

Autonomous Theft Proof Delivery Robot for Food and E-Commerce

**Prof. Dr. B. R. Borker, Varpe Shivani Somnath, Borde Satish Prakash,
Sanap Swapnil Dattatray, Ram Shibika Hariram**

Department of Automation and Robotics Engineering

Amrutvahini College of Engineering, Maharashtra

bhaskar.borkar@avcoe.org, varpeshivani4@gmail.com

satishborde18838@gmail.com, swapnilsanap110@gmail.com, shibikahariram@gmail.com

Abstract: *The Autonomous Delivery Robot is an intelligent robotic system designed to perform secure and efficient indoor delivery of items in places such as hospitals, offices, warehouses, and institutions. The system is developed using an ESP32 microcontroller as the main controller, integrated with DC gear motors, motor driver, ESP32-CAM module, keypad, solenoid lock, relay module, and 16×2 I2C display. The robot is capable of autonomous movement and remote monitoring through an IoT-based web interface. Live video streaming allows users to track the robot's movement and surroundings in real time.*

To ensure delivery security, the robot uses a One-Time Password (OTP) authentication system. The delivery box remains locked using a solenoid lock and opens only when the correct OTP is entered through the keypad. This prevents unauthorized access and ensures safe handling of sensitive materials such as medicines, documents, and valuable items. The proposed system reduces human effort, saves time, improves operational efficiency, and provides a smart contactless delivery solution for modern indoor environments.

Keywords: Autonomous Robot, WiFi Monitoring, OTP Security, ESP32-CAM, Indoor Navigation, Smart Robot, Contactless Delivery System, Automation

I. INTRODUCTION

In the modern era, automation and robotics have become important technologies that are transforming industrial, commercial, and domestic operations. Robotic systems are widely used to improve productivity, reduce manual effort, and increase operational accuracy. Among various robotic applications, autonomous delivery systems have gained significant importance because they provide efficient transportation of goods without continuous human involvement. Traditional indoor delivery methods in offices, hospitals, warehouses, and institutions mainly depend on workers to transport materials manually. This often leads to delays, increased labour cost, misplaced items, and reduced efficiency. Therefore, the demand for intelligent robotic delivery systems has increased rapidly in recent years.

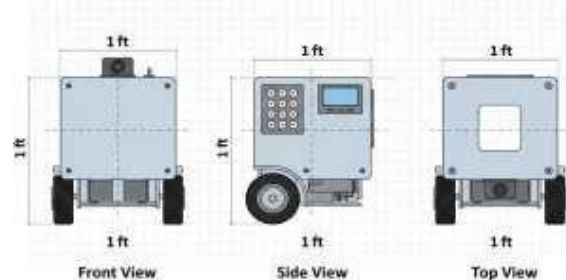


Fig 1: Orthographic View of Robot



The Autonomous Delivery Robot is designed as a compact and smart robotic platform capable of performing secure and efficient indoor deliveries. The system is built around the ESP32 microcontroller, which offers high processing capability along with built-in Wi-Fi and Bluetooth connectivity. These features allow the robot to perform multiple operations such as motor control, OTP verification, live monitoring, and communication with a web-based interface. The robot uses DC gear motors connected through a motor driver for smooth movement and precise navigation in narrow corridors and indoor pathways. Its compact dimensions make it suitable for hospitals, office cabins, classrooms, laboratories, and warehouse aisles where larger delivery systems may not operate effectively.

Security is one of the major concerns in delivery systems, especially when transporting confidential documents, medicines, or valuable materials. To solve this issue, the proposed robot uses a One-Time Password (OTP) based authentication mechanism. The delivery compartment is protected using a solenoid lock controlled through a relay module. Only when the authorized user enters the correct OTP through the keypad does the system unlock the storage box. This feature prevents unauthorized access and ensures safe package delivery. In addition, a 16×2 I2C display provides status messages such as robot movement, OTP prompts, and successful delivery notifications, improving transparency and user interaction.

The robot also includes an ESP32-CAM module for real-time video streaming, allowing users to remotely monitor the delivery process and surrounding environment. This feature is highly useful in sensitive areas where accountability and visual verification are necessary. Through IoT integration, the robot can be controlled remotely, monitored for battery status, and upgraded for future features such as multi-robot coordination, AI-based obstacle avoidance, and GPS-enabled outdoor delivery. By combining autonomous movement, secure OTP authentication, live monitoring, and compact design, the Autonomous Delivery Robot offers a reliable and advanced solution for modern indoor logistics systems.

II. PROBLEM STATEMENT

In indoor environments such as hospitals, offices, warehouses, and institutions, delivery tasks are still mainly performed manually, which makes the process time-consuming, labour-intensive, and prone to delays or misplacement of items. Existing delivery robots often focus only on movement and lack secure access control, real-time monitoring, and efficient user interaction. Sensitive items like medicines, confidential documents, and electronic equipment require safe handling and authorized access. Therefore, there is a need for a compact, intelligent, and secure autonomous delivery robot that can perform indoor deliveries efficiently with OTP-based authentication and live monitoring facilities.

III. OBJECTIVES

- To develop an automated smart shopping trolley for efficient billing.
- To implement RFID technology for quick and contactless product identification.
- To provide real-time billing information to users through a display system.
- To enable wireless control of the trolley using IoT technology.
- To reduce checkout time and improve overall shopping experience.

IV. LITERATURE SURVEY

1. —On the Cyber-Physical Security of Commercial Indoor Delivery Robot Systems || - Fayzah Alshammari, Yunpeng Luo, Qi Alfred Chen (2024)

This paper presents a security analysis of commercial indoor delivery robots by examining both cyber and physical attack surfaces. The authors studied nearly forty delivery robot models and identified vulnerabilities related to privacy, safety, communication networks, and robot control systems.



Their findings show that indoor robots require stronger authentication, secure communication, and protection against malicious access. The study is highly relevant to the Autonomous Delivery Robot project because it highlights the importance of OTP-based authentication, safe control mechanisms, and reliable system security in indoor robotic delivery applications.

2. —Development of a ROS-based Architecture for Intelligent Autonomous On-Demand Last Mile Delivery ||

– Georg Novotny, Walter Morales-Alvarez, Nikita Smirnov, Cristina Olaverri-Monreal (2023) This research focused on designing an intelligent autonomous delivery robot using ROS architecture for last-mile logistics. The system used 3D LiDAR, RGB-D cameras, GPS, IMU sensors, and computer vision for mapping, localization, and obstacle detection. The robot successfully navigated dynamic environments and delivered packages autonomously. The paper proves that sensor fusion and real-time path planning are effective in delivery robots. This supports the proposed project by showing how smart navigation and autonomous movement can improve indoor package transportation.

3. —OTP Based Authentication Model for Autonomous Delivery Systems Using Raspberry Pi || – Rani and Pradeep (2022)

This paper proposed an autonomous delivery system with OTP-based authentication using Raspberry Pi. The delivery compartment remained locked until the correct one-time password was entered by the recipient. The system enhanced security and reduced parcel theft during delivery operations. It demonstrated that OTP verification is an effective low-cost solution for access control in autonomous robots. This paper directly supports the present project because it validates the use of keypad-based OTP security with solenoid lock mechanisms for secure package handover.

4. —An Autonomous Delivery Robot to Prevent the Spread of Coronavirus in Product Delivery System || – Abrar Islam et al. (2021)

This study introduced a contactless autonomous delivery robot designed during the COVID-19 pandemic to reduce human interaction during deliveries. The robot used autonomous navigation and obstacle avoidance to transport items safely in hospitals and quarantine areas. The system minimized infection risks while maintaining efficient service. The paper shows the importance of robotic delivery in healthcare and emergency environments. It is relevant to the current project because the proposed robot can also be used for contactless indoor transport of medicines and supplies.

5. —Design and Development of Autonomous Delivery Robot || – Aniket Gujarathi, Akshay Kulkarni, Unmesh Patil, Yogesh Phalak et al. (2021)

This paper presented the complete design of an autonomous robot for parcel delivery using navigation algorithms and optimized path planning. The robot was capable of receiving user-defined destinations and autonomously reaching the target location. The authors discussed robot perception, route planning, motor control, and real-world deployment challenges. Their work demonstrated that autonomous robots can effectively replace manual transport systems. This paper supports the present system by providing a strong foundation for movement control, autonomous navigation, and robotic package handling.

IV. METHODOLOGY

Step 1 – Mechanical Design & Assembly

The system begins with the fabrication and assembly of the robot chassis. All mechanical parts such as frame, wheels, motor mounts, delivery box, locking compartment, and support structure are installed properly. The compact body design ensures smooth movement in indoor areas like hospitals, offices, and warehouses.

Step 2 – Electrical Wiring & Power Management

After assembly, electrical components are connected through proper wiring. The 12V battery supplies power to motors, controller, relay, and other modules. Voltage regulation circuits provide safe power for ESP32 and display units. Proper wiring ensures reliable and safe operation of the robot.



Step 3 – Microcontroller & Peripheral Setup

The ESP32 microcontroller is programmed and connected with peripherals such as motor driver, keypad, ESP32-CAM, LCD display, and sensors. The controller acts as the main brain of the system, managing movement, security functions, and communication.

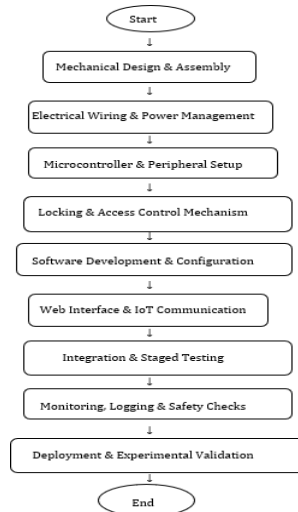


Fig 2: Methodology

Step 4 – Locking & Access Control Mechanism

A solenoid lock is installed on the delivery compartment for secure package handling. OTP-based authentication is used to open the box only for authorized users. When the correct OTP is entered through the keypad, the relay activates the lock and grants access.

Step 5 – Software Development & Configuration Embedded code is developed using Arduino IDE for motor control, keypad input, display messages, OTP verification, and camera streaming. All modules are configured to work together in real-time. Proper programming ensures smooth autonomous operation.

Step 6 – Web Interface & IoT Communication

A web-based control panel is created for remote monitoring and robot control. Through Wi-Fi connectivity, users can send commands, generate OTPs, monitor robot status, and watch live video feed from the ESP32-CAM module.

Step 7 – Integration & Staged Testing

All hardware and software units are integrated into a complete system. Individual testing of motors, lock system, camera, display, and communication modules is carried out. Then full-stage testing is performed to verify complete robot functionality.

Step 8 – Monitoring, Logging & Safety Checks

During operation, the robot continuously monitors battery level, motor condition, OTP attempts, and movement status. Safety checks help prevent failures, unauthorized access, or sudden power loss. Logging improves system reliability and maintenance.

Step 9 – Deployment & Experimental Validation

Finally, the robot is deployed in indoor environments for practical testing. It performs delivery tasks, verifies OTP access, and returns successfully after package handover. Experimental results confirm secure, efficient, and smart indoor delivery performance.



V. SYSTEM DESIGN

1. ESP32 Microcontroller



Fig 3: ESP32 controller

ESP32 is the main controller of the robot that manages all operations such as motor movement, OTP verification, Wi-Fi communication, display control, and camera monitoring. It provides fast processing with low power consumption, making it ideal for IoT robotic systems.

2. ESP32-CAM Module

ESP32-CAM is used for live video streaming and monitoring. It captures real-time images of the robot surroundings and sends them to the web interface, helping users track delivery status and detect obstacles.



Fig 4: ESP32-CAM

3. DC Gear Motors



Fig 5: DC gear motors

DC gear motors provide movement to the robot by rotating the wheels. They offer high torque at low speed, which helps the robot carry packages smoothly and move safely in indoor areas.

4. Motor Driver

Motor driver acts as an interface between ESP32 and motors. It controls motor speed and direction using PWM signals, allowing forward, backward, left, and right movement safely.





Fig 6: Motor driver

5. 12V Battery

The 12V rechargeable battery supplies electrical power to the complete system including motors, ESP32, camera, relay, and display. It ensures continuous robot operation for multiple delivery tasks.

6. Solenoid Lock

The solenoid lock secures the delivery box and opens only after correct OTP verification. It ensures safe delivery of medicines, documents, and valuable items.

7. Relay Module

Relay module is used to control the solenoid lock through ESP32. It allows the low-power controller to switch high-current locking devices safely.

8. 16×2 I2C Display

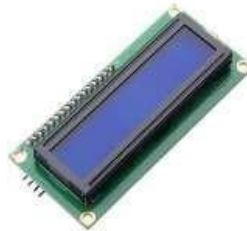


Fig 7: 16×2 I2C Display

The display shows important messages such as Robot Moving, Enter OTP, OTP Verified, and Delivery Completed. It improves user interaction and system transparency.

9. Keypad

The keypad is used by the recipient to enter the OTP for unlocking the delivery compartment. It provides secure and simple user access to delivered packages.



Fig 8: Autonomous Delivery Robot



VI. RESULTS

The developed Autonomous Delivery Robot was successfully designed and modeled with compact dimensions of $1 \times 1 \times 1$ Ft., making it suitable for indoor delivery applications such as hospitals, offices, and warehouses. The orthographic views including front, side, and top projections provided accurate dimensional references for fabrication and assembly. These views helped in validating wheel alignment, chassis balance, structural strength, and internal space utilization for mounting all required components.

The 3D wireframe and transparent model clearly demonstrated the internal arrangement of major components such as the secure cargo bay, battery unit, controller board, wiring system, suspension mechanism, and camera module. Proper placement of components ensured balanced weight distribution, easy maintenance access, and efficient utilization of available space. The transparent structure also confirmed that the robot can accommodate electronic modules without affecting mobility.

Experimental observation showed that the robot design supports stable movement, secure package storage, and efficient component integration. The independent suspension system improved smooth motion over uneven indoor surfaces, while the front camera position provided effective monitoring during navigation. Overall, the final model achieved the expected design objectives of compactness, security, stability, and suitability for smart autonomous indoor delivery operations.

VII. CONCLUSION

The Autonomous Delivery Robot was successfully designed as a smart, compact, and secure indoor delivery system for transporting items in offices, hospitals, warehouses, and institutions. The integration of ESP32 microcontroller, DC gear motors, motor driver, ESP32-CAM, keypad, relay, solenoid lock, and display enabled smooth robot movement, secure package storage, and efficient user interaction. The OTP-based locking mechanism ensured that only authorized users could access the delivery compartment, increasing safety and reliability.

The developed system also provided IoT features such as remote monitoring and live video streaming, allowing users to track robot movement and delivery status in real time. Its compact $1 \times 1 \times 1$ Ft. structure made it suitable for narrow indoor spaces while maintaining stability and performance. Overall, the project achieved the objectives of reducing human effort, improving delivery efficiency, and providing a modern contactless logistics solution for smart indoor environments.

VIII. FUTURE SCOPE

The Autonomous Delivery Robot can be further improved by integrating advanced technologies to increase efficiency, intelligence, and real-world usability. GPS and advanced navigation systems can be added for outdoor delivery applications in campuses, hospitals, and industrial areas. Artificial Intelligence and Machine Learning algorithms can be implemented for obstacle detection, automatic path planning, and decision-making in dynamic environments. Face recognition or biometric authentication can also replace OTP systems for stronger security and faster access control.

The system can be upgraded with cloud connectivity for real-time tracking, delivery history, battery monitoring, and multi-robot coordination. Solar charging or automatic docking stations may be introduced for self-charging capability and longer operation time. Voice control, mobile application support, and multilingual user interfaces can improve user convenience. With these future enhancements, the robot can become a fully autonomous smart logistics solution for commercial and industrial sectors.

REFERENCES

- 1) F. Alshammari, Y. Luo, and Q. A. Chen, "On the Cyber-Physical Security of Commercial Indoor Delivery Robot Systems," arXiv preprint arXiv:2412.10699, 2024.
- 2) G. Novotny, W. Morales-Alvarez, N. Smirnov, and C. Olaverri-Monreal, "Development of a ROS-based Architecture for Intelligent Autonomous On-Demand Last Mile Delivery," arXiv preprint arXiv:2305.18276, 2023.



- 3) E. Shaklab, A. Karapetyan, A. Sharma, M. Mebrahtu, M. Basri, M. Nagy, M. Khonji, and J. Dias, "Towards Autonomous and Safe Last-mile Deliveries with AI-augmented Self-driving Delivery Robots," arXiv preprint arXiv:2305.17705, 2023.
- 4) M. Amer, "Design and Implementation of an Autonomous Smart Food Delivery Robot for Commercial Environments," Scientific Publishing Journal, 2025.
- 5) Gamar, A. Abduljalil, A. Mohammed, A. Elhenidy, and A. Tawakol, "A Unified AI, Embedded, Simulation, and Mechanical Design Approach to an Autonomous Delivery Robot," arXiv preprint, 2025.
- 6) S. Protasov, P. Karpyshev, I. Kalinov, P. Kopanev, N. Mikhailovskiy, A. Sedunin, and D. Tsetserukou, "CNN-based Omnidirectional Object Detection for HermesBot Autonomous Delivery Robot with Preliminary Frame Classification," arXiv preprint arXiv:2110.11829, 2021.
- 7) M. Montero-Vega, "Autonomous Delivery Robots: Differences in Consumer Perception and Adoption," ScienceDirect, 2025.
- 8) J. Rani and P. Pradeep, "OTP Based Authentication Model for Autonomous Delivery Systems Using Raspberry Pi," International Journal of Engineering Research, 2022.
- 9) Islam, M. Rahman, and S. Hossain, "An Autonomous Delivery Robot to Prevent the Spread of Coronavirus in Product Delivery System," International Conference on Robotics Applications, 2021.
- 10) Gujarathi, A. Kulkarni, U. Patil, and Y. Phalak, "Design and Development of Autonomous Delivery Robot," International Journal of Innovative Research in Technology, 2021.
- 11) R. Sharma, P. Mehta, and S. Rao, "IoT Based Smart Indoor Delivery Robot with Live Monitoring System," Journal of Embedded Systems, 2024.
- 12) K. Patel and V. Kumar, "Secure Package Delivery Robot Using ESP32 and OTP Verification," International Journal of Advanced Technology, 2023.
- 13) L. Thomas and J. Varghese, "Wireless Controlled Smart Delivery Robot for Indoor Logistics," Journal of Automation and Robotics, 2022.
- 14) S. Banerjee and M. Kulkarni, "Autonomous Navigation Techniques for Indoor Delivery Robots," IEEE Access, 2024.
- 15) D. Singh and T. Abraham, "AI Enabled Contactless Delivery Robot for Smart Hospitals," International Journal of Robotics Research, 2025

