

Secure Autonomous Last-Mile Delivery Robot using IoT

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ABSTRACT: The Secure Autonomous Last-Mile Delivery Robot using IoT is an intelligent system designed to automate parcel delivery while ensuring security and efficiency. The robot uses GPS for navigation, ultrasonic sensors for obstacle detection, and IoT technology for real-time monitoring. An OTP-based authentication mechanism ensures that only authorized recipients can access the package. The system reduces human intervention, enhances delivery security, and supports contactless delivery. Experimental results demonstrate reliable navigation, secure parcel handover, and effective obstacle avoidance, making the proposed solution suitable for smart logistics and automated delivery applications.

KEYWORDS: Internet of Things (IoT), Autonomous Delivery Robot, OTP Authentication, Obstacle Avoidance

I. INTRODUCTION

The rapid growth of e-commerce and online services has significantly increased the demand for efficient and reliable delivery systems. However, the last-mile delivery stage remains one of the most expensive and time-consuming components of the logistics chain. Traditional delivery methods often suffer from traffic congestion, labor shortages, package theft, delayed deliveries, and increasing operational costs. These challenges highlight the need for innovative technological solutions that can improve delivery efficiency while maintaining security and reliability. Autonomous delivery robots have emerged as a promising alternative by reducing human intervention and enabling automated transportation of parcels in controlled environments.

Recent advancements in robotics, embedded systems, sensors, and IoT technologies have enabled the development of intelligent delivery platforms capable of autonomous navigation and real-time communication. By integrating GPS modules, ultrasonic sensors, microcontrollers, and cloud-based platforms, autonomous robots can navigate predefined routes, detect obstacles, and communicate delivery information to users. The Internet of Things facilitates seamless interaction between the robot, cloud server, and end users, enabling real-time monitoring, remote control, and data management. These technologies contribute to improved delivery performance, enhanced operational visibility, and reduced human dependency.

The proposed Secure Autonomous Last-Mile Delivery Robot using IoT focuses on providing a secure, contactless, and efficient package delivery solution. The system employs OTP-based authentication to ensure that parcels are handed over only to authorized recipients. An IoT-enabled cloud platform continuously monitors robot status, location, and delivery progress. Obstacle detection mechanisms enhance operational safety, while autonomous navigation improves delivery efficiency. The integration of security, automation, and IoT connectivity makes the system suitable for applications such as educational campuses, hospitals, residential communities, office complexes, and smart city environments.

II. LITERATURE SURVEY

N. U. et al. – The authors reviewed autonomous delivery robots that utilize machine learning techniques for navigation, obstacle detection, route optimization, and package delivery. The study highlights the importance of AI-based decision-making in improving delivery efficiency and reducing human intervention. Various machine learning algorithms were analyzed to enhance robot autonomy, accuracy, and operational performance in real-world delivery applications.

S. Roy et al. – This research proposed an IoT-enabled multi-robot system integrated with a cloud framework for rescue and delivery operations. The study focused on secure communication, resource management, and real-time monitoring

of robots through cloud computing. The proposed architecture improves coordination among multiple robots while ensuring data security and efficient task execution in dynamic environments.

M. Hossain – The paper presented a comprehensive literature review of autonomous delivery robots, discussing recent advancements in navigation systems, sensing technologies, artificial intelligence, and logistics applications. The study examined the challenges of robot deployment in urban environments, including obstacle avoidance, localization, safety, and regulatory concerns, while identifying future research opportunities in last-mile delivery systems.

R. Patel et al. – The authors proposed a cloud-based IoT architecture for autonomous delivery robots to facilitate remote monitoring, data processing, and communication. The system leverages cloud services to manage robot operations efficiently while reducing computational load on onboard devices. The study demonstrated how IoT connectivity can improve scalability, reliability, and real-time decision-making in delivery applications.

S. Lee and K. Park – This study explored the role of autonomous logistics robots in smart city environments for last-mile delivery services. The proposed system integrates IoT devices, intelligent navigation algorithms, and real-time traffic information to optimize delivery routes. The research highlighted the potential of autonomous robots to reduce transportation costs, improve delivery speed, and support sustainable urban logistics.

K. Shankar et al. – The researchers developed an IoT-based delivery robot equipped with theft detection mechanisms for secure transportation of food and goods. The robot incorporates sensors, GPS tracking, and alert systems to monitor package safety during transit. The proposed solution enhances delivery security while ensuring efficient and reliable logistics operations through real-time IoT connectivity.

P. Sundaraavadivel et al. – This paper introduced an autonomous transport robot designed for smarter last-mile logistics using advanced IoT features and dynamic route planning. The robot continuously analyzes environmental conditions and performs route changes based on obstacle detection and avoidance. The proposed system improves delivery efficiency, minimizes delays, and enhances navigation performance in complex environments.

A. Gamar et al. – The authors presented a unified approach for autonomous delivery robot development by integrating artificial intelligence, embedded systems, simulation tools, and mechanical design. The study demonstrated how combining these technologies creates a robust and intelligent delivery platform capable of autonomous navigation, obstacle avoidance, and efficient package transportation in real-world scenarios.

III. GAP ANALYSIS

Existing delivery robot systems primarily focus on autonomous navigation and parcel transportation but often lack robust security mechanisms for package handover. Many solutions rely on manual verification or unsecured delivery methods, increasing the risk of package theft and unauthorized access. Furthermore, several systems provide limited real-time monitoring and cloud integration, reducing operational visibility. Challenges related to obstacle avoidance, secure authentication, communication reliability, and fail-safe operations remain inadequately addressed. The proposed system bridges these gaps by integrating IoT-based monitoring, OTP-based recipient authentication, autonomous navigation, obstacle detection, and automatic return-to-base functionality, thereby providing a comprehensive and secure last-mile delivery solution.

IV. PROPOSED SYSTEM

The proposed Secure Autonomous Last-Mile Delivery Robot is an IoT-enabled robotic platform designed to automate parcel delivery while ensuring security and reliability. The system consists of an ESP32 controller, GPS module, ultrasonic sensors, keypad, LCD display, motor driver, secure compartment, and cloud-based IoT platform. The robot autonomously navigates toward a predefined destination while continuously monitoring obstacles. Upon arrival, an OTP is generated and sent to the recipient through the IoT platform. The recipient enters the OTP using the keypad, and the package compartment unlocks only after successful verification. The delivery status is updated in real time through the cloud server. In case of authentication failure or timeout, the system triggers a fail-safe mechanism and returns the robot to the base location.

V. ALGORITHM

OTP-Based Secure Delivery Authentication Algorithm

The OTP-Based Secure Delivery Authentication Algorithm is used to ensure secure parcel handover to the authorized recipient. When the robot reaches the delivery destination, the system automatically generates a unique One-Time Password (OTP) and sends it to the recipient through the IoT cloud platform. The recipient enters the received OTP using the keypad mounted on the robot. The ESP32 controller compares the entered OTP with the stored OTP. If both values match, the package compartment is unlocked, allowing the recipient to collect the parcel. If the OTP is incorrect, access is denied and the compartment remains locked. This algorithm enhances delivery security, prevents unauthorized access, and ensures that parcels are delivered only to the intended recipient.

VI. RESULTS

The developed prototype successfully performed secure package delivery using IoT-based monitoring and OTP authentication. The GPS module provided real-time location tracking, while ultrasonic sensors effectively detected obstacles and prevented collisions. The OTP verification mechanism successfully restricted parcel access to authorized users. The motor control system enabled smooth navigation and movement, and the flap mechanism operated correctly during parcel collection. Testing demonstrated reliable system performance, secure authentication, effective obstacle avoidance, and successful completion of delivery tasks, validating the practicality of the proposed solution for smart delivery applications.

VII. CONCLUSION

The Secure Autonomous Last-Mile Delivery Robot using IoT successfully addresses major challenges associated with traditional delivery systems, including security concerns, delivery delays, and high operational costs. By integrating IoT communication, autonomous navigation, obstacle detection, GPS tracking, and OTP-based authentication, the system provides a secure, efficient, and contactless delivery solution. Experimental testing confirmed reliable navigation, secure package handover, and stable overall performance. The project demonstrates the practical implementation of smart logistics using embedded systems and IoT technologies, making it suitable for modern automated delivery environments.

VIII. FUTURE SCOPE

- Integration of Artificial Intelligence and Machine Learning for intelligent route planning.
- Implementation of Computer Vision for object recognition and autonomous navigation.
- Development of a dedicated mobile application for delivery tracking and notifications.
- Integration of cloud-based analytics and data storage systems.
- Enhancement of security through facial recognition and biometric authentication.
- Use of advanced GPS and mapping technologies for higher navigation accuracy.

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