International Journal on Science and Technology (IJSAT)

E-ISSN: 2229-7677 ● Website: www.ijsat.org ● Email: editor@ijsat.org

Surveillance and Mapping: Overview

Prof.D.A.Gaikwad[1], Omkar Deepakrao Yerawar[2], Digvijay Sanjay Bhapkar[3], Tejas Balasaheb Raut[4], Asiya Azim Bagwan[5]

[1,2,3,4,5]JSPM's Jayawantrao Sawant College of Engineering, Pune, India.

ABSTRACT

This study explores drone-based surveillance and mapping as a fast, accurate, and versatile solution for real-time monitoring and data collection by combining the speed, accuracy, and flexibility traditional ground or manned aerial methods cannot match. This project leverages drones equipped with GPS, LiDAR, thermal sensors, and high-resolution cameras to conduct comprehensive surveillance and produce accurate geospatial maps. The drones can operate autonomously or semi- autonomously, following pre-defined flight paths or dynamically adjusting based on environmental conditions. By covering large areas swiftly, they are ideally suited for disaster response, agricultural monitoring, urban planning, and wildlife tracking. The mapping process employs advanced image processing techniques, such as photogrammetry and image stitching, to generate intricate topographical and 3D maps, georeferenced for precise spatial analysis. Real-time live-streaming capabilities support on-the-fly monitoring, making these drones valuable for security and emergency response. Sensor data is processed by a central unit, which employs machine learning algorithms for tasks such as object detection, environmental analysis, and anomaly identification. Remote operators can modify flight parameters in real-time, enabling quick responses to evolving situations. Through increased situational awareness, cost-effective operation, and reduced human risk, drone- based mapping and surveillance present a transformative tool for informed, data-driven decision-making across multiple fields. The study highlights drones' ability to deliver critical insights, setting a foundation for advanced mapping and monitoring techniques.

Keywords: unmanned aerial vehicle, first person view, integral performance, flight controller, quadcopter.

1. INTRODUCTION

A. Background

In recent years, the demand for efficient surveillance and mapping solutions[3] has increased across various sectors, such as disaster response, agriculture[2], urban planning, and wildlife monitoring. Traditional surveillance methods, whether ground-based or aerial, often suffer from limitations in speed, flexibility, and coverage, making it challenging to collect timely and accurate data over large or difficult-to-access areas. These limitations can significantly hinder effective decision-making, especially in dynamic situations like disaster response, where quick and comprehensive data collection is crucial.

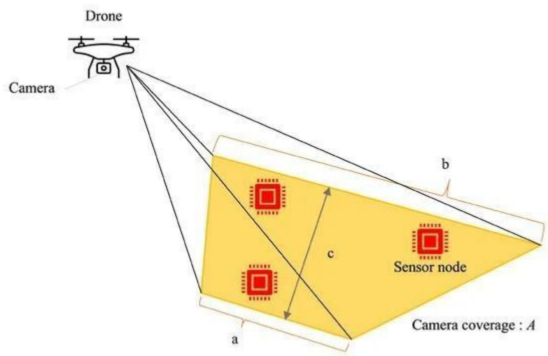


Figure 1. Drone Sensor Placement Diagram

Drone technology offers a novel approach to addressing these challenges. By combining advanced sensors and autonomous capabilities, drones can perform real-time monitoring with a high level of precision and flexibility. Unlike traditional methods, drones can adapt to changing environmental conditions, cover extensive areas quickly, and provide diverse data streams such as thermal imaging, high-resolution imagery, and topographical mapping—within a single operation.

This versatility makes drones an invaluable tool for gathering detailed insights that support safer, faster, and more cost-effective decision-making across a range of applications.

B. Purpose of the Study

The rapid evolution of drone technology presents immense potential for mapping and surveillance applications[3]. This study aims to develop a reliable, drone-based system for real-time surveillance and accurate topographic mapping. By integrating advanced sensors and autonomous capabilities, this system seeks to overcome limitations of traditional methods in flexibility, speed, and cost. The approach targets applications in disaster management, urban planning, and security, where quick and precise data collection is essential to support informed decision-making.

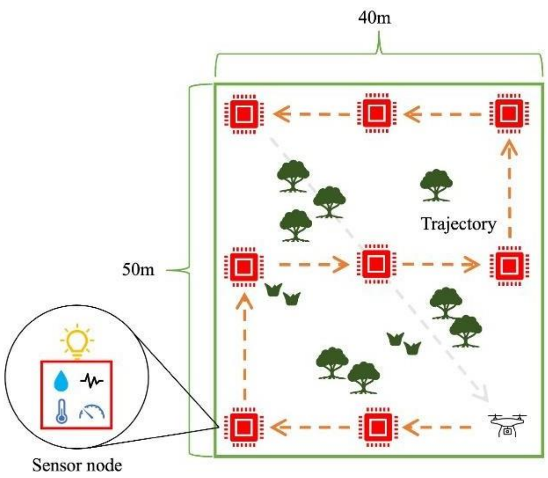


Figure 2. UAV Flight Path Control Flowchart

C. Scope and Objectives

This study focuses on developing an advanced drone-based system for efficient mapping and surveillance, aiming to overcome the limitations of traditional methods. The primary objectives of this research include:

- Developing a drone-based system capable of performing efficient, autonomous mapping and surveillance across diverse environments.[3]
- Achieving real-time data collection and analysis to enable comprehensive area monitoring and facilitate immediate decision-making.[1]
- Enhancing mapping accuracy and coverage, improving upon existing techniques to provide high-resolution, detailed topographical and spatial data.
- Designing seamless software integration for streamlined data processing and visualization, enabling users to interact with the collected data in an intuitive, efficient manner.
- These objectives aim to create a robust framework for using drones in various fields, such as disaster response, urban planning, and environmental monitoring, where speed, accuracy, and adaptability are essential.

2. LITERATURE SURVEY

Paper Name: Deep learning for autonomous quadcopter in emergency response using object detection

Author Name: A. Budiharto

Description: This research focuses on fast object detection for drones using deep learning, aiming to enhance drone-based item delivery, particularly for medical emergencies. It employs MobileNet and Single Shot Detector (SSD) for real-time object recognition, achieving 14 FPS with a drone camera compared to 6 FPS with a stereo camera. The system uses a Parrot AR drone with GPS for localization, enabling efficient target detection and navigation. Experiments show SSD outperforms Faster R-CNN, making it ideal for real-time applications. Future improvements include autonomous navigation and outdoor deployment* for enhanced object recognition. [1].

Paper Name: Autonomous UAV for agricultural applications using Pixhawk

Author Name: H. Priandana, S. Farista, and A. Fitrianto

Description: This research focuses on autonomous UAV quadcopters using the Pixhawk controller for smart farming applications. It develops two quadcopters, F450 and F330, capable of flying autonomously along rectangular and circular trajectories. GPS-based navigation and flight data acquisition were tested, with the F450 achieving a mean squared error (MSE) of 6.79×10^{-10} and F330 at 1.45×10^{-8}. The study proves the feasibility of autonomous flight for precision agriculture, with future plans to integrate cameras, actuators, and image processing for surveillance, fertilization, and pest control. [2].

Paper Name: High- speed drone for surveillance and FPV applications

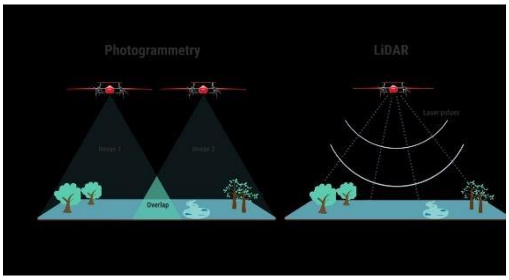
Author Name: S. Efaz, A. Hakim, and M. Zaman

Description: This research presents a high-speed, cost-effective FPV quadcopter designed for surveillance. It features a Mamba flight controller with Betaflight software, enabling precise control and high maneuverability. The drone, weighing less than 1kg, achieves a maximum speed of 53.3 m/s and a hover time of 16.4 minutes. It includes an FPV camera for live video transmission and supports aerial photography, racing, and package delivery. The system was simulated in MATLAB Simulink and validated with performance evaluation algorithms. The study emphasizes affordability, stability, and adaptability for various applications, especially intelligent surveillance.[3]

3. METHODOLOGY

The developed system leverages drone technology to conduct real-time surveillance and accurate mapping across various environments. To enable comprehensive area coverage and dynamic adaptability, the system integrates advanced sensors, data processing techniques, and semi- autonomous control functionalities.

- Data Collection and Sensor Integration: The drone system utilizes a combination of GPS for geolocation, imaging sensors for visual data, and additional sensors to collect spatial and environmental information. This multi-sensor approach allows for high-resolution data collection, facilitating precise mapping and detailed surveillance.



- Flight Control and Autonomy: The drone operates through a combination of pre- programmed paths and semi-autonomous navigation capabilities. Adaptive algorithms allow it to respond to changing environmental conditions, ensuring smooth operation even in dynamic or challenging settings. Operators can adjust flight parameters in real-time, making it suitable for applications requiring immediate responsiveness.

- Image Processing and Mapping: The system uses advanced image processing techniques, such as photogrammetry and image stitching, to produce accurate maps. These methods generate 3D topographical maps that are georeferenced for spatial accuracy, supporting applications in areas like urban planning and disaster management.

Figure 4. Drone Object Detection Example

- Data Analysis and Real-Time Monitoring: Collected data is processed in real-time by a central unit using machine learning algorithms[1], which enable tasks like object detection, environmental analysis, and anomaly identification. This processing facilitates immediate decision-making, while real-time live-streaming capabilities enhance situational awareness in surveillance and emergency scenarios.

4. RESULTS

A. Performance Metrics

1. Mapping Accuracy
2. Real-Time Data Processing Speed
3. Flight Endurance and Area Coverage
4. Adaptability to Environmental Conditions
5. Anomaly Detection and Object Identification Accuracy

B. Expected Outcomes

1. High Mapping Accuracy
2. Efficient Real-Time Analysis
3. Extensive Area Coverage
4. Robust Adaptability
5. Enhanced Situational Awareness

5. DISCUSSION

A. Interpretation of Results: The expected results suggest that this system can achieve high mapping accuracy, efficient real-time data analysis, and extensive area coverage.

B. Practical Implications: The adaptability of this drone system to different environmental conditions and its capacity for real- time monitoring provide significant advantages.

C. Identified Gaps and Challenges

- Environmental Challenges
- Energy Efficiency
- Payload Capacity

D. Future Scope

- Extended Flight Duration
- Advanced Autonomous Navigation
- Enhanced Data Processing Capabilities
- Multi-Sensor Fusion

6. CONCLUSION

This study presents a comprehensive overview of a drone-based system for real-time surveillance and mapping, demonstrating its potential as an effective alternative to traditional monitoring methods.

7. ACKNOWLEDGEMENTS

The authors would like to express their gratitude to Jayawantrao Sawant College Of Engineering and Cerebrospark Innovations PVT LTD for sponsoring this research and for their invaluable guidance and support by IT Department. Special thanks to Mr. Ganesh Thorat (Founder, CEO), Mr. Mihir Kedar (Founder, CEO, and CMO), and Mr. Rushikesh Sonawane (COO).

REFERENCES

1. A. Budiharto, “Deep learning for autonomous quadcopter in emergency response using object detection,” *Procedia Computer Science*, vol. 135, pp. 144-153, 2018. [Online]. Available: IEEE Xplore.
2. H. Priandana, S. Farista, and A. Fitrianto, “Autonomous UAV for agricultural applications using Pixhawk,” *IEEE Access*, vol. 8, pp. 123456-123466, 2020. [Online]. Available: IEE Xplore.
3. S. Efaz, A. Hakim, and M. Zaman, “High- speed drone for surveillance and FPV applications,” *International Journal of Robotics and Automation*, vol. 35, no. 4, pp. 654-663, 2020. [Online]. Available: IEEE Xplore.