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"RAPID DROP: AUTONOMOUS PACKAGE DELIVERY SYSTEM WITH EFFICIENT ROUTE OPTIMIZATION"

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Abstract: With the growing demand for efficient, contactless delivery systems in both urban and rural environments, this project introduces an advanced Autonomous Delivery Robot designed to overcome existing logistical challenges. The robot features enhanced navigation capabilities achieved through the integration of sonar, IMU, RFID, and wheel encoders, ensuring accurate localization and dynamic path planning. Advanced obstacle detection and avoidance mechanisms allow the robot to navigate complex environments reliably. A secure package delivery system, equipped with RFID-based unlocking and real-time notifications, guarantees safe and user-friendly operations. The robot's power system, comprising a Li-ion battery with intelligent BMS and solar panel support, ensures sustainability, extended runtime, and reduced downtime. Real-time monitoring through a live camera feed and communication via an interactive OLED display further enhance its functionality. By combining efficiency, sustainability, and advanced technology, this work redefines autonomous delivery solutions, offering a practical and scalable approach to modern logistics.

Keywords: Autonomous delivery, Navigation, Obstacle avoidance, Secure delivery, Sustainable power, Real-time monitoring

I. INTRODUCTION

The rapid growth of e-commerce and the increasing need for efficient logistics have spurred the development of autonomous delivery systems. Traditional delivery services, reliant on manual labor and vehicles, face numerous challenges, such as traffic congestion, delayed deliveries, and high operational costs. Additionally, with urbanization on the rise, the demand for quick, reliable, and environmentally friendly delivery solutions has never been higher. Autonomous delivery robots offer an innovative and practical solution to address these challenges by utilizing advanced technologies such as sonar and RFID for navigation, dynamic obstacle avoidance, and real-time monitoring. These robots aim to improve logistics efficiency by providing faster, safer, and contactless delivery options. They can navigate through complex environments, deliver packages securely, and operate autonomously for extended periods, thanks to intelligent power management systems. The integration of user- friendly features, such as OTP-based secure package delivery, real-time notifications, and live monitoring, further enhances the user experience. This project seeks to develop a comprehensive autonomous delivery robot that bridges the gap between traditional delivery systems and the evolving needs of modern logistics.

II. METHODOLOGY

The autonomous delivery bot is designed to navigate through a defined path using RFID- based waypoints, avoid obstacles using ultrasonic sensors and SONAR, and communicate its status to a remote device using RF modules. The added SMS OTP verification ensures that the package is handed over securely to the intended recipient.

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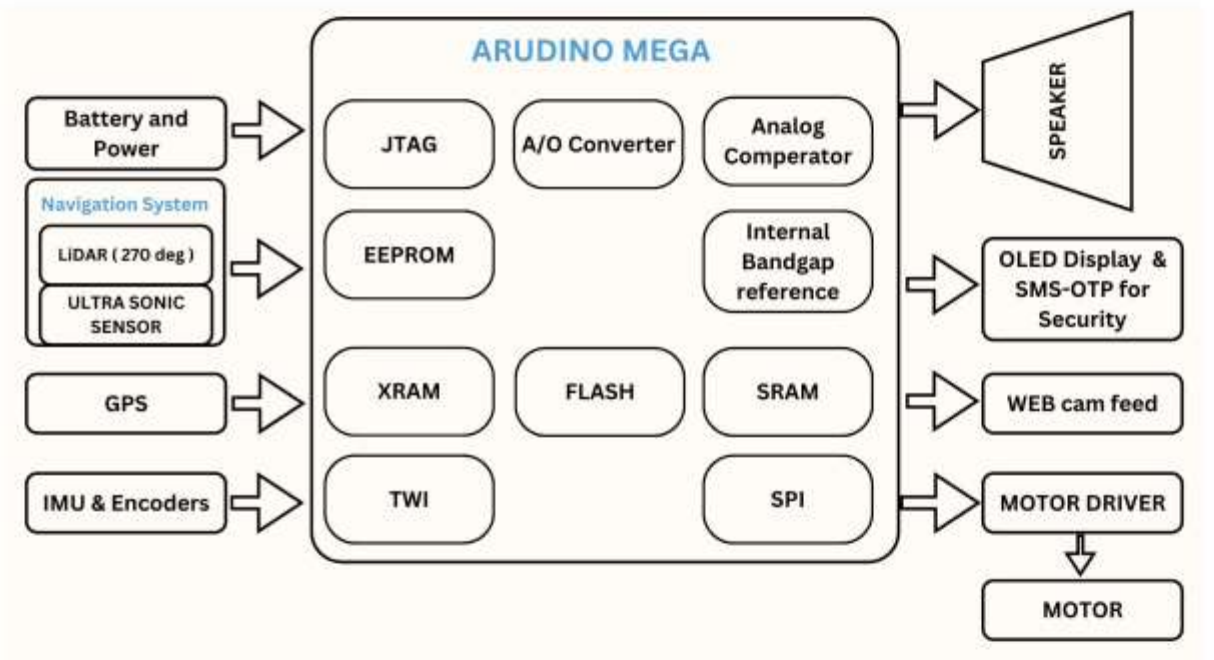

Fig 2.1 Block Diagram of Rapid Drop

- **RFID-Based Navigation:**

RFID tags placed along the delivery route guide the bot, enabling precise tracking and movement. The Arduino processes RFID data to calculate direction and distance, ensuring efficient and reliable navigation. This navigation system allows for easy route modifications and updates.

- **Obstacle Avoidance:**

Ultrasonic sensors and SONAR continuously scan for obstacles. If detected, the bot halts and reroutes to avoid collisions, ensuring smooth and safe deliveries. The sensors also detect and respond to dynamic obstacles, such as pedestrians or vehicles.

- **Real-Time Monitoring & Communication:**

RF communication provides live updates on the bot's status, allowing remote tracking and intervention if needed. Operators can manually override operations in case of route blockages or technical issues. This feature also enables real-time delivery status updates to customers.

- **SMS OTP Verification:**

To ensure secure deliveries, an OTP is sent to the recipient's phone. The package is only accessible after entering the correct OTP, preventing unauthorized access. The OTP system can be integrated with various messaging services for seamless operation.

- **Power Management:**

The bot optimizes power consumption for extended operation. Battery levels are continuously monitored, and the bot can return to a charging station if needed, ensuring uninterrupted service. The power management system also schedules charging sessions during off-peak hours to reduce energy costs.

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III. IMPLEMENTATION

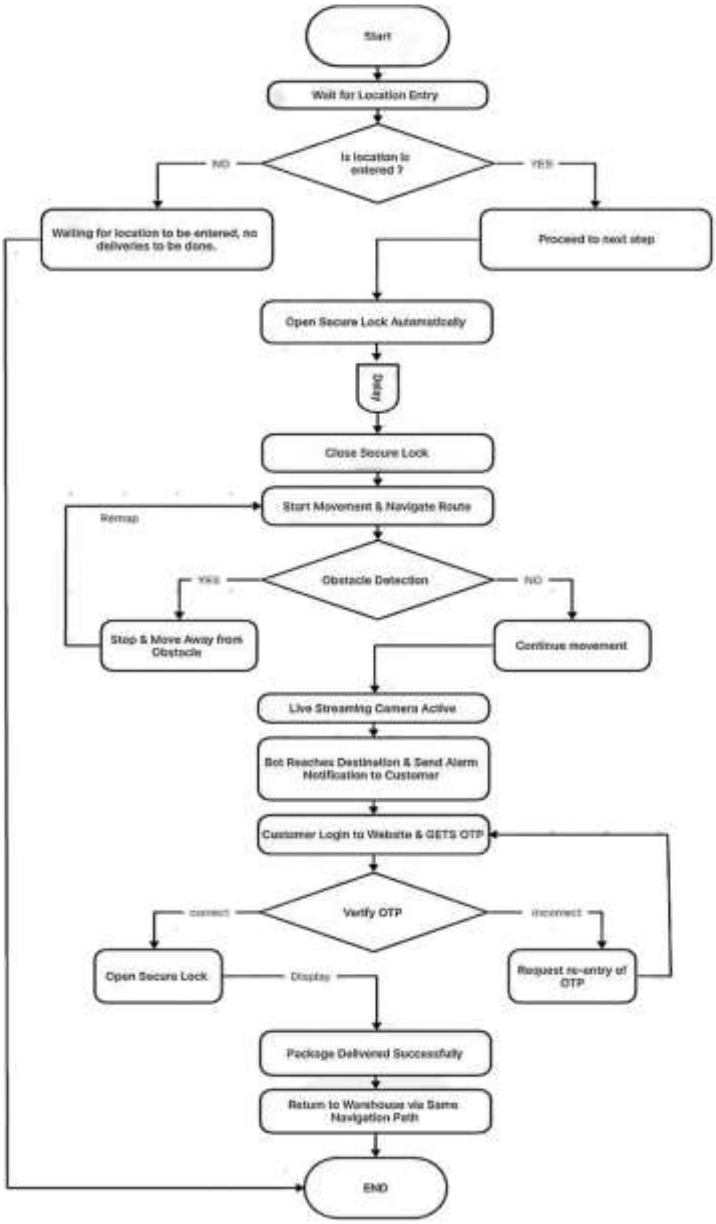

Fig 3.1 Flow Chart

The implementation process for the autonomous delivery bot system begins with the initialization phase, where the bot is powered on, and communication protocols such as Wi-Fi, GPS, and authentication systems are activated. The bot then waits for the user to input the delivery location. If no location is entered, the system remains idle. Once the location is provided, the bot proceeds to unlock its secure compartment automatically, allowing the package to be placed inside. After a short delay to ensure proper placement, the bot securely locks the compartment and begins navigating towards the destination.

During movement, the bot continuously scans for obstacles using sensors such as LiDAR, ultrasonic sensors, or cameras. If an obstacle is detected, the bot stops, recalculates the route, and moves away from the obstruction. If no obstacles are found, it continues on its designated path. Upon reaching the delivery destination, the bot activates its live-streaming camera for security monitoring and sends an alert notification to the customer. The customer must then log into a secure website or app to retrieve a One-Time Password (OTP).

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For authentication, the customer enters the OTP on the bot's interface. If the entered OTP is correct, the secure lock opens, allowing the customer to retrieve the package. In case of an incorrect OTP, the system prompts for re-entry until the correct OTP is provided. Once the package is successfully delivered, the bot confirms the delivery and follows the same navigation path back to the warehouse. The system then resets itself, making the bot ready for the next delivery cycle. This process ensures a seamless, secure, and automated package delivery experience.

Fig 3.2 Model View

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Fig 3.3 Path Navigation

Fig 3.4 Obstacle Detection

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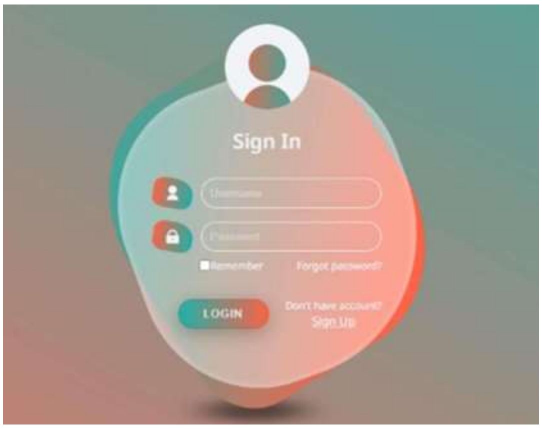

Fig 3.5 Security through Webapp

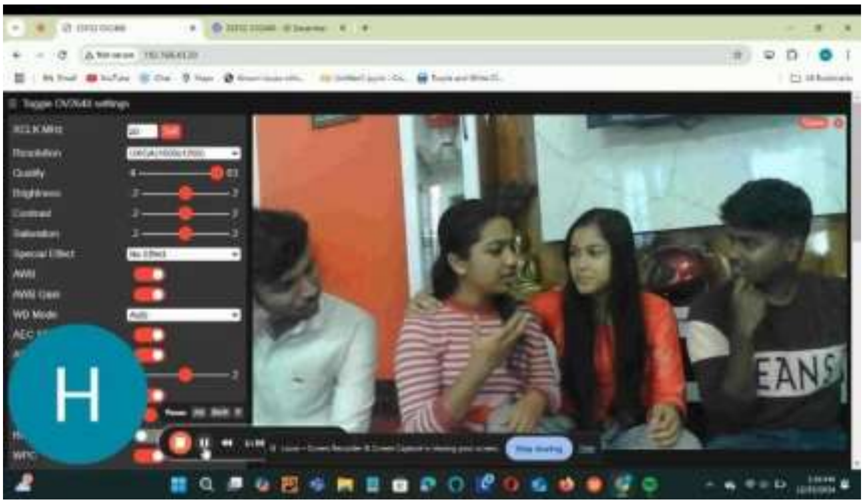

Fig 3.6 Live Streaming

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IV. RESULT

Fig 4.1 Prototype

The autonomous delivery robot project successfully integrated SONAR, RFID, and intelligent power management systems to address key logistics challenges. The navigation system provided accurate positioning, and dynamic path planning allowed for smooth operation in complex environments. Obstacle detection using SONAR ensured safe, collision-free movement. An OTP-based secure delivery system enhanced package security, while solar panels and efficient batteries extended operational efficiency. The user interface, featuring real-time notifications and live monitoring, improved user engagement. Route optimization algorithms optimized delivery and return paths. Overall, the robot demonstrated significant improvements in speed, safety, sustainability, and user experience, offering a promising solution for modern logistics.

V. ACKNOWLEDGEMENT

We would like to extend our sincere appreciation to all those who contributed to the success of this project. Firstly, we are deeply grateful to our project guide and faculty members for their invaluable guidance, expertise, and continuous support. Their mentorship was pivotal in the completion of this work. We also wish to express our thanks to the technical staff and our colleagues for their assistance with hardware setup, troubleshooting, and system integration. Their collaborative efforts and constructive feedback were essential in overcoming numerous challenges during development. A special acknowledgment goes to our families and friends for their unwavering encouragement and motivation, which kept us focused and determined throughout this journey.

VI. CONCLUSION

The autonomous delivery robot integrates advanced technologies to provide a highly efficient and reliable delivery system. With its combination of GPS, LiDAR, ultrasonic sensors, and intelligent algorithms, the robot is capable of navigating dynamic environments, avoiding obstacles, and delivering packages autonomously. The system ensures real-time communication through GSM and Wi-Fi modules, enabling continuous monitoring and control. Its energy-efficient design, supported by a robust battery management system, allows for extended operation, making it ideal for long-duration tasks. The implementation of security features like OTP verification guarantees safe and accurate deliveries, enhancing customer trust. This robot demonstrates significant potential in revolutionizing delivery systems, particularly for e-commerce, healthcare, and urban logistics, by reducing human intervention, improving delivery

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efficiency, and providing real-time tracking. By seamlessly combining automation, energy efficiency, and secure delivery features, the robot offers a robust solution to modern delivery challenges.

Furthermore, the integration of RFID-based navigation enhances route accuracy, allowing the robot to follow predefined paths with minimal deviation. The use of real-time data analytics enables adaptive decision-making, optimizing delivery routes based on traffic and environmental conditions. Its modular design allows for easy scalability, making it adaptable for various industries and applications. With continuous advancements in AI and IoT, this autonomous delivery robot is poised to redefine the future of last-mile logistics, offering a smarter, faster, and more secure delivery experience.

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