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FIXED WING VTOL DRONE

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Abstract: This collection of studies explores advancements in drone technology and its applications across various domains. The first study introduces a novel algorithm for generating aerobatic trajectories for VTOL fixed-wing aircraft using differential flatness, enhancing maneuverability and computational efficiency. Another study focuses on drone detection through ISAR imaging with a millimeter-wave MIMO radar, employing a backprojection algorithm to achieve high-resolution images and improved object distinction. The development of a hybrid VTOL-UAV for surveillance applications is detailed in a third study, which highlights design, testing, and performance evaluations. The Node and Edge Drone Surveillance Problem (NEDSP) is addressed in another paper, optimizing surveillance routes and battery management using mixed-integer linear programming. RF-UAVNet, an advanced CNN for RF-based drone surveillance systems, is introduced, demonstrating high accuracy and efficiency in detection and classification. The security of IoD communications is enhanced through an identity-based proxy signcryption scheme, simplifying key management while ensuring confidentiality and authenticity. A real-time homomorphic authenticated encryption scheme is proposed to secure drone communications, balancing privacy and operational efficiency. The application of Transformer-based models for Named Entity Recognition in drone flight logs is explored to support forensic investigations by improving data extraction accuracy. Finally, a data-driven simulator using a Genetic Algorithm optimizes the positioning of aerial ambulance drones for emergency response, potentially transforming emergency medical services with improved response times. Together, these studies contribute significantly to the advancement of drone technology, addressing challenges in trajectory planning, detection, security, and emergency response.

Keywords: Aerial Ambulance Drones, Out-of-Hospital Cardiac Arrests, Genetic Algorithm, Emergency Response, Simulation, Optimized Deployment, Medical Services

I. INTRODUCTION

Recent advancements in drone technology and its applications have sparked significant interest across various fields, from aeronautics to security and emergency response. Innovations in trajectory generation for VTOL fixed-wing aircraft have enhanced their maneuverability and real-time capabilities, while sophisticated radar systems utilizing ISAR imaging have improved drone detection and differentiation. The development of hybrid VTOL-UAVs demonstrates a leap in surveillance capabilities, integrating fixed-wing and rotary-wing features for versatile performance. In optimizing drone surveillance, new models address critical factors like observation quality and battery management.

Concurrently, cutting-edge neural networks, such as RF-UAVNet, are revolutionizing RF-based drone surveillance with high accuracy and efficiency. Ensuring secure communications in the Internet of Drones (IoD) is crucial, with novel cryptographic schemes like identity-based proxy signcryption and real-time homomorphic authenticated encryption enhancing data protection. Additionally, the application of Transformer-based models to analyze drone flight logs supports forensic investigations, while data-driven simulators using Genetic Algorithms offer new strategies for positioning aerial ambulances in emergency situations. Collectively, these advancements reflect the dynamic progress in drone technology, offering solutions to complex challenges and expanding their capabilities in various critical domains.

II. LITERATURE REVIEW

1]. The paper introduces a novel algorithm for generating aerobatic trajectories for VTOL (Vertical Take-Off and Landing) fixed-wing aircraft using differential flatness. The paper discusses the advantages of VTOL aircraft in terms of maneuverability and efficiency. It delves into existing methods of trajectory generation, particularly focusing on the differential flatness approach, which transforms trajectories from a flat output space to the state and control input space. Previous studies have applied this method to quadcopters and fixed-wing aircraft, albeit with simplified models. The authors propose a comprehensive 6-DOF (six degrees of freedom) flight dynamics model, incorporating aerodynamic equations, to enable complex aerobatic maneuvers. The limitations of earlier models and the benefits of the proposed method in terms of computational efficiency and feasibility for real-time applications.

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2]. The study explores the use of Inverse Synthetic Aperture Radar (ISAR) imaging for drone detection, utilizing a backprojection algorithm with millimeter-wave fast chirp modulation MIMO radar. The literature review emphasizes the growing threat posed by drones in security and defense contexts, necessitating advanced detection technologies. The various radar-based detection methods, including traditional and modern approaches, and their respective strengths and weaknesses. The study particularly focuses on the backprojection algorithm for ISAR imaging, which provides high-resolution images and is effective in distinguishing drones from other objects. The technical challenges and solutions in implementing this technology, such as signal processing techniques and hardware considerations. Previous research on MIMO radar systems and their application in surveillance is also examined, underscoring the innovation and potential impact of this study in enhancing drone detection capabilities

3]. The study refers to the development and testing of a Vertical Take-Off and Landing Unmanned Aerial Vehicle (VTOL-UAV) for surveillance purposes, focusing on the design, fabrication, and performance evaluation of the VTOL-UAV prototype. The VTOL-UAV is designed to combine the advantages of both fixed-wing and rotary-wing aircraft, featuring a hybrid configuration that allows for vertical take-off and landing as well as efficient horizontal flight. The UAV is constructed using lightweight materials like Depron foam for the wings and aluminum for structural support, with key components including a Pixhawk flight controller, GPS, telemetry unit, and a Li-Ion battery. The flight control system uses PID controllers to ensure stability and precise control during various flight modes, with the software setup involving Mission Planner for firmware updates and PID tuning. The design process utilized SolidWorks for 3D modeling of the wing and tail sections, and simulations were conducted to validate the design before physical fabrication. The prototype underwent extensive testing, including stability and performance evaluations. Flight tests demonstrated acceptable levels of vibration and roll response, indicating good stability and control. The study concludes that the hybrid VTOL-UAV design meets the desired performance criteria for surveillance applications, with future work focusing on further optimization of the design and integration of additional sensors for enhanced surveillance capabilities.

4]. The study of complexities of drone surveillance, specifically focusing on the Node and Edge Drone Surveillance Problem (NEDSP). The factors such as required observation quality and battery replacement, which are crucial for effective and continuous surveillance operations. The paper highlights the significance of balancing observation quality with the practical limitations of drone battery life, introducing the NEDSP as a variant of the Traveling Salesman Problem (TSP) adapted for drone operations. The authors propose a model that integrates observation quality requirements with battery replacement schedules, employing a mixed-integer linear programming (MILP) approach to optimize surveillance routes and battery management. The model addresses challenges in managing the limited battery life of drones while ensuring high-quality surveillance, devising strategies for optimal battery replacement without compromising surveillance continuity. The novel optimization model that considers both node and edge surveillance tasks, using MILP to derive feasible routes and schedules that meet predefined observation quality thresholds. The proposed model was tested in various scenarios, demonstrating its effectiveness in optimizing surveillance routes and battery usage. Comparative analysis with traditional TSP-based approaches showed significant improvements in operational efficiency. The successfull integrates observation quality and battery constraints into the drone surveillance routing problem, offering practical insights and solutions for real-world surveillance operations, and highlighting the model's applicability and scalability.

5]. The study introduces an advanced convolutional neural network (CNN) designed specifically for enhancing RF-based drone surveillance systems. The motivation behind this research is the increasing challenge of detecting unauthorized drone activities, which pose security risks in restricted areas. RF-UAVNet stands out for its innovative architecture that employs one-dimensional grouped convolutional layers, significantly reducing computational costs and the number of parameters needed. By incorporating multi-level skip connections and pooling layers, the network efficiently preserves gradient flow and captures informative features, which boosts learning efficiency and overall performance. Impressively, RF-UAVNet achieves a detection accuracy of 99.85%, a classification accuracy of 98.53%, and an operation mode recognition accuracy of 95.33% on the DroneRF dataset. These results position RF-UAVNet as a leading solution compared to existing models, particularly due to its ability to process multi-scale RF signal resolutions with minimal implementation complexity. However, the paper could delve deeper into the scalability of RF-UAVNet for larger datasets and more complex environments, as well as provide more detailed real-world integration scenarios. Despite these gaps, RF-UAVNet marks a significant step forward in RF-based drone surveillance, offering a promising approach to improving detection and classification tasks through advanced deep learning techniques.

6]. The study addresses the critical need for robust security measures in the Internet of Drones (IoD) ecosystem. As drones become increasingly interconnected and integrated into various applications, the security of their communication networks becomes paramount to prevent unauthorized access and data breaches.

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It introduces an identity-based proxy signcryption (IBPSC) scheme tailored for the IoD environment, aiming to enhance both the confidentiality and authenticity of drone communications. The proposed IBPSC scheme combines the functionalities of encryption and signature in a single cryptographic operation, thereby reducing computational overhead and communication costs. This dual-purpose approach is particularly advantageous for the resource-constrained nature of drones, which often have limited processing power and battery life. The authors detail the mathematical foundation of the scheme, demonstrating how it ensures secure message transmission and verification between drones and control stations. A significant feature of this scheme is its identity-based framework, which simplifies key management by using unique identifiers (such as drone serial numbers) as public keys. This eliminates the need for complex public key infrastructure (PKI), streamlining the deployment of secure communication channels in large-scale drone networks. The paper also addresses potential threats, including man-in-the-middle attacks and replay attacks, and provides formal security proofs to validate the robustness of the IBPSC scheme. Through extensive simulations and performance evaluations, the authors show that their proposed scheme offers superior security guarantees while maintaining efficiency. The results indicate that IBPSC can be feasibly implemented in real-time drone communication systems without significant performance degradation. The potential extensions of this work, such as integrating the scheme with blockchain technology for decentralized security management in the IoD.

7]. The study explores the synergy between drones and the Internet of Things (IoT) in enhancing the functionality and efficiency of smart cities. It provides a comprehensive overview of the potential applications and benefits of integrating drones with IoT frameworks to address urban challenges such as traffic management, environmental monitoring, and public safety. The authors emphasize the role of collaborative drones and IoT in creating more responsive and adaptive urban environments. By leveraging real-time data collection and processing capabilities, these technologies can provide valuable insights for city planners and administrators. For instance, drones equipped with sensors can monitor air quality, while IoT devices on the ground can track traffic patterns, enabling dynamic adjustments to reduce congestion and pollution. The several key areas where drone-IoT collaboration can make a significant impact. In disaster management, drones can quickly assess damage and locate survivors, while IoT devices can facilitate efficient resource allocation and coordination of rescue efforts. In public safety, drones can provide aerial surveillance and real-time incident reporting, enhancing the capabilities of law enforcement agencies. The technical challenges and considerations in implementing such systems, including issues of data security, privacy, and interoperability. The authors advocate for the development of standardized protocols and robust encryption methods to protect sensitive information and ensure seamless communication between drones and IoT devices. The envisioning a future where smart cities are seamlessly connected through an integrated network of drones and IoT, leading to improved quality of life and sustainable urban development. The authors call for continued research and innovation to overcome existing barriers and fully realize the potential of these transformative technologies.

8]. The study addresses critical security concerns in drone communication systems by proposing a novel real-time homomorphic authenticated encryption (HAE) scheme. The research is pivotal in enhancing data privacy and integrity during drone operations, where secure communication between drones and control stations is paramount. The HAE scheme uniquely combines homomorphic encryption with authentication mechanisms, allowing computations to be performed on encrypted data without decryption. This ensures that data confidentiality, integrity, and authenticity are maintained throughout processing, making the solution well-suited for dynamic and latency-sensitive drone applications. The proposed secure communication framework leverages HAE to protect data from unauthorized access and tampering, with experimental results demonstrating its effectiveness without compromising drone performance.

The authors also provide a robust security analysis, showcasing the scheme's resilience against attacks such as replay and man-in-the-middle attacks. However, the paper does not extensively cover the scalability of the solution for larger networks or its practical integration into existing systems. While it addresses computational overhead concerns, especially for resource-constrained drones, further optimization and real-world case studies are needed to substantiate its applicability across diverse scenarios. Nonetheless, this paper presents a ground breaking approach to drone system security, offering a comprehensive solution to the challenges of data privacy and integrity, with potential for significant impact on future drone operations.

III. SUMMARY

This collection of studies highlights advancements in drone technology and its applications, focusing on trajectory planning, detection, hybrid designs, and security improvements. Key findings from the studies are summarized as follows:

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Study	Objective	Key Findings	Metrics/Performance
1. Aerobatic Trajectory Generation	Novel algorithm for aerobatic trajectories in VTOL fixed-wing aircraft	Improved maneuverability and computational efficiency	Enhanced real-time performance, 6-DOF model, and aerodynamic equations
2. ISAR Imaging for Drone Detection	High-resolution drone detection using ISAR imaging with MIMO radar	High-resolution images, effective object distinction	Backprojection algorithm, millimeter-wave fast chirp modulation
3. VTOL-UAV Development	Design and testing of a hybrid VTOL-UAV for surveillance	Combines fixed-wing and rotary-wing benefits	Lightweight materials, stable flight, and performance evaluations
4. Node and Edge Drone Surveillance Problem (NEDSP)	Optimization of surveillance routes and battery management	integrated observation quality and battery replacement	Mixed-integer linear programming (MILP) approach, improved operational efficiency
5. RF-UAVNet	Advanced CNN for RF-based drone surveillance	High accuracy and efficiency in detection and classification	Detection accuracy of 99.85%, classification accuracy of 98.53%
6. Securing IoD with IBPSC	Identity-based proxy signcryption for IoD security	Enhanced confidentiality and authenticity	Simplified key management, formal security proofs
7. Real-Time Homomorphic Authenticated Encryption	Secure drone communication using homomorphic encryption	Data privacy and integrity with real-time capabilities	Protection against unauthorized access, computational efficiency
8. Transformer-Based NER for Flight Logs	Application of Transformer models for NER in flight logs	Improved data extraction accuracy for forensic investigations	Superior performance in processing complex flight data
9. Genetic Algorithm for Aerial Ambulance Drones	Optimization of drone positioning for emergency response	Improved response times for out-of-hospital cardiac arrests	Data-driven simulation, cost-benefit analysis

The summarized findings illustrate the ongoing progress in drone technology, emphasizing enhancements in trajectory planning, detection accuracy, hybrid UAV designs, and robust security measures. Each study contributes to solving specific challenges in drone operations, from real-time maneuvering to secure communications and efficient emergency responses.

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IV. CONCLUSION

The collection of studies presented illustrates significant strides in the field of drone technology, encompassing enhancements in trajectory planning, detection capabilities, hybrid designs, and security measures. The research reveals a substantial evolution in each area, reflecting the increasing sophistication and integration of drones into various domains. The novel algorithm for aerobatic trajectory generation in VTOL fixed-wing aircraft highlights improvements in maneuverability and computational efficiency, enabling more complex and dynamic flightmaneuvers. Advances in detection technology, demonstrated through ISAR imaging with millimeter-wave MIMO radar, offer high-resolution imaging and superior object distinction, crucial for addressing security challenges. The development of hybrid VTOL-UAVs showcases the effective merging of fixed-wing and rotary-wing features, enhancing surveillance capabilities and operational versatility. Additionally, the introduction of a mixed-integer linear programming model to optimize surveillance routes and battery management presents a practical solution to balancing observation quality with battery constraints. The high-performance RF-UAVNet convolutional network exemplifies a leap in detection and classification accuracy, setting a new standard for RF-based drone surveillance systems. Security enhancements are addressed through innovative cryptographic schemes, such as identity-based proxy signcryption and real-time homomorphic authenticated encryption, which bolster data confidentiality and integrity while streamlining key management. The application of Transformer-based models for Named Entity Recognition in drone flight logs enhances forensic analysis, offering a robust framework for data extraction and incident reconstruction. Finally, the use of a Genetic Algorithm for optimizing the positioning of aerial ambulance drones represents a transformative approach to emergency medical services, promising significant improvements in response times and effectiveness. Collectively, these studies underscore the dynamic progress in drone technology, presenting solutions to complex challenges and expanding the potential applications of drones in security, surveillance, and emergency response.

V. RESULT

Fig 1. Prototype of an VTOL Drone

REFERENCES

[1]. Ezra Tal, Gilhyun Ryou, and Sertac Karaman, “Aerobatic Trajectory Generation for a VTOL Fixed-Wing Aircraft Using Differential Flatness,”IEEE, vol. 39, pg. 4805-4819, Dec. 2023.

[2]. Kenshi Ogawa, Dovchin Tsagaanbayar, and Ryohei Nakamura, “ISAR imaging for drone detection based on backprojection algorithm using millimeter-wave fast chirp modulation MIMO radar,” IEICE Communications Express, vol. 13, no. 7, 276-279, may 2024.

[3]. Yasir Ashraf Abd Rahman1, Mohammad Taghi Hajibeigy1,*, Abdulkareem Shafiq Mahdi Al-Obaidi1, and Kean How Cheah,1. School of Engineering, Taylor’s University, Malaysia,2. School of Engineering and Physical Sciences, Heriot-Watt University, Malaysia, “Design and Fabrication of Small Vertical-Take-Off-Landing Unmanned Aerial Vehicle,”MATEC Web of Conferences 152,pg.1-15,2023.

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[4]. IVAN KRISTIANTO SINGGIH, JONGHWA LEE, AND BYUNG-IN KIM, "Node and Edge Drone Surveillance Problem With Consideration of Required Observation Quality and Battery Replacement," IEEE, vol. 8, no. 10, pg. 44125-44139, Sept. 2020.

[5]. THIEN HUYNH-THE, QUOC-VIET PHAM, TOAN-VAN NGUYEN, DANIEL BENEVIDES DA COSTA, AND DONG-SEONG KIM, "RF-UAVNet: High-Performance Convolutional Network for RF-Based Drone Surveillance Systems", IEEE, vol.10,pg.49696-49707, may 2022.

[6]. MUHAMMAD ASGHAR KHAN, HABIB SHAH, SAJJAD UR REHMAN, NEERAJ KUMAR ROZAIDA GHAZALI, DANISH SHEHZA, AND INSAF ULLAH1, "Securing Internet of Drones With Identity-Based Proxy Signcryption", IEEE, vol.9, pg.89133-89142,2021.

[7]. SAEED H. ALSAMHI, OU MA, MOHAMMAD SAMAR ANSARI, AND FARIS A. ALMALKI, "Survey on Collaborative Smart Drones and Internet of Things for Improving Smartness of Smart Cities", IEEE, vol.7, pg.128125-128152, sep 2019.

[8]. JUNG HEE CHEON1, KYOOHYUNG HAN, SEONG-MIN HONG, HYOUN JIN KIM, JUNSOO KIM SUSEONG KIM, HOSUNG SEO ,HYUNGBO SHIM AND YONGSOO SONG, "Toward a Secure Drone System: Flying With Real-Time Homomorphic Authenticated Encryption", vol.6, pg. 24325, 2018.