Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 5, No.12, May : 2024

ENHANCING SURVEILLANCE CAPABILITIES OF DRONES IN PORT ENVIRONMENTS

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ABSTRACT
This research paper aims to enhance maritime security and monitor vessels navigating through port areas, preventing encroachments, and ensuring efficient port operations. The objectives include improving accuracy for precise navigation, providing real-time video communication, designing drones to operate in various environments and weather conditions, improving safety in surveying, and building a cost-effective and easy-to-maintain solution. The utilization of GPS systems has improved stability during drone flight, reducing the risk of accidents and enhancing safety in applications.

Keywords: maritime surveillance, real-time video communication, precise navigation, safety enhancements.

Introduction
The utilization of surveillance drones in port environments has emerged as a critical component of modern security and logistical operations. These unmanned aerial vehicles (UAVs) offer unique advantages in terms of flexibility, coverage, and accessibility, making them indispensable tools for monitoring and safeguarding port facilities. However, as the threat landscape evolves and security challenges become increasingly complex, there is a pressing need to enhance the surveillance capabilities of drones to ensure comprehensive and effective port security. This research paper aims to explore the various strategies and technologies geared towards improving the surveillance capabilities of drones within port areas. By delving into advancements in sensor technologies, autonomous navigation systems, real-time threat detection methods, communication systems, and addressing regulatory and ethical considerations, this study seeks to provide valuable insights into the current state and future-prospects of drone-based port surveillance. To Enhance Accuracy and Precision.

Navigation:
One of the key enhancements in the drone system for port surveillance is the implementation of the Pixhawk flight controller, which has significantly improved accuracy for precise navigation. By leveraging advanced navigation algorithms and sensor fusion techniques, the drone can navigate with greater precision, ensuring optimal coverage of the port area. This improvement not only enhances the effectiveness of surveillance operations but also contributes to safer operations by reducing the risk of collisions and ensuring reliable navigation in challenging environments.

Real-Time Video Communication:
The integration of high-quality cameras and mission planner software has enabled real-time data collection during drone flights in port areas. This capability allows security personnel to obtain timely and accurate information about port activities, potential security threats, and suspicious behavior. Real-time data collection enhances situational awareness and enables security teams to make informed decisions and respond promptly to security incidents, thus improving overall security in port environments.

Cost-Effective Solution:

In addition to performance improvements, the drone system has been designed to be a cost-effective solution for port surveillance. Compared to conventional drone systems, the implemented solution is easier to maintain and repair, resulting in reduced operational costs over the system's lifecycle. This cost-effectiveness makes the drone system a viable option for port authorities seeking to enhance their surveillance capabilities within budget constraints.

Stability and Safety:

The utilization of GPS systems has significantly improved the stability of drone flights in port environments. GPS technology provides accurate positioning data, allowing the drone to maintain stability and navigate effectively even in adverse weather conditions or challenging terrain. This improvement not only reduces the risk of accidents but also enhances safety in port applications, ensuring reliable and secure surveillance operations.

These improvements contribute to more effective surveillance operations, ultimately bolstering port security and safety.

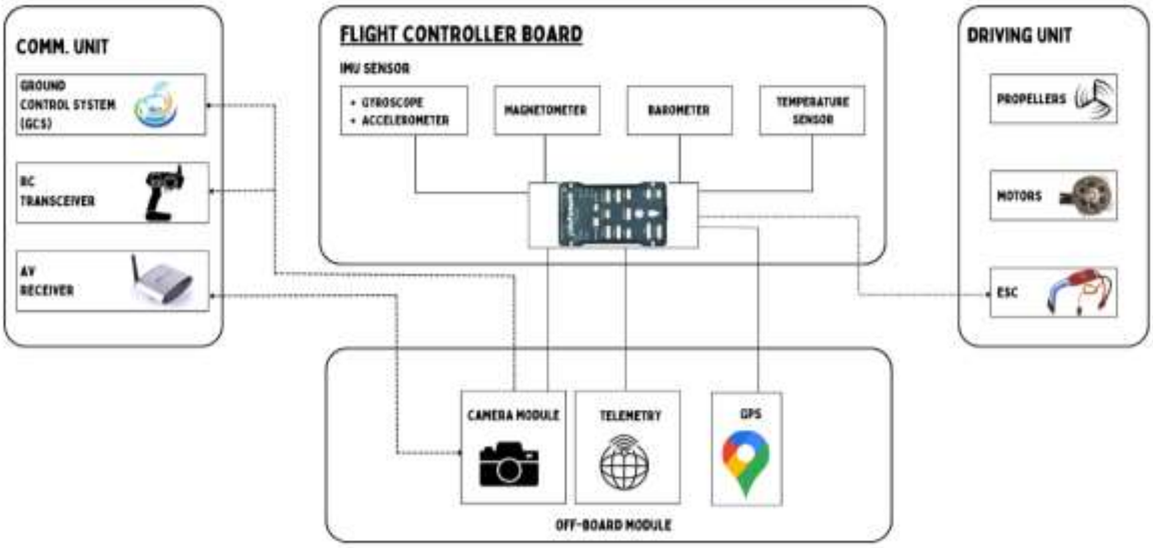

Figure 1: Overall System Architecture

Literature Review & Current Techniques

These unmanned aerial vehicles (UAVs) play a crucial role in enhancing situational awareness and operational efficiency, particularly in challenging environments where traditional surveillance methods fall short. Moreover, recent research endavors have explored the practical applications of autonomous drones in diverse domains.

Sriram et al.'s study focuses on the implementation of an autonomous UAV for defence machinery maintenance and surveillance, demonstrating the integration of deep learning algorithms for human motion detection and auxiliary drone deployment in unforeseen circumstances [1]. Suparnunt et al. present a pragmatic parallel of autonomous UAVs, leveraging specialized software like Mission Planner to optimize flight paths for remote sensing applications, thereby enhancing coverage and resolution in aerial photography [2]. Similarly, Steinhäusler and Georgiou explore the utilization of UAVs in wide-area search and rescue operations, highlighting the technical and logistical considerations in drone fleet deployment [3]. Pinney et al.'s investigation into exploration and object detection via low-cost autonomous drones showcases the efficacy of path-planning algorithms in identifying targets within a designated area of interest [4]. Sato and Anezaki delve into the development of GPS-non-GPS integrated navigation systems for infrastructure inspection, addressing collision avoidance protocols to ensure safe drone operations [5]. Finally, Dilshad et al.'s survey delves into the challenges and opportunities in video surveillance via drones, underscoring the scalability and flexibility of vision sensors mounted on UAVs while addressing pertinent issues such as processing constraints and transmission disturbances [6].

2.1 Current Trends and Techniques

Surveillance drones have evolved significantly to meet the growing demands of security and monitoring applications. One notable trend is the adoption of autonomous operation, facilitated by advanced flight controllers like Pixhawk. This enables drones to navigate predefined paths and execute surveillance missions without constant human intervention. Another key advancement is in real-time data acquisition capabilities. Modern drones are equipped with high-resolution cameras and telemetry systems, allowing them to capture and transmit imagery and video in real-time. This capability enhances situational awareness for security personnel by providing immediate access to surveillance data. Furthermore, surveillance drones now incorporate enhanced sensor technologies, including thermal cameras and LiDAR. These specialized sensors enable drones to detect heat signatures and map terrain features with greater precision, enhancing their surveillance capabilities in various environments.Intelligent mission planning software, such as Mission Planner, has also become integral to surveillance drone operations. This software optimizes flight trajectories and parameters based on specific surveillance objectives, ensuring efficient resource utilization and enhancing mission effectiveness. Additionally, the integration of counter-drone technologies is gaining prominence in the surveillance drone industry. These systems detect and respond to unauthorized drone activities, safeguarding critical infrastructure and sensitive areas from potential threats. Lastly, data analytics and AI-driven insights play a crucial role in modern surveillance drones. These technologies analyse large volumes of surveillance data in real-time, extracting actionable insights to improve decision-making and enhance overall security operations.

Figure 2: Appearance of the model side view

Proposed Methodology

In the development of a drone for surveillance purposes in port areas, several key components were integrated to ensure efficient operation and reliable performance. These components include of Pixhawk 2.4.8 flight controller, consisting of four brushless DC motors, a GPS module and receiver. Power for the entire system was supplied by an 14V Lithium Polymer battery connected via a power module. Upon power-up, the system underwent essential configuration and calibration procedures before being armed for flight. Communication between the flight controller and other units was facilitated through standard interfaces such as the pulse width modulation (PWM) module. The Pixhawk controller emerged as the preferred choice for autonomous missions due to its versatility and support for various flight modes, many of which relied on GPS signals. For instance, the "Return to Launch" (RTL) mode enabled the drone to automatically return to its takeoff coordinates in case of emergencies like low battery or poor signal strength. Prior to takeoff, the ArduPilot conducted fail-safe checks, including assessing battery voltage, GPS lock status, and sensor calibration, ensuring the drone's readiness for flight. Operational control and mission planning were facilitated through the "Mission Planner" software, which offered a user-friendly graphical interface for setting waypoints, adjusting flight modes, and modifying flight directions. During flight operations, the drone remained connected to a ground station computer running the Mission Planner software via a GPS module, utilizing radio frequency (MAV-link protocol) communication.From a structural perspective, drones were equipped with a variety of components, including main processors, power systems, sensors, and communication modules, to support their operation. The flight-controller board served as the central hub, periodically collecting data from sensors and coordinating adaptive control of the drone. This board, typically equipped with an inertial measurement unit (IMU), housed various sensors crucial for drone operation, with the option to integrate additional sensors to enhance performance.Commonly utilized sensor modules in drones included the Inertial Measurement Unit (IMU), camera, and GPS. The IMU played a fundamental role in navigation, precisely estimating the drone's attitude using data from the gyroscope and accelerometer. Cameras captured visual data for analysis, while GPS modules received signals from satellites to calculate the drone's precise position, essential for navigation and mission planning. Overall, the proposed methodology for the research paper involves integrating hardware components like the flight controller and sensors, along with software like the ArduPilot and Mission Planner software, to design a drone capable of performing surveillance missions in port environments. This comprehensive approach aims to ensure effective and reliable drone operations for enhanced security and monitoring in port areas.

Implementation

Mission Planner software, developed by Michael Oborne, is specifically designed for autonomous flight missions, enabling seamless communication between the base station and the UAV. This software serves as a vital tool for programming commands into the drone, including returning conditions, GPS coordinates, and altitude points. It allows the flight controller to operate in various flight modes such as acrobatic mode, altitude hold, loiter mode, and stabilize mode, offering flexibility in mission execution.In addition to programming commands, Mission Planner facilitates hardware calibrations essential for optimal drone performance. One crucial calibration involves compass calibration to compensate for the magnetic fields generated by the motors and surrounding areas, ensuring the drone maintains its intended flight path. Another important calibration is Electronic Speed Controller (ESC) calibration, which ensures the motors rotate at the required speeds as dictated by the ArduPilot, enhancing flight control precision.

Connecting the transmitter and receiver is integral to establishing real-time video communication, enhancing situational awareness during drone operations. The transmitter is linked to the drone's camera, transmitting live video feeds to the ground station through the video receiver. This setup allows operators to monitor the drone's surroundings in real-time, facilitating timely decision-making and effective mission execution.

Furthermore, Mission Planner software offers comprehensive mission planning capabilities, enabling users to define mission parameters and waypoints for autonomous drone navigation. Operators can specify flight paths, altitude profiles, and actions to be executed at each waypoint, tailoring missions to specific objectives. This intuitive software interface streamlines mission planning processes, optimizing drone operations for surveillance, monitoring, and other applications.

Component Name	Model Name	Weight
Flight Controller	Pixhawk 2.4.8	0.06 kg
R/C Receiver	FlySky FS-i6 2.4G 6CH	0.48 kg
Carbon Fiber Frame	S500 Carbon Fiber Quadcopter	0.9 kg
4x Motors	Emax ECOII-2807-1700KV Brushless Motor	0.292 kg
ESC	Readytosky 80A ESC 2-6S Brushless	0.38 kg
Battery	Orange 14.8V 5200 mAh 35C 4S Lithium Polymer	0.9 kg
FPV Camera	Eachine 1000TVL 1/3 CCD 110 Degree 2.8mm Lens	0.015 kg
Transmitter & Receiver	TS832 48Ch 5.8G 600mW AV Transmitter & 5.8G UVC OTG Android AV Receiver	0.080 Kg

Table 1. Weight Contribution of Components

Conclusion

The research has successfully enhanced the surveillance capabilities of drones in port environments. The improvements in accuracy, real-time video communication, and safety operations contribute to more effective maritime security and efficient port operations. The development of a cost-effective and easy-to-maintain solution addresses practical concerns in drone deployment, ensuring sustainability and scalability in port surveillance. The utilization of GPS systems has further enhanced the stability of drone flights, reduces the risk of accidents and improving safety in applications. Overall, the research findings underscore the importance of continuous innovation and improvement in drone technology to meet the evolving needs of port security and surveillance.

Acknowledgements

We want to express our deep gratitude to AISSMS Institute of Information Technology Pune for providing us with a supportive learning environment that helped us think creatively and achieve our goals. The institute has been instrumental in building our confidence and enabling us to turn our project into reality. We are thankful for their continuous support and encouragement throughout our research journey.

We also want to thank Mr. Sachin Ratnakar Kokane for his help in reviewing our paper and offering valuable suggestions that contributed to its successful completion.

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