

|| Volume 7, Issue 1, April 2024 ||

International Conference on Recent Development in Engineering and Technology – ICRDET 24

Organized by

Dhaanish Ahmed Institute of Technology, KG Chavadi, Coimbatore, Tamilnadu, India

[4] Kulkarni S and Junghare S 2013 International Conference on Control, Automation, Robotics and Embedded Systems, Robot based indoor autonomous trash detection algorithm using ultrasonic sensors.

[5] Sengupta A, Varma V, Sai Kiran M, Johari A, Marimuthu R 2019 Cost-Effective Autonomous Garbage Collecting Robot System Using IoTand Sensor Fusion.

[6]Pinheiro, Paulo, et al. "Cleaning task planning for an autonomous robot in indoor places with multiples rooms." International Journal of Machine Learning and Computing 5.2 (2015): 86. DOI: 10.7763/IJMLC.2015.V5.488.

[7] Nagasaka, Y., Saito, H., Tamaki, K., Seki, M., Kobayashi, K. and Taniwaki, K. (2009), An autonomous rice transplanter guided by global positioning system and inertial measurement unit. J. Field Robotics, 26: 537-548. https://doi.org/10.1002/rob.20294

[8] Anh Tuan Le, D. C. Rye and H. F. Durrant-Whyte, "Estimation of track-soil interactions for autonomous tracked vehicles," Proceedings of International Conference on Robotics and Automation, Albuquerque, NM, USA, 1997, pp. 1388-1393 vol.2, doi: 10.1109/ROBOT.1997.614331

[9] A. Chung, D. Y. Kim, E. Kwok, M. Ryan, E. Tan and R. Gamadia, "Cloud Computed Machine Learning Based Real-Time Litter Detection using Micro-UAV Surveillance," 2018 IEEE MIT Undergraduate Research Technology Conference (URTC), Cambridge, MA, USA, 2018, pp. 1-4, doi: 10.1109/URTC45901.2018.9244800

[10] Palacin J, Salse JA, Valganon I, Clua X. Building a Mobile Robot for a Floor-Cleaning Operation in Domestic Environments. *IEEE Transactions on Instrumentation and Measurement*. 2004;53(5):1418–1424. Available from: https://dx.doi.org/10.1109/tim.2004.834093.

[11] Takeshita T, Tomizawa T. A house Cleaning Robot System - path indication and Position estimation using ceilingcamera. In: SICE-ICASEInternational Joint Conference. Busan, Korea. 2006.

[12] Bai J, Lian S, Liu Z, Wang K, Liu D. Deep Learning Based Robot for Automatically Picking Up Garbage on the Grass. *IEEE Transactions onConsumer Electronics*. 2018;64(3):382–389. Available from: https://dx.doi.org/10.1109/tce.2018.2859629. doi:10.1109/tce.2018.2859629.

[13] Apoorva S, Chaithanya, Prabhu RS, Shetty SB, D'Souza D. Autonomous Garbage Collector Robot. *International Journal of Internet ofThings*. 2017;6(2):40–42.

[14] Khandare S, Badak S, Sawant Y, Solkar S. Object Detection Based Garbage Collection Robot. *International Research Journal of Engineeringand Technology (IRJET)*. 2018;05(3).

[15] V. Nguyen, A. Harati, R. Seigwart, "A lightweight SLAM algorithmusing orthogonal planes for Indoor mobile robotics" Proc. of IEEEInternational Conference on Intelligent Robotics an Systems, San Diego,CA, Oct 2007, pp. 658-663

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH

IN SCIENCE, ENGINEERING AND TECHNOLOGY

| Mobile No: +91-6381907438 | Whatsapp: +91-6381907438 | ijmrset@gmail.com |

www.ijmrset.com