International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 • Website: www.ijfmr.com • Email: editor@ijfmr.com

Lidar-Guided Autonomous Campus Delivery Robot Using Raspberry Pi and Ros 2

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

[1,2,3,4]Student, Electronics and Telecommunication, Terna Engineering College, Navi Mumbai.
[5]Assistant Professor, Electronics and Telecommunication, Terna Engineering College, Navi Mumbai.

Abstract
This project presents the design and implementation of a **LiDAR-guided autonomous campus delivery robot using ROS 2 and a Raspberry Pi 4** as the core processing platform. The system is developed to perform reliable and efficient delivery tasks in structured campus environments without human intervention by integrating sensing, computation, and control modules. Additionally, the robot is designed to carry small payloads, enabling it to transport materials such as documents, packages, or lightweight items from one location to another.
The robot utilizes an RPLiDAR sensor to perform real-time environment perception and mapping through SLAM (Simultaneous Localization and Mapping), enabling accurate localization and path planning. To enhance navigation robustness, additional sensors such as the MPU6050 and HC-SR04 Ultrasonic Sensor are incorporated for orientation estimation and close-range obstacle detection. The sensor fusion approach improves the system's ability to operate in dynamic and partially unknown environments.
Navigation commands generated by the ROS 2 framework are transmitted to an ESP32, which handles low-level motor control using an L298N Motor Driver. The integration of wheel encoders enables closed-loop feedback control, ensuring precise motion, speed regulation, and improved trajectory tracking.
Furthermore, the system supports real-time monitoring and visualization using RViz, allowing users to observe mapping, localization, and robot movement remotely. A dual power supply architecture is implemented to maintain stable operation of both computational and actuation units.
Overall, the proposed system offers a cost-effective, scalable, and reliable solution for autonomous delivery applications in campus settings, particularly for transporting small loads efficiently, with potential extensions toward smart logistics, indoor automation, and service robotics.

Keywords: Autonomous Delivery Robot, ROS 2, SLAM (Simultaneous Localization and Mapping), Path Planning and Navigation, Obstacle Avoidance, Raspberry Pi 4.

1. Introduction

"**LIDAR-Guided Autonomous Campus Delivery Robot Using Raspberry Pi and ROS 2**" focuses on the development of an autonomous robotic system capable of performing delivery tasks in a structured campus environment without human intervention. The system is designed by integrating sensing, processing, and control components, to achieve intelligent navigation and real-time decision-making.

At the core of the system, the Raspberry Pi 4 acts as the main processing unit running ROS 2, which handles mapping, localization, and path planning. The robot utilizes an RPLidar sensor to scan the environment and generate real-time maps using SLAM techniques. Additional sensors such as the MPU6050 (IMU) and HC-SR04 ultrasonic sensor enhance the robot's ability to detect orientation and avoid obstacles effectively. A camera module is also integrated for visual input and future enhancements.

The control of the robot is managed by an ESP32 microcontroller, which receives commands from the Raspberry Pi and drives the motors through the L298N motor driver. The system uses a dual power supply configuration to ensure stable operation of both logic and motor components. Furthermore, wireless communication enables real-time monitoring and visualization through RViz. By combining LIDAR-based sensing, ROS 2-based processing, and embedded motor control, the proposed system provides a efficient autonomous delivery solution for campus environments, reducing human effort and improving operational efficiency.

2. Project Objectives

1. To design and develop an autonomous delivery robot capable of operating in a structured campus environment without human intervention.
2. To implement real-time mapping and localization using ROS 2 and LiDAR-based SLAM techniques.
3. To integrate a Raspberry Pi 4 as the main processing unit for handling navigation, sensor data processing, and decision-making.
4. To develop an efficient path planning and navigation system for safe and optimized movement of the robot.
5. To enhance obstacle detection and avoidance by combining LiDAR with sensors like HC-SR04 Ultrasonic Sensor and MPU6050.
6. To implement reliable motor control using an ESP32 and L298N Motor Driver.
7. To achieve precise movement and stability using wheel encoders and closed-loop feedback control mechanisms.
8. To enable real-time monitoring and visualization of the robot's operation using RViz.
9. To develop a cost-effective and scalable system suitable for campus delivery and similar automation applications

International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

3. Block Diagram for Campus Delivery Robot

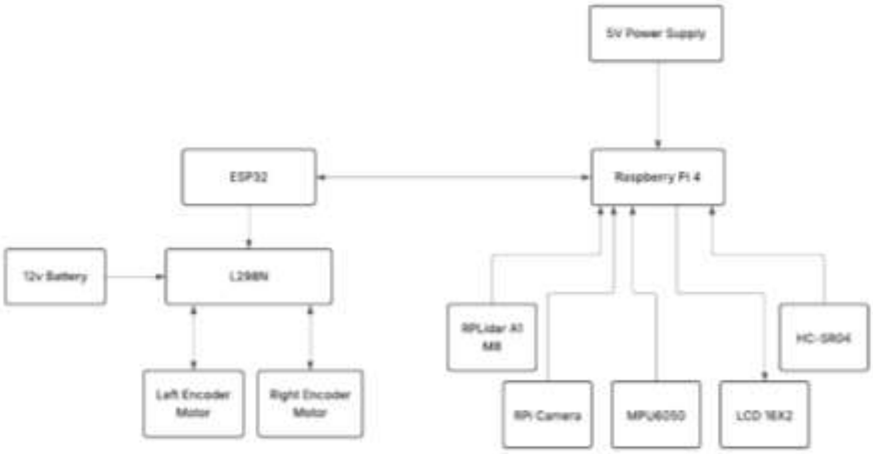

Fig1. Block Diagram of Campus Delivery Robot

The proposed system is a LiDAR-based autonomous delivery robot in which a Raspberry Pi 4 acts as the main processing unit, powered by a 5V supply, while a separate 12V battery is used to drive the motors through the motor driver. The Raspberry Pi runs ROS 2 to perform mapping, localization, and path planning. It receives input from multiple sensors including the RPLiDAR A1 M8 for environment scanning, an RPi camera for visual input, the MPU6050 for orientation, and the HC-SR04 Ultrasonic Sensor for obstacle detection, while an LCD 16×2 displays system information. Based on the processed data, the Raspberry Pi generates navigation commands and sends them to the ESP32, which controls the motors via the L298N Motor Driver. The motors enable the robot to move in different directions, and encoder feedback from both wheels ensures accurate speed and position control through a closed-loop system. This integrated process allows the robot to navigate autonomously, avoid obstacles, and reach its destination efficiently.

4. Working of the Project

The proposed LiDAR-guided autonomous delivery robot operates by integrating sensing, processing, and control modules to perform navigation and delivery tasks in a structured environment.

1. System Initialization

The robot is powered on, and the ROS 2 framework running on the Raspberry Pi 4 initializes all nodes related to sensors, mapping, localization, and motor control.

2. Environment Scanning and Mapping

The LiDAR sensor continuously scans the surroundings and generates real-time distance data. Using SLAM (Simultaneous Localization and Mapping), the robot creates a map of the environment while simultaneously determining its position within that map.

3. Sensor Fusion for Accuracy

Additional sensors like the MPU6050 provide orientation and motion data, while the HC-SR04 Ultrasonic Sensor detects nearby obstacles. This combined data improves navigation accuracy and stability.

4. Path Planning and Decision Making

Based on the generated map and target location, the system computes the optimal path using path planning algorithms. The robot continuously updates its path if dynamic obstacles are detected.

5. Navigation Command Generation

The processed data is converted into movement commands such as forward, backward, left, and right. These commands are generated by ROS 2 and sent to the control unit.

6. Motor Control Execution

The commands are transmitted to the ESP32, which controls the motors through the L298N Motor Driver to drive the robot.

7. Feedback and Motion Correction

Wheel encoders continuously provide feedback on wheel rotation and speed. This enables closed-loop control, allowing the robot to correct its movement and maintain accurate trajectory tracking.

8. Obstacle Avoidance

If any obstacle is detected in the robot's path, the system dynamically adjusts the route or stops temporarily to prevent collisions.

9. Real-Time Monitoring and Visualization

The entire process can be monitored using RViz, where the map, robot position, and sensor data are displayed in real time.

10. Task Completion

The robot navigates to the desired destination, completes the delivery task, and can either stop or return to its starting position.

5. Results

Fig2. Internal electronics layout of the proposed robot system

Fig3. Motor driver and control circuitry implementation

Fig4. Mechanical structure and LiDAR placement carrying capability

Fig5. Experimental setup showing payload

6. Conclusion

The project successfully develops a LiDAR-based autonomous delivery robot using ROS 2 and a Raspberry Pi 4. The system performs mapping, localization, and obstacle avoidance using multiple sensors. It efficiently navigates in a structured environment without human intervention. The robot is also capable of carrying small payloads, making it useful for campus delivery applications. The integration of ESP32 and motor driver ensures smooth and accurate movement. Overall, the system is cost-effective, reliable, and suitable for real-world automation.

7. 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.