Dean&Francis

ISSN 2959-6157

An Automated Detection System for Drones Based on Quantum Technology

Yuchi Du[1, *],

Tiansu Han[2]

and Xincen Luo[3]

[1]College of Electronic Information Engineering, Zhengzhou University of Aeronautics, Zhengzhou, 450015, China

[2]Adcote International School, Shanghai, 200120, China

[3]College of Photonic and Electronic Engineering, Quanzhou Normal University, Quanzhou, 362000, China

*Corresponding author: duyuchi93@gamil.com

Abstract:

Automatic optical inspection (AOI) systems for drones are increasingly becoming core tools for intelligent operation and maintenance of industrial infrastructure. However, their traditional implementation paradigms face fundamental technical bottlenecks in communication security, collaborative control, and harsh environment perception. This paper aims to provide a systematic review and analysis of research progress in enabling next-generation UAV AOI systems through emerging quantum technologies, including quantum communication, quantum computing, and quantum sensing. The article first provides a comprehensive overview of the unique potential and current engineering challenges faced by technologies such as quantum key distribution (QKD), quantum approximate optimization algorithms (QAOA), and quantum imaging in addressing the limitations of classical systems. Furthermore, this analysis delved into the cutting-edge concept of a "quantum-classical hybrid architecture" that integrates quantum modules with mature classical systems, analyzing its integration mechanisms and performance gains across three dimensions: communication, computation, and sensing. The review indicates that while this fusion paradigm can theoretically significantly enhance system security, optimize efficiency, and improve robustness, its practical deployment remains constrained by the environmental sensitivity of quantum devices, high costs, and complex system integration. Finally, this paper offers a forward-looking discussion on future development directions in hardware miniaturization, algorithmic collaboration frameworks, and standardization research within this field, providing a framework for researchers to comprehensively understand the opportunities and challenges in this interdisciplinary domain.

Keywords: Quantum technology; automated optical inspection; quantum-classical fusion; quantum computing.

ISSN 2959-6157

1. Introduction

Industrial automation keeps moving forward, and with it, UAV-based automated optical inspection (AOI) systems have become absolutely essential—not just helpful, but necessary—across various sectors. These applications include infrastructure assessment, industrial equipment maintenance, and security monitoring. Why have they become so popular? Well, it's really about their unique flexibility, solid operational efficiency, and when you crunch the numbers, they're just more cost-effective compared to old-school manual inspection methods. It's no wonder they're gradually replacing traditional approaches.

Here's the thing, though: even with all this progress, current UAV AOI systems built on classical technologies still run into major technical limitations in real-world applications, especially when conditions get complicated. These aren't minor issues; they seriously hinder any meaningful improvements in detection performance and reliability.

At the communication level, conventional wireless tech is pretty vulnerable. Think about it—during data transmission, it's open to electromagnetic interference and possible eavesdropping. Sure, today's encryption offers some protection, but how long will that last when quantum computers become more powerful? Truth be told, this is one area where current security just feels temporary [1].

Moving to control mechanisms—this is where things get tricky. The distributed control algorithms are used for coordinating multiple UAVs. They often fall short when it comes to real-time responsiveness and achieving truly optimal global solutions [2]. In highly dynamic environments where split-second decisions matter, they simply don't cut it. It's frustrating, really—these systems can't keep up with the pace of operational demands.

And then there's the sensor problem. Let's be honest: traditional optical sensors struggle in bad weather (e.g. rain, fog) or complex lighting situations. The drop in detection accuracy isn't just slightly significant, and this weakness undermines the whole system's effectiveness. Anyone who's worked in the field has probably faced this headache.

Recent advances in quantum technology have opened new pathways for addressing these challenges. In communications, Quantum Key Distribution (QKD) leverages fundamental quantum principles such as the no-cloning theorem and uncertainty to provide theoretically unconditional security for key exchange, representing a fundamental solution to eavesdropping risks [3]. For computational optimization, quantum-classical hybrid algorithms, such as the Quantum Approximate Optimization Algorithm (QAOA), exhibit strong potential to surpass classical counterparts in solving complex combinatorial optimization problems—including multi-UAV path planning and task allocation. In sensing, emerging quantum technologies such as quantum radar and quantum imaging exploit phenomena like entanglement and coherent illumination to achieve substantial gains in sensitivity and robustness against environmental disturbances [4]. Nonetheless, current research remains largely confined to theoretical or small-scale experimental demonstrations of individual quantum technologies. A systematic investigation into the integration of multiple quantum enhancements into mature classical UAV AOI systems is still lacking.

This paper aims to systematically evaluate the performance boundaries of quantum and classical technologies within UAV-based AOI systems and proposes a novel "Quantum-Classical Hierarchical Collaborative Architecture" designed to leverage the complementary strengths of both paradigms. By developing a structured comparison and fusion framework across system layers, this research seeks to narrow the gap between theoretical quantum advances and practical engineering applications, thereby contributing robust and scalable solutions for critical fields such as industrial inspection and smart city infrastructure.

2. Related Research

2.1 Evolution and Limitations of Classical Drone AOI Systems

Classical drone automatic optical inspection (AOI) systems have undergone remarkable development. They have evolved from initial dependence on traditional image processing-based visual sensing to breakthroughs in defect recognition supported by deep learning. These systems incorporate centralized and distributed control methods, along with essential communication networks and data processing workflows. However, classical systems encounter three fundamental constraints. First, traditional communication encryption algorithms risk compromise by future quantum computing capabilities [1]. Second, real-time performance control remains inadequate, and optimization poses extreme complexity, making dynamic requirements difficult to meet. Third, conventional optical detection systems suffer from limited precision and stability due to environmental interference susceptibility. Addressing these issues, quantum technology is perceived as a promising solution, but its application research in various fields remains at an early stage.

2.2 Mobile Applications of Quantum Communication Technology

Quantum communication technology has progressed from theoretical research to global implementation, with multiple research teams achieving significant accomplishments. In 2016, Pan Jianwei's team at the University of Science and Technology of China launched the Micius satellite, implementing the decoy-state BB84 protocol for satellite-to-ground quantum key distribution. However, these systems frequently face security issues due to side-channel attacks on light sources. Alexander Miller from the National University of Singapore analyzed actual communication data between the Micius satellite and ground stations. He identified significant timing desynchronization among the satellite's eight laser diodes, exceeding 100 ps with maximum time differences around 300 ps [5]. This vulnerability enables eavesdroppers to theoretically distinguish between signal and decoy states with over 98.7% accuracy. This could lead to photon-splitting attacks and introduce potential eavesdropping risks throughout the key distribution process [5]. These investigations demonstrate practical progress in quantum communication while revealing the gap between theoretical security and engineering deployment. They emphasize that achieving unconditional security requires overcoming physical hardware vulnerabilities.

2.3 Potential and Challenges of Quantum Computing in Path Planning

Currently, quantum computing in combinatorial optimization predominantly utilizes hybrid frameworks for practical exploration [2]. Exemplifying this trend, Ruslan Shaydulin et al. demonstrated the potential of the Quantum Approximate Optimization Algorithm (QAOA) to achieve a scaling advantage over classical solvers on the classically intractable Low Autocorrelation Binary Sequences (LABS) problem through extensive numerical simulations [6]. This work provides key evidence that QAOA, as a leading hybrid algorithm, can be a core component for realizing quantum speedups in optimization, even though the results were obtained from noiseless simulations.

2.4 Application Prospects of Quantum Sensing in Defect Detection

In sensor detection, quantum-enhanced AOI employs quantum technology to overcome traditional detection limitations. It provides high precision and rapid response capabilities, making it suitable for highly dynamic environments. However, this technology currently faces practical challenges, including poor environmental adaptability, high equipment costs, and complex data processing requirements.

2.5 Summary of Research Gaps

In summary, current research remains fragmented, focusing primarily on optimizing individual technologies or localized applications. There is insufficient holistic perspective on cross-layer collaborative design integrating communication, control, and sensing components with classical systems. Most studies concentrate on optimizing classical solutions or applying single quantum technologies. Specifically, the lack of quantum-classical hybrid architecture for dynamic drone scenarios prevents adaptive allocation of heterogeneous resources based on mission requirements. Furthermore, the absence of unified performance evaluation standards hampers quantifying the synergistic benefits of such collaborative efforts. Therefore, this study attempts to develop an adaptive, evaluable, integrated framework to enhance overall drone AOI performance.

3. Core Technology Comparison Analysis

3.1 Communication Layer: Quantum vs. Classical Approaches

At the communication level, quantum communication's advantages in speed and security complement classical communication's strengths in stability and transmission distance. Quantum communication, particularly QKD, derives its security from quantum no-cloning theorem, providing unconditional security for quantum key distribution immune to electromagnetic interference [3]. However, its transmission distance is constrained by single-photon detection efficiency and maintains relatively low transmission rates. In contrast, classical communication excels in high transmission rates and broad coverage, suitable for transmitting substantial inspection imagery and real-time data. However, it is more susceptible to environmental and spectrum interference, resulting in relatively lower security. Therefore, in military or high-security civilian applications, QKD can handle key and core command transmission, while classical channels manage bulk data transmission, achieving a balance between security and efficiency.

3.2 Control Layer: Optimization and Collaboration Strategies

At the control layer, quantum collaborative algorithms such as QAOA utilize their parallel computing capabilities to offer potential computational acceleration benefits in solving global optimal path planning problems, particularly excelling in offline, global collaborative optimization

ISSN 2959-6157

[6]. However, their current applications are constrained by qubit count and electromagnetic interference. Classical control algorithms (e.g., DRL) provide rapid response and mature technology, making them suitable for real-time local decision-making, but they commonly get trapped in local optima [7]. The synergistic integration between the two should be hierarchical: the quantum layer addresses complex global task allocation problems, while the classical layer receives policies and executes high-frequency real-time control and feedback. Simultaneously, a confidence assessment mechanism dynamically selects optimal strategies to ensure control reliability [8].

3.3 Detection Layer: Perception and Recognition Capabilities

At the detection layer, quantum-enhanced AOI leverages quantum entanglement and squeezed states to significantly enhance detector signal-to-noise ratio and sensitivity. Compared to classical sensors, it demonstrates superior anti-interference and recognition capabilities under adverse weather such as fog and haze, or in extremely low-light environments, making it suitable for precise recognition in highly dynamic settings [4]. However, it demands stringent environmental conditions, features bulky equipment, and requires further stability improvements [9]. Conventional AOI, utilizing mature deep learning and multimodal sensor fusion approaches, offers stable detection, low-cost implementation, and ease of deployment under normal conditions, making it highly suitable for large-scale routine inspections and situational awareness. Therefore, the system should demonstrate environmental adaptability, employing conventional sensors under normal conditions while switching to or integrating quantum-enhanced detection in harsh environments.

4. Feasibility Analysis of the Quantum-Classical Fusion Architecture

4.1 Conceptual Design and Architectural Framework

The quantum-classical hybrid architecture, grounded in the core principle of “quantum empowerment with classical assurance,” aims to fully exploit the acceleration and security potential of quantum technology for specific tasks. Simultaneously, it relies on classical system maturity and stability to build an efficient, reliable, and secure next-generation information processing platform. This architecture consists of three functional layers: the quantum-enhanced layer executes tasks where quantum properties provide substantial advantages, such as quantum cryptographic communication and quantum optimization computing [10], Specifically for multi-UAV path planning, Shaydulin et al. have demonstrated that QAOA combined with quantum minimum finding provides the best empirical scaling of any algorithm for the LABS problem, outperforming the best classical heuristic algorithms [6]; the classical assurance layer provides foundational system support, real-time control, and backup redundancy; the intelligent decision layer employs artificial intelligence to dynamically schedule quantum and classical resources and optimize fusion strategies in real-time, achieving system-level balance between performance and robustness [11].

The system workflow initiates with task input and requirement analysis, including assessment of factors such as security levels, real-time demands, and computational scale. This is followed by resource allocation, then algorithm selection based on task type (e.g., choosing purely classical algorithms, quantum-classical hybrid algorithms, or quantum algorithms). During the parallel processing phase, quantum and classical computing units collaborate according to assigned tasks. Outputs from multiple sources are integrated through result fusion mechanisms (e.g., weighted averaging, confidence filtering), and the final outcome is generated through the decision output stage. Throughout the process, channel quality, computational complexity, and real-time requirements are critical factors influencing system decisions.

4.2 Inter-Layer Fusion Mechanisms Review

4.2.1 Communication Layer Integration

At the communication layer, existing research has proposed various methods for integrating quantum and classical channels. For instance, wavelength division multiplexing (WDM) technology enables the parallel transmission of quantum signals and classical optical signals within the same channel, thereby significantly enhancing channel utilization. In dense wavelength division multiplexing (DWDM) systems employing optimal wavelength allocation strategies, the achievable secret key generation rate for quantum key distribution (QKD) channels can be enhanced by approximately 70%. Simultaneously, by interleaving quantum and classical channels across the wavelength spectrum, background noise introduced by nonlinear effects such as Raman scattering can be effectively reduced [12]. Channel transmission efficiency is significantly affected by atmospheric turbulence. Experimental data indicate that its average value typically ranges between 0.4 and 0.5 but may abruptly drop to 0.2 under conditions of strong turbulence [13]. This fluctuation is directly reflected in communication quality metrics—NGMI

(Normalized Generalized Mutual Information) degrades from 0.85 to 0.6 under strong turbulence, leading to reduced decoding performance. Regarding the core security metric SKR (Secret Key Rate), stable optical paths enable a key generation rate of 2.7 Mbit/s, whereas severe turbulence reduces it to only around 100 kbit/s [12, 13].

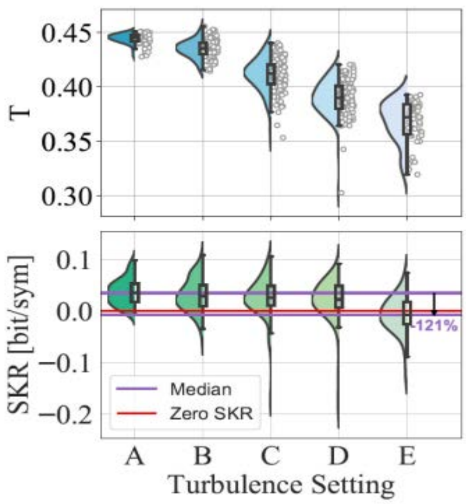

Fig. 1 SKR Data distribution of transmittance [13]

Figure 1 further quantifies the novel dynamic scheduling mechanism's effectiveness by displaying the SKR data distribution, showing how the strategy achieves a 40% reduction in SKR fluctuation during UAV field testing, as detailed in the following paragraph [13]. The data distribution pattern shown is consistent with real-world measurements of entanglement-based quantum communication [14].

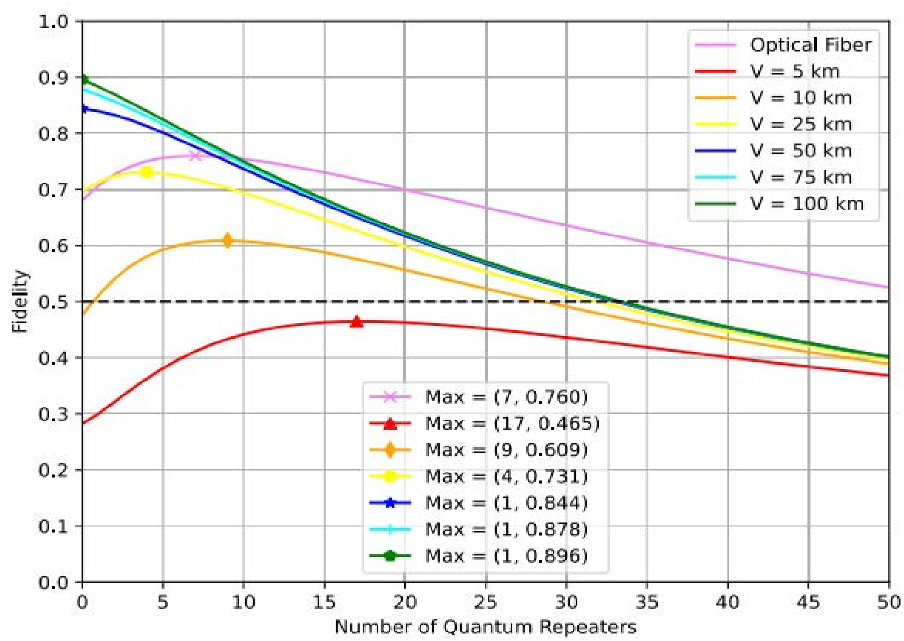

Fig. 2 Fidelity at varying meteorological conditions at 1550 nm [14]

Figure 2 quantifies the performance trade-offs between quantum drone networks and optical fiber systems under varying environmental conditions by displaying fidelity values across different meteorological scenarios [14].

To address such challenges, a study proposed a dynamic scheduling mechanism: based on real-time state feedback from the classical channel, the system automatically prioritizes classical data transmission when channel transmission efficiency falls below 0.3 during periods of strong turbulence. During stable periods when channel transmis-

ISSN 2959-6157

sion efficiency exceeds 0.5, quantum key distribution is performed in a centralized manner. This strategy achieved a 40% reduction in SKR fluctuation during field testing on unmanned aerial vehicle platforms while ensuring that the throughput of conventional data transmission declined by no more than 15%, providing critical technical support for enhancing practicality in complex environments [3]. Additional signal isolation solutions include multi-layer optical network switching nodes with fiber Bragg gratings (FBGs), which effectively separate quantum signals from classical ones while compensating for the time delay issues of synchronization signals [15]. This separation improves system reliability and increases the code rate.

4.2.2 Control Layer Integration

At the control layer, a dynamic arbitration mechanism based on confidence assessment has been developed to address coordination challenges between quantum optimization and classical control algorithms [8]. By establishing confidence thresholds for different algorithm outputs, this method enables intelligent arbitration and fusion when decision conflicts arise, significantly enhancing system robustness and decision reliability in uncertain environments [7]. Previous research has established that hybrid quantum-classical methods are effective for solving combinatorial optimization problems.

This thesis adopts a hybrid quantum-classical approach for scheduling optimization, where a quantum annealing algorithm solves resource allocation problems on a D-Wave quantum annealer, with classical algorithms used for comparative validation [16, 17]. This hybrid approach demonstrates the synergy between quantum computational advantages and classical algorithm flexibility, establishing a foundation for the aforementioned dynamic arbitration mechanism [16].

4.2.3 Detection Layer Integration

At the detection layer, system perception capabilities in adverse environments are enhanced through a dual-sensor fusion and redundancy mechanism integrating quantum radar with classical optical sensors. Quantum radar delivers high-sensitivity target detection, particularly excelling in low-visibility conditions [4], while industrial cameras provide high-resolution image detail. In case of anomalous data from one sensor, the system automatically switches to redundant sensor and initiates data recovery processes.

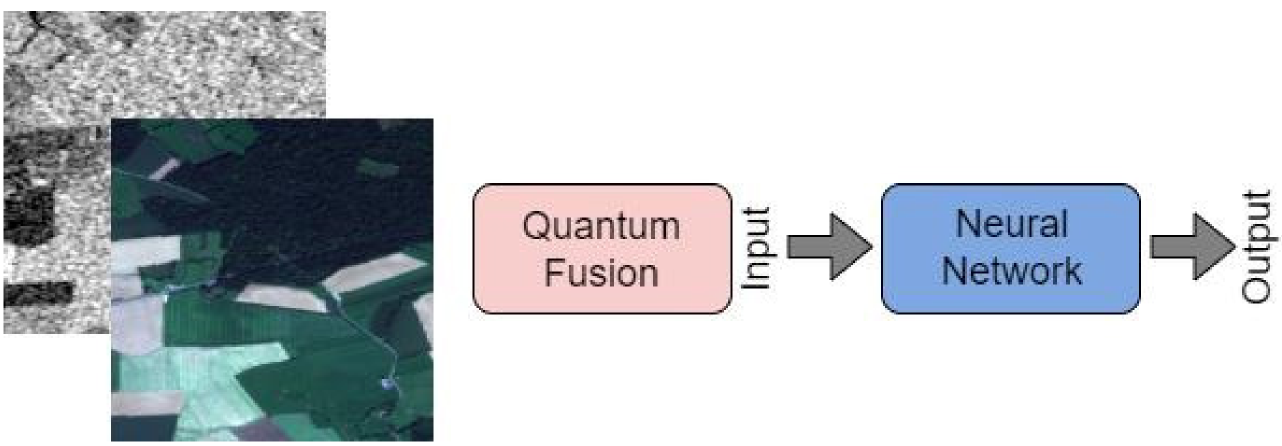

Fig. 3 Implementation of model with Quantum Fusion [9]

Figure 3 visually demonstrates the implementation architecture of the quantum fusion method, showcasing the complete workflow from quantum-processed SAR data to final classification output [9].

Subsequently, algorithms such as Bayesian filtering are used to fuse multi-source information, significantly reducing false alarm and missed detection rates and improving overall system reliability. Research indicates that radar change detection methods based on quantum state modeling can improve accuracy by 30%-40% in complex scenarios compared to conventional coherent change detection techniques. Furthermore, this method maintains detection probability exceeding 95% in weak-signal environments (SNR of 10dB), significantly outperforming the 65% probability of traditional methods [18]. Finally, multi-source information fusion enabled by quantum entanglement reduces false positive rates in target identification by approximately 60%, considerably increasing detection reliability in complex environments.

4.3 Performance Evaluation Framework

To objectively assess quantum-classical hybrid architectures, it is necessary to establish a multidimensional, quantifiable performance evaluation system [11]. The system should encompass aspects such as communication security level, control real-time performance, detection reliability, and system robustness. Specifically, communication security can be evaluated through metrics such as key distribution success rate, bit error rate, and secure capacity. Controlling real-time performance requires attention to the end-to-end latency from perception to execution and the execution precision. Detection reliability primarily encompasses false alarm rate and false negative rate, serving to evaluate the accuracy of the perception subsystem in complex environments [4]. System robustness measures a system's ability to maintain performance under abnormal conditions such as channel disturbances, equipment failures, or resource fluctuations. Establishing unified evaluation standards is crucial for advancing technology from the laboratory to engineering applications.

5. Challenges and Future Outlook

5.1 Technical and Engineering Challenges

Integrating quantum technology into UAV platforms presents serious, multifaceted technical challenges that can't be ignored [1]. Let me outline the most pressing issues:

The primary challenge lies in the fragility of quantum states, which are highly susceptible to environmental disturbances. Vibrations, temperature fluctuations, and electromagnetic noise encountered during UAV flight can all induce quantum decoherence, severely compromising the performance of quantum computing, sensing, and communication systems [10, 12].

Secondly, dynamic operational environments impose higher demands on system adaptability. Changes in UAV attitude, atmospheric turbulence, and complex background noise can interfere with optical alignment, increase QKD error rates, and degrade imaging quality [13, 19].

Third major hurdle: quantum devices are generally bulky, power-hungry, and expensive. This creates significant conflicts with UAV payload constraints [20]. Let's be realistic—UAVs have strict weight and power limitations, and current quantum systems often exceed these significantly. Miniaturization and integration represent genuine engineering bottlenecks that researchers need to overcome.

On the algorithmic front, quantum-classical fusion lacks a unified framework. Under resource constraints, error-correcting mechanisms and hybrid collaborative algorithm design remain largely exploratory, with inadequate task decomposition and interface standards [6]. Many researchers are working on these problems independently, but without coordination, progress remains fragmented.

5.2 Non-Technical Considerations

Beyond technical constraints, practical deployment of quantum drone systems faces numerous non-technical challenges. Currently, cross-disciplinary research lacks unified technical standards and regulatory support, including airspace control regulations, quantum measurement certification, and security assessment procedures [14, 15]. Its potential military applications may also trigger new regulatory and ethical discussions. While quantum sensing's exceptional detection capabilities and QKD's absolute security enhance system performance, they also raise potential privacy protection and data ethics concerns requiring societal and legal consensus [5]. Additionally, the economic viability of this technology requires attention. High R&D and deployment costs, uncertain return cycles, and full lifecycle maintenance expenses are crucial factors affecting large-scale adoption.

5.3 Future Research Directions

Looking forward, quantum drone system development should advance along four primary pathways: hardware, algorithms, applications, and ecosystem. At the hardware level, efforts should focus on developing quantum bit systems robust against decoherence, such as topological qubits and solid-state color center systems. Combining chip-level integration with active intelligent compensation technologies will enhance environmental robustness and integration capabilities. At the algorithm and system level, focus should be placed on constructing novel noise-adaptive quantum-classical hybrid algorithms and developing unified scheduling and management frameworks for heterogeneous computing resources to achieve efficient coordination [7, 8]. For applications, pilot projects are recommended in high-value scenarios where cost sensitivity is relatively low, but demand is urgent, such as military reconnaissance, energy facility monitoring, and disaster relief. These typical applications will drive technological iteration and validation. Finally, proactive cross-disciplinary collaboration should be pursued to establish an innovative ecosystem encompassing technical standards, open-source platforms, and industry alliances, thereby providing sustained support for long-term system development.

6. Conclusion

This study systematically reviews the application prospects, integrated architecture, and core challenges of quantum technologies in overcoming the existing performance bottlenecks of unmanned aerial vehicle (UAV) automatic optical detection systems. Analysis indicates that quantum key distribution, quantum optimization algorithms, and quantum sensing technologies offer highly promising technical pathways for constructing next-generation high-reliability UAV detection systems, addressing communication

ISSN 2959-6157

security, control efficiency, and perception accuracy respectively. However, current research exhibits pronounced fragmentation, with most efforts confined to laboratory validation of individual technologies. Effectively integrating these quantum modules with classical UAV platforms, communication networks, and data processing systems to form an adaptive, highly robust "quantum-classical" collaborative framework is key to achieving their engineering application. This process faces multiple challenges at the underlying hardware level (e.g., environmental decoherence of quantum states, device miniaturization), the intermediate algorithmic level (e.g., unified scheduling of hybrid frameworks), and the upper-level system level (e.g., lack of standards, cost-effectiveness). Future research should focus on enabling cross-layer collaborative design, developing integrated quantum hardware platforms resistant to interference, and establishing unified performance evaluation standards. Prioritizing pilot applications in specific scenarios with high security demands and high-value returns will be a crucial step in advancing this technology from theory to engineering practice. This review outlines a clear development roadmap and research directions for this emerging interdisciplinary field, aiming to provide a solid theoretical foundation and planning guidance for subsequent studies.

Authors Contribution
All the authors contributed equally and their names were listed in alphabetical order.

References

[1] Xia Tao, Wang Menglin, He Jun, et al. Research on drone network security issues under quantum attack threats. 2024 4th International Conference on Communication Technology and Information Technology (ICCTIT), IEEE, 2024, 230-234.

[2] Amodu O A, Jarray C, Raja Mahmood R A, et al. Deep reinforcement learning for AoI minimization in UAV-aided data collection for WSN and IoT applications: a survey. IEEE Access, 2024, 12: 108000-108040.

[3] Abulkasim H, Goncalves B, Mashatan A, et al. Authenticated secure quantum-based communication scheme in Internet-of-Drones deployment. IEEE Access, 2022, 10: 94963-94972.

[4] Djordjevic I B. Entanglement assisted MIMO quantum radars. International Conference on Transparent Optical Networks (ICTON), 2023, 1-4.

[5] Miller A. Micius, the world's first quantum communication satellite, was hackable. International Conference on Quantum Communication, Networking and Computing, 2025, 411-415.

[6] Shaydulin R, Li C, Chakrabarti S, et al. Evidence of scaling advantage for the quantum approximate optimization algorithm on a classically intractable problem. Science Advances, 2024, 10(22): eadm6761.

[7] Intoccia G, Chirico U, Schiano di Cola V, et al. Quantum adaptive search: a hybrid quantum-classical algorithm for global optimization of multivariate functions. Frontiers in Applied Mathematics and Statistics, 2025, 11: 1662682.

[8] Goyal R, Kumar K, Sharma V, et al. Quantum-inspired optimization algorithms for scalable machine learning in edge computing. International Conference on Technological Advancements in Computational Sciences, 2024, 1888-1892.

[9] Miller L, Uehara G, Spanias A. Quantum image fusion methods for remote sensing. IEEE Aerospace Conference, 2024, 1-9.

[10] Hu Haoran, Lun Huazhi, Wang Ya, et al. Entanglement routing with guaranteed fidelity for drone-based quantum networks. Journal of Communications and Networks, 2025, 27(4): 241-251.

[11] Davinder N K, Singh P S J, Kavitha V R, et al. Investigating hybrid algorithms for quantum computing in machine learning: improving data processing speed and handling complex problems. International Conference on Networks and Cryptology (NETCRYPT), 2025, 1438-1443.

[12] Xu Qi, Yu Chao, Cui Dajian, et al. Compact and fully functional high-frequency sine wave gating InGaAs/InP single-photon detector module. IEEE Journal of Selected Topics in Quantum Electronics, 2025, 31(5): 1-7.

[13] Dos R F, Van V, Van D H, et al. Co-propagation of classical and continuous-variable QKD signals over a turbulent optical channel with a real-time QKD receiver. Optical Fiber Communication Conference, 2024, Th1C-5.

[14] Chiti F, Picchi R, Pierucci L. Metropolitan quantum-drone networking and computing: a software-defined perspective. IEEE Access, 2022, 10: 126062-126073.

[15] Chen C. Research on switching nodes of multi-layer optical networks based on quantum-classical fusion. International Conference on Electronic Engineering and Informatization, 2024, 1723-1727.

[16] Vista F, Iacovelli G, Grieco L A. Hybrid quantum-classical scheduling optimization in UAV-enabled IoT networks. Quantum Information Processing, 2023, 22(1): 47.

[17] Hua R, Di L D, Chinesta F, et al. Quantum annealing solutions for drone route planning problems. IEEE International Conference on Quantum Computing and Engineering (QCE), 2024, 1: 600-610.

[18] Sabry R. A quantum-state-based change formalism for radar sensing and potential applications for dual and compact polarimetric SAR. IEEE Transactions on Geoscience and Remote Sensing, 2022, 60: 1-9.

[19] Tian Xiaohui, Yang Ran, Liu Huaying, et al. Experimental Demonstration of Drone-Based Quantum Key Distribution. Physical Review Letters, 2024, 133(20): 200801.

[20] Tu Chengxiang, Shen Jiayi, Dai Jiansheng, et al. A lower size, weight acquisition and tracking system for airborne quantum communication. IEEE Photonics Journal, 2022, 14(6): 1-8.