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Autonomous Theft Proof Food Delivery Drone

Prof. A. S. Utane^{*1}, Shreya Ajane^{*2}, Mohit Manmode^{*3}, Aayushi Mahalle^{*4}, Daivish Modak^{*5}

Assistant Professor, Department of Electronics & Telecommunication Engineering, Prof. Ram Meghe Institute of

Technology & Research, Amravati, Maharashtra, India*1

Students, Department of Electronics & Telecommunication Engineering, Prof. Ram Meghe Institute of Technology &

Research, Amravati, Maharashtra, India*2,3,4,5

ABSTRACT: India has a logistics operation of around 100 million package deliveries per day. Restrictions of Heavy Motor Vehicles (HMV) to commute in cities during the daytime, Severe vehicle Congestion, inadequate delivery person, leads to the decrease in productivity of the courier services from 85% to 50%. Motive of this project is to cut down the operational cost in conventional last mile delivery systems and to execute timely delivery. Idea is to build a Drone delivery system that provides a secure and efficient delivery service. The precise location of the destination point is fed to the drone from Ground Control Station and with the package placed in the drone, it executes autopilot with the help of the flight controller. Maneuverability is eased out by flight controller and collision avoidance system. The package delivery mechanism is aided with an authentication system to ensure a safe and secure delivery. At the destined location, it is achieved through scanning the ARTag/QR code which will be sent to the customer at the time of flight. Package is delivered only when ARTag/QR code matches with the appended data. Entire process is executed by the integration of the Robot Operating System and open source autopilot software suite with the hardware. Drone delivery is a disruptive technology that is redefining the traditional logistics industry. Drones offer a more cost-effective way to deliver packages by minimizing operational cost and overhead cost, allowing businesses to grow their revenues and bottom lines.

KEYWORDS: Drone, Smart Drone, Autonomous, Online ordering, low cost, secured, unmanned, packages

I. INTRODUCTION

The rapid expansion of e-commerce has transformed consumer expectations and logistics operations globally. Online shopping offers unparalleled convenience, but it also places significant demands on delivery systems. As e-commerce companies strive to meet the growing consumer demand for faster, more efficient deliveries, traditional methods face increasing pressure. Factors such as urban traffic congestion, last-mile delivery challenges, and rising operational costs create substantial hurdles in maintaining timely and cost-effective delivery services. In recent years, technological advancements have introduced new solutions to these challenges. Among these, drones-unmanned aerial vehicles (UAVs)—have emerged as a cutting-edge technology with the potential to revolutionize delivery logistics. Originally developed for military reconnaissance and surveillance, drones have expanded into various commercial applications, including agriculture, infrastructure inspection, and emergency response. Their ability to navigate autonomously and reach remote or congested areas makes them particularly promising for last-mile delivery in e-commerce. The purpose of this report is to provide a comprehensive analysis of the potential for drone technology to revolutionize e-commerce delivery systems. This involves assessing the technological feasibility, operational requirements, regulatory landscape, and overall impact of implementing drone-based delivery solutions. The report aims to offer valuable insights into how drones can address current delivery challenges and enhance the efficiency and effectiveness of e-commerce logistics. A detailed examination of drone types and technologies relevant to e-commerce delivery, including payload capacities, battery life, and navigation systems. Guidelines for designing an effective drone delivery system, including hardware requirements, software platforms, and integration with existing e-commerce infrastructure. Strategies for managing drone fleets, optimizing delivery routes, and coordinating with logistics operations to ensure efficient and reliable deliveries. An overview of relevant regulations, safety standards, and privacy concerns, along with recommendations for navigating the regulatory landscape. Recommendations for conducting pilot tests to evaluate the effectiveness of drone deliveries and gather data for further refinement. A comprehensive analysis of the financial aspects of drone deliveries, including investment, operational costs, and potential savings.





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The adoption of drone technology in e-commerce delivery represents a significant opportunity to overcome many of the limitations of traditional logistics methods. Drones can provide faster delivery times, reduce costs associated with human labour and transportation, and enhance the overall customer experience by offering reliable and timely service. Additionally, drones have the potential to improve environmental sustainability by reducing reliance on fuel-intensive delivery vehicles. By addressing the challenges and leveraging the benefits of drone technology, e-commerce companies can position themselves at the forefront of innovation in logistics and maintain a competitive edge in the rapidly evolving market. This report aims to provide a detailed roadmap for integrating drones into e-commerce delivery systems, ultimately contributing to the future success and efficiency of the industry.

II. LITERATURE SURVEY

Rapid technological developments in autonomous unmanned aerial vehicles (UAV or drones) and an evolving legislation may soon open the way for their large scale implementation in the last mile delivery of products. The use of drones could drastically decrease labour costs and has been hyped as a potential disruptor to the parcel delivery industry. Online retailers and delivery companies such as Amazon, are already filling up patents for the development of multi-level fulfilment centres for unmanned aerial vehicles or "drone-bee hives" that would allow the deployment of this technology within the built environment. A substantial amount of research has been carried out in the last years on the potential use of drones for parcel delivery, principally in the area of logistic optimisation.

The demand for delivery cannot be fulfilled efficiently due to the excessive traffic in dense urban areas. Therefore, many innovative concepts for intelligent transportation of freight have recently been developed. One of these concepts relies on drone-based parcel delivery using rooftops of city buildings. To apply drone logistics systems in cities, the operation design should be adequately prepared. In this regard, a mixed integer programming model for drone operation planning and a heuristic based on block stacking are newly proposed to provide solutions. Additionally, numerical experiments with three different problem sizes are 16 conducted to check the feasibility of the proposed model and to assess the performance of the proposed heuristic.

The experimental results show that the proposed model seems to be viable and that the developed heuristic provides very good operation plans in terms of the optimality gap and the computation time. The localization and flight control pipeline is only one of the several onboard pipelines. As the Pixhawk middleware provides a precise time based ,a standard textbook estimation and control pipeline already performs well for autonomous flight. The overall pipeline, including camera interfacing and communication, consumes only 10-15% of the total CPU power. Other implemented pipelines are stereo obstacle avoidance and planar pattern recognition. Individual Pipeline can be activated/ deactivated at runtime and individual pipeline components can be replaced by different algorithms without changes to the overall system.

The concept of drone usage for commercial purposes by retailers worldwide is still in its early stages, and unheard of in Pakistan. Moreover, research on consumer perceptions regarding commercial drones in Pakistan and around the world is very sparse. The purpose of this paper is to gauge the level of acceptability and concerns Pakistani consumers may have in accepting the drone delivery technology. This study offers new insights that retailers and delivery companies can use to penetrate target markets in early stages. The authors have executed a quantitative analysis through the means of a survey. A sample of middle- and upper class residents of two cities in Pakistan was selected on which purposive sampling technique was applied. A total of 307 responses were collected and these responses were analysed in SPSS. Various analysis techniques were applied including Cronbach's alpha, the Pearson correlation analysis, regression analysis and cluster analysis. The results show that consumers in Pakistan perceive privacy issues as a primary concern in relation to drone delivery. The results also shed light on the profile of consumer segments that can be targeted by retailers who may desire to use the drone delivery technology in the near future. Using these findings, retailers using the drone delivery mechanism can address consumer's fears and ambiguities. Retailers can resolve consumer concerns by designing pro-privacy parameters in the initial service design stage and the infrastructure deployment of drones.

The interest in using drones in various applications has grown significantly in recent years. The reasons are related to the continuous advances in technology, especially the advent of fast microprocessors, which support intelligent autonomous control of several systems. Photography, construction, and monitoring and surveillance are only some of





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the areas in which the use of drones is becoming common. Among these, last-mile delivery is one of the most promising areas. In this work we focus on routing problems with drones, mostly in the context of parcel delivery.

In rural areas, drones are designed to replace road deliveries so as to overcome infrastructure challenges; though drones notably consume less fuel and consequently have a smaller impact on the environment, their full life cycle assessment should still be evaluated to comprehensively understand their environmental impact. This study presents a life cycle assessment study on drone delivery in Thailand using CML2001, the life cycle impact assessment (LCIA) method, to convert life cycle inventory data into environmental impacts. The observed results show that an online shopping system using drone delivery is one of the most environmentally friendly transportation options throughout a wide range of scenarios. However, the parts production contributed to significant impacts on environmental issues while the drone operation showed the least impact to all impact categories. The dominant contributors to global warming, abiotic depletion (ADP elements and fossil), acidification air, eutrophication, ozone layer depletion, and photochemical ozone creation impact categories were the coal mining and electricity generating station operation. However, the carbon fibers and the battery, are the main contributors to other impact categories, which include the human toxicity, freshwater aquatic ecotoxicity, marine aquatic ecotoxicity, and terrestrial ecotoxicity.

III. METHODOLOGY

The architecture of a theft-proof food delivery autonomous drone system requires a systematic approach combining robotics, cybersecurity, IoT, and aviation regulation principles. The system should be autonomous, safely deliver payloads, and ensure against tampering and unauthorized access during the delivery process. The approach describes a theoretical, layered structure for designing, securing, and running such a system.

It is the physical design that forms the basis of the system, with the need to maximize payload protection and flight efficiency. The physical structure of the drone is created from high-strength, light materials like carbon fibers composites to achieve an optimal payload-to-weight ratio and durability. Electric multi-rotor configurations form the propulsion system, chosen because of their inbuilt stability and maneuverability within the urban context. The payload is contained in an intelligent, theft-proof package with an electric locking system. The package is insulated to preserve the freshness of food and fitted with tamper sensors like pressure sensors, motion sensors, and accelerometers to identify attempts at unauthorized access. Software Section:

The delivery drone is controlled by an AI-driven navigation algorithm with dynamic route optimization capability. The system utilizes a dual-layer localization approach, leveraging Global Positioning System (GPS) information and Simultaneous Localization and Mapping (SLAM) to provide robust position tracking in weak or spoofed GPS signal environments. Environment sensing is enabled using the combined sensors of LiDAR, ultrasonic rangefinders, stereo cameras, and inertial measurement units (IMUs). Collectively, they make possible live real-time collision avoidance and surface evaluation for securing a safe delivery site landing.

The essence of the theft-proof design is in the secure payload management system. The container is locked during the entire flight, and the unlock mechanism is initiated only upon reaching the proper geolocation, as confirmed by a multi-factor authentication (MFA) process of the end user. Once at the point of delivery, the drone authenticates customer identity by means of OTP or QR code handshake, and optionally biometric authentication from the customer's device. The payload container unlocks only upon successful authentication, thus keeping out unauthorized parties.

Data integrity and secure access to the drone are essential to hijacking prevention and data theft. The system uses Transport Layer Security (TLS) protocols and high-level encryption (AES-256) for all telemetry, command, and customer interaction data. Also, the drone has a Trusted Platform Module (TPM) that provides secure boot, which allows only verified and manufacturer-signed firmware to run on the system. The blockchain-based logging also prevents tampering of delivery confirmations and operation records.

Prior to field deployment, the system is subjected to virtual simulations via digital twins to ensure its navigation algorithms, security protocols, and fail-safe mechanisms. These simulations mimic real-world delivery conditions, environmental factors, and attempted tampering. After successful virtual verification, controlled field testing is done in





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actual urban and suburban settings. These trials quantify system dependability, tamper resistance, customer authentication speed, and general delivery performance.

The drone is built to function within the bounds of aviation rules, making use of geofencing to avoid the entry into offlimits airspace. The flight management system onboard enables automatic return-to-home (RTH) as well as autonomous emergency landing upon battery drain, loss of signal, or mechanical failure. Compliance is facilitated through the installation of protocols directed by applicable civil aviation authorities such as registration, flight logging, and remote identification.

Block Diagram:



The block diagram of autonomous food delivery drone. The other components in the system includes Speed Controller, Flight Controller, Motors, Camera, Battery, Transmitter and Receiver, etc.

Flow Chart :



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Figure(a) Image of Drone

Figure(b) Image of Package Holder



Figure(c) Top view of Drone



Figure(b) Side View of Drone



Figure(e) Flying of Drone



Figure(f) Flying of Drone





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Figure(g) Image of App

V. CONCLUSION

The real-time tracking of the drone can be visualized using a telemetry device where the GPS data is obtained through the controller. The collision avoidance mechanism is employed making it easier to navigate through any conditions. This project is all about delivering the packages to users using drones. The project aims to build a drone logistic system. The entire device is built in the middleware ROS to have an integrated system and to implement the master slave concept. The 'last mile' problem is growing in tandem with soaring e-commerce sales and, while technology offers better tracking systems and analysis tools that can optimise the delivery process. This project is about implementing a drone logistic system with accurate and secure package delivery service.

The proposed solution primarily solves the last mile problem in urban areas. As of this writing, the project has returned encouraging results. The project is not yet complete and is expected to reinforce previously returned results along with additional valuable design insights upon completion. Due to the necessary scope reduction brought about by the student, further research is necessary. Some of the major defects of this project is that it tends to fail in a few areas of implementation such as stabilisation of drones in varied weather conditions, reaching the destination accurately in densely packed areas. However, this can be eliminated to a certain extent by using ARTags for delivering it to the right customer.

The future work of this project is making it navigable in all conditions and testing it in the real world. Future work is going to focus on scaling and including additional features like live tracking to the end customer. Once it is achieved, the plan is to deploy it for different use cases like Medicine delivery, Food delivery, cold chain logistics and many more. Multiple drones can also be made to work as a network (SWARM) with the master slave concept enabled through ROS. Through master slave implementation, the drone logistics system could be enhanced and scaled. One of the biggest show stoppers is the DGCA rules and regulations for flying commercial drones.

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