IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

REVIEW ON LIDAR-GUIDED AUTONOMOUS CAMPUS DELIVERY ROBOT USING RASPBERRY PI AND ROS 2

[1]Kasturi Patil, [2]Mansi Patil, [3]Ganesh Kawade, [4]Kalpesh Bait, [5]Ashok Mane

[1, 2, 3, 4]Students, [5]Assistant Professor

Department of Electronics and Telecommunication Engineering,

Terna Engineering College, Navi Mumbai

Abstract: Autonomous robotic systems are increasingly applied in areas such as material transportation, surveillance, and indoor logistics, where safe navigation and reliable obstacle detection are essential. This paper presents the design and development of a smart obstacle detection and navigation robot with load carrying capability using a hybrid sensing and control architecture. The proposed system integrates Raspberry Pi 4B, LIDAR sensor, Pi Camera, Arduino, DC motors, and a motor driver to achieve effective environment perception, decision making, and motion control.

The LIDAR sensor provides accurate real-time distance measurements for detecting obstacles, while the Pi Camera supports visual perception and path awareness. Raspberry Pi serves as the primary processing unit for sensor data analysis and navigation logic, whereas Arduino is employed for precise motor control and low-level actuation. Based on obstacle detection and navigation constraints, the robot dynamically modifies its path to avoid collisions while maintaining stability during load transportation. Experimental evaluation shows smooth obstacle avoidance, efficient path correction, and reliable load movement in dynamic indoor environments. The proposed system offers a low-cost and scalable solution suitable for warehouses, campuses, and industrial applications.

Index Terms **-** Obstacle Detection, Smart Detection, LIDAR, Raspberry Pi, Arduino, Load Carrying Robot.

I. INTRODUCTION

In recent years, autonomous robots have gained significant attention due to their wide range of applications in material handling, indoor logistics, surveillance, and service robotics. A key requirement for such systems is the ability to navigate safely in unknown or dynamic environments while avoiding obstacles in real time. Obstacle detection and smart navigation are therefore essential for ensuring collision-free movement and reliable operation, especially when robots are designed to carry loads.

Conventional obstacle avoidance systems often rely on single sensing technologies such as ultrasonic sensors, which offer limited accuracy and are sensitive to environmental conditions. To address these limitations, advanced sensing technologies such as Light Detection and Ranging (LIDAR) and vision-based systems are increasingly adopted. LIDAR provides accurate distance measurement and wide-area environmental scanning, while camera-based systems enhance perception by providing visual information for navigation and path planning.

navigation and path planning. With the advancement of embedded platforms, Raspberry Pi has emerged as a cost-effective solution for real-time sensor processing and decision-making, while Arduino is commonly used for reliable low-level motor control. In addition to navigation, load carrying introduces challenges related to stability, speed regulation, and safe maneuvering. This paper presents the design and implementation of an obstacle detection robot with autonomous navigation and load carrying capability using a combination of LIDAR sensor, Pi Camera, Raspberry Pi 4B, Arduino, DC motors, and motor driver modules. The proposed system aims to provide accurate obstacle detection, intelligent navigation, and reliable load transportation in indoor environments. The developed robot demonstrates an efficient, low-cost, and scalable solution for autonomous mobile robotic applications.

II. LITERATURE SURVEY

Autonomous robots have gained considerable attention due to their ability to operate without continuous human intervention in structured environments such as campuses and institutions. Early developments in autonomous robotics mainly focused on basic obstacle avoidance using embedded platforms like Raspberry Pi. Camera-based systems were employed to detect obstacles through real-time image processing and adjust the robot's direction accordingly. Although effective in controlled conditions, these systems were sensitive to lighting variations and background complexity, limiting their reliability in real world environments.[1]

To improve robustness, several researchers integrated ultrasonic sensors with Raspberry Pi–based robotic platforms. Ultrasonic sensors measure distance using sound waves and are less affected by lighting conditions. Studies showed that robots equipped with ultrasonic sensors could reliably detect nearby obstacles and avoid collisions in unknown environments. However, due to limited sensing range and lack of environmental representation, such systems were unsuitable for large-area navigation and autonomous delivery applications. [2]

With advancements in sensing technologies, LiDAR emerged as a powerful solution for obstacle detection and environment perception. LiDAR sensors provide accurate distance measurements and generate point cloud data, enabling robots to perceive their surroundings in detail. Researchers demonstrated that 2D LiDAR sensors mounted on Raspberry Pi platforms could successfully detect obstacles over longer ranges compared to ultrasonic sensors, making them suitable for autonomous navigation tasks.[3]

To enable full autonomy, researchers incorporated Simultaneous Localization and Mapping (SLAM) techniques with LiDAR sensors. SLAM allows a robot to generate a map of an unknown environment while simultaneously determining its own position. Studies using ROS-based SLAM packages showed that Raspberry Pi–based systems could build real-time maps and navigate efficiently in indoor environments. These approaches significantly improved navigation accuracy and decision-making capability.[4]

Despite the accuracy of LiDAR, certain material such as transparent or reflective surface pose detection challenges. To overcome this limitation, recent studies proposed sensor fusion approaches combining LiDAR with ultrasonic sensors. The integration of ultrasonic data enhanced obstacle detection reliability by identifying objects missed by LiDAR alone. Researchers further integrated this sensor fusion approach with ROS 2 navigation frameworks, enabling improved path planning using cost maps and A* algorithms.[5]

The adoption of ROS 2 further strengthened autonomous robotic systems by offering improved real-time performance, reliable communication, and better scalability. ROS 2–based navigation frameworks demonstrated efficient integration of LiDAR sensors, SLAM algorithms, and navigation stacks for autonomous robots operating in large environments. These features make ROS 2 particularly suitable for autonomous campus delivery robots requiring stable and scalable navigation solutions.[5]

In summary, existing literature confirms that camera- and ultrasonic-based robots are suitable for basic obstacle avoidance, while LiDAR-based systems combined with SLAM and ROS 2 provide superior autonomy, accuracy, and scalability. However, limited work has specifically focused on LiDAR-guided autonomous campus delivery robots using Raspberry Pi and ROS 2, thereby establishing a clear research gap that the proposed project aims to address.

III. HARDWARE AND SOFTWARE DESCRIPTION

The hardware design of the proposed obstacle detection robot is developed to achieve reliable navigation, accurate obstacle sensing, and stable load carrying performance.

3.1 Raspberry Pi Raspberry Pi 4B shown in figure 1, serves as the main processing and control unit of the robot. It is responsible for collecting sensor data from the LIDAR and visual input from the Pi Camera. The Raspberry Pi performs real-time data analysis, decision-making, and path planning to determine safe movement directions. It also manages communication with the Arduino through UART, sending motion commands based on obstacle detection results. The high processing capability of Raspberry Pi allows smooth handling of multiple sensor inputs simultaneously.

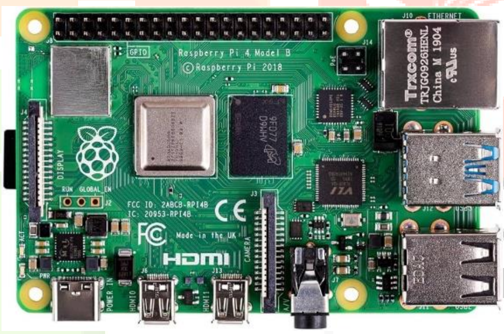


Figure 1. Raspberry Pi 4 Model B

3.2 Pi Camera

The Pi Camera shown in figure 2, it is integrated to provide visual perception of the environment. It captures live video frames, which help the system understand surrounding conditions and assist in navigation. The camera enhances obstacle awareness and supports smart navigation, especially in situations where distance data alone may not be sufficient. Visual feedback also improves the robot's ability to operate in indoor environments with varying lighting conditions.

Figure 2. Pi Camera

3.3 RP LiDAR

The LIDAR sensor which is shown in figure 3, it's plays a critical role in precise obstacle detection by continuously measuring distances between the robot and nearby objects. It provides accurate range data over a wide field of view, enabling early detection of obstacles. The sensor data is directly fed to the Raspberry Pi, where it is processed to identify obstacle position and distance. This allows the robot to make timely decisions and adjust its path smoothly while carrying a load.

Figure 3. RP LiDAR

3.4 Python

Python is a high-level, interpreted programming language widely used in robotic and embedded applications due to its simplicity and flexibility. In this project, Python is used on the Raspberry Pi to implement sensor data processing, decision-making, and navigation logic. Its extensive library support enables easy integration of the LIDAR sensor, Pi Camera, and communication with Arduino, allowing real-time control and efficient system operation.

3.5 OpenCV

OpenCV (Open-Source Computer Vision Library) is an open-source library designed for real-time image processing and computer vision applications. In this project, OpenCV is used to process images captured by the Pi Camera for visual perception and path awareness. It assists in analyzing the environment and supports obstacle detection by extracting relevant visual information, thereby enhancing the robot's navigation and decision-making capabilities.

IV. WORKING

The proposed obstacle detection robot operates through coordinated sensing, processing, mapping, and actuation using the Robot Operating System (ROS) framework. ROS provides a modular communication environment that enables efficient data exchange between sensors, processing units, and control modules.
During operation, the LIDAR sensor continuously scans the surroundings and provides distance measurements, while the Pi Camera captures real-time visual data. These sensor inputs are processed on the Raspberry Pi 4B, where ROS nodes handle data acquisition and control. Using Simultaneous Localization and Mapping (SLAM) techniques, the robot builds a map of the environment while estimating its position within that map. This allows the system to understand obstacle locations and plan safe navigation paths in real time.
Based on the SLAM output and obstacle information, the navigation module determines the appropriate movement direction. Motion commands are then transmitted from the Raspberry Pi to the Arduino through UART communication. The Arduino generates control signals for the motor driver, which drives the DC motors to execute the desired movement. This process runs continuously, enabling dynamic obstacle avoidance, accurate navigation, and stable load transportation without human intervention.

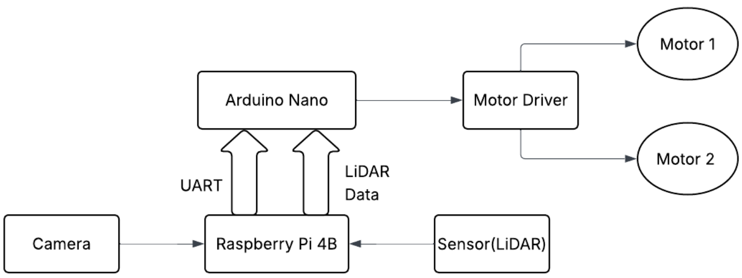
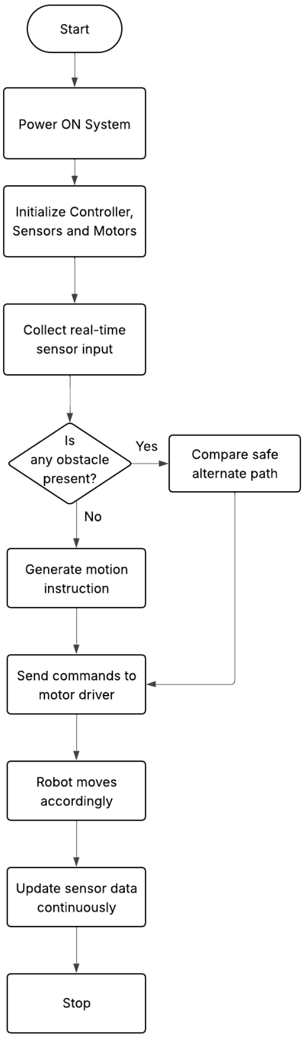


Figure 4. Block Diagram of Campus Delivery Robot

4.1 Flowchart of Campus Delivery Robot



The given flowchart explains the complete working sequence of an autonomous robotic system in a clear and systematic manner. The process begins with powering ON the system, which activates the controller and all associated hardware components [1]. Once the system is turned on, the controller initializes the sensors and motors to ensure that every component is functioning properly before the robot starts its operation [2]. After initialization, the robot begins collecting real-time sensor data from its surroundings. This sensor data enables the system to understand the environment and detect any obstacles that may exist in the robot's path [3].

The collected sensor information is then analyzed to determine whether an obstacle is present. If an obstacle is detected, the system does not proceed along the original path. Instead, it evaluates available safe alternate paths using real-time sensor data and selects the most suitable route to avoid collisions [4][5]. This decision-making process ensures safe and efficient navigation in dynamic environments. If no obstacle is detected, the system directly generates motion instructions such as moving forward, turning, or adjusting speed based on predefined control logic [3].

Once the motion instructions are finalized, they are sent to the motor driver, which converts these commands into appropriate electrical signals required to drive the motors [6]. As a result, the robot moves according to the given instructions. During movement, sensor data is continuously updated and monitored to detect any changes in the environment in real time [7]. This continuous feedback mechanism allows the robot to respond quickly to new obstacles or path deviations. The entire process operates in a closed-loop manner until a stop command is issued, after which the system safely terminates its operation [8].

V. Future Scope

The autonomous campus delivery robot can be further enhanced to improve usability, safety, and real-world performance. Future development may include advanced human–robot interaction through mobile apps, touch interfaces, or voice commands for user-friendly operation. Intelligent obstacle classification can help the robot distinguish between pedestrians, vehicles, and static objects for smoother navigation. The system can be extended with wireless communication and cloud connectivity to enable remote monitoring, data logging, and control. Additionally, incorporating machine learning or deep learning models for object recognition and decision-making can enhance the robot's ability to understand and respond to different types of obstacles. Hardware upgrades such as higher-resolution cameras, improved LIDAR sensors, and better motor control mechanisms can further increase navigation precision and load handling capability.

With these enhancements, the proposed system has the potential to evolve into a more intelligent, autonomous, and scalable robotic platform suitable for advanced indoor automation tasks.

VI. Conclusion

This project demonstrates the effective use of LiDAR for accurate obstacle detection and safe navigation in a campus environment. The integration of SLAM enables the robot to create maps and determine its position in real time. Using Raspberry Pi as the main controller provides a compact and cost-effective hardware solution. The ROS2 framework improves system modularity, communication, and real-time performance. The robot is capable of dynamically adjusting its path in the presence of obstacles. The system remains stable even under load conditions during operation. Sensor integration enhances reliability compared to traditional camera or ultrasonic methods. Overall, the proposed system is efficient, scalable, and suitable for autonomous campus delivery applications.

References

[1] M. Krishna, A. Vinitha, L. Shivprasad, and K. Manisha, "Obstacle Avoiding Robot Car Using Raspberry Pi," *Journal of Cardiovascular Disease Research*, vol. 10, no. 4, pp. 683–685, 2019.

[2] C. Day, L. McEachen, A. Khan, S. Sharma, and G. Masala, "Pedestrian Recognition and Obstacle Avoidance for Autonomous Vehicles Using Raspberry Pi," in *Advances in Intelligent Systems and Computing*. Springer, 2019, doi: 10.1007/978-3-030-29513-4_5.

[3] S. Kamble and S. Kharche, "Obstacle Detection Using LiDAR," *International Journal of Scientific Research & Engineering Trends*, vol. 7, no. 4, pp. 2537–2539, July–Aug. 2021.

[4] M. Calcroft and A. Khan, "LiDAR-Based Obstacle Detection and Avoidance for Autonomous Vehicles Using Raspberry Pi 3B," in *Proc. IEEE Int. Conf. Control*, 2022, doi: 10.1109/control55989.2022.9781465.

[5] R. Hurnen, "Overcoming the Limitations of Standard LiDAR in Autonomous Robots Using Ultrasonic Sensors," B.E. Project Report, Dept. of Engineering, 2023.

[6] T. Bin Mohamed, N. S. Abd Karim, and A. A. Bin Rosli, "RPLIDAR Integration Module for Obstacle Avoidance Robot," *International Journal of Advanced Trends in Computer Science and Engineering*, vol. 8, no. 1.6, pp. 504–508, 2019, doi: 10.30534/ijatcse/2019/7381.62019.

[7] B. Anitha and A. K. Amsavalli, "Obstacle Avoidance Robot Using Raspberry Pi," *International Journal of Advance Research and Innovative Ideas in Education (IJARIIE)*, vol. 6, no. 2, pp. 1067–1070, 2020, ISSN: 2395-4396.

[8] S. Petersen and N. Haws, *Autonomous Delivery Robot*, Project Report, Department of Engineering, 2021.