drones

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Editorial

UAV IoT Sensing and Networking

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1. Introduction

Research on unmanned aerial vehicles, also known as drones or by the acronym UAVs, has been increasing in recent years. These devices have specific characteristics that make them useful for working in a multi-task manner [1,2] and for a multitude of applications, meaning they can be employed in agriculture [3,4], in the fallout of emergency and disaster events [5,6], in addressing coverage issues [7], in healthcare [8], in human and environmental monitoring [9,10], in internet of things (IoT)-aided surveillance [11], in UAV-supported vehicular ad hoc network (VANET) applications [12], and in many other fields [13,14]. Using UAVs in conjunction with IoT devices [15,16] is fundamental in helping different human activities and facilitating various value-added services. However, the joint application of these devices opens up to many integration issues, prompting researchers to study and propose new and specific solutions at various protocol stack levels.

In addition, of particular interest is the use of new paradigms, such as software-defined networking (SDN) [17], in UAV networks to unveil new aspects of research concerning the advantages of virtualization and artificial intelligence (AI) techniques [18].

Hence, this Special Issue focuses on applications, platforms, and services where UAVs can play an important role in stimulating the continuous efforts being made to study and analyze the intrinsic issues of FANET environments.

2. The Present Special Issue

This Special Issue features seven papers, six of which are articles presenting novel research and approaches to resolve issues in UAV environments, while the remaining one is a review that discusses the design aspects of UAVs and IOT devices and opportunities for age-aware UAV-aided data collection for sensor networks and internet of things applications. Each of these seven papers is concisely summarized below.

In the first contribution, Dawei Wang et al. present an AoI-inspired strategy for ensuring secure transmission from a maritime wireless sensor network to an onshore base station using a UAV and reconfigurable intelligent surface (RIS), addressing eavesdroppers near the base station (BS). The scheme divides transmission into data collection and upload periods, optimizing AoI with two scheduling schemes and heuristic algorithms, particle swarm optimization algorithm (PSO) and genetic algorithm (GA). An iterative optimization algorithm enhances RIS reflection during the upload period. Simulation results show that the scheme reduces average AoI by about 10 s compared to current methods.

In the second contribution, Huan Lai et al. discuss the use of UAVs and the security challenges inherent in wireless communications due to eavesdropping and interference. To address such challenges, combining full-duplex (FD) UAVs with reconfigurable intelligent surfaces (RISs) can enhance security by improving spectral efficiency and signal reflection. This paper explores secure communication in urban areas using an FD UAV and RIS. The UAV receives sensitive information and sends jamming signals to eavesdroppers. The

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authors propose an approach for optimizing user scheduling, transmission power, UAV jamming power, RIS phase shift, and UAV trajectory to maximize the worst-case secrecy rate. In this study, despite the central problem's non-convexity, they used alternating optimization (AO), slack variable techniques, successive convex approximation (SCA), and semi-definite relaxation (SDR) to develop an effective suboptimal solution. Simulation results show that the algorithm significantly improves the secrecy rate compared to benchmark methods.

In the third contribution, Janiele Custodio and Hernan Abeledo propose a location–allocation model for environmental emergency response using a drone network. In the proposed approach, drones verify emergencies and gather data to aid response efforts. The model, operated by first responders, seeks to minimize costs while meeting operational goals. Through conducting a case study in Ji-Parana in the Brazilian Amazon, the authors used data from a whistleblower app and satellite imagery to test the model's effectiveness under various demand and capacity scenarios. A set of experiments were performed to evaluate the effectiveness and feasibility of the proposed model.

In the fourth contribution, Bongjae Kim et al. propose a dynamic checkpoint interval decision algorithm for drone recovery, enhancing reliability and stability in large-scale monitoring. Drones often face mission interruptions due to network errors, low battery capacities, or physical defects. Checkpointing periodically saves the system's state, enabling mission restoration. The proposed algorithm minimizes energy consumption while increasing checkpoint operations, consuming only 3.51% more energy but performing 25.97% more checkpoints than the Fixed Interval Checkpointing (FIC) scheme. This approach boosts checkpoint availability and quickly resumes missions, improving the overall efficiency of drone-based services.

In the fifth contribution, Fan Li et al. [5] show how with the rise of IoT in remote and complex areas, UAV-based edge computing addresses challenges where base stations are impractical. Their paper proposes a multi-UAV-assisted MEC system to optimize energy consumption and resource allocation. A joint deployment and task scheduling algorithm is developed, showing improved energy efficiency and task handling compared to benchmark algorithms.

In the sixth contribution, Oluwatosin Ahmed Amodu et al. discuss the use of UAVs to assist in data transmission from sensor nodes (SNs) in WSNs or IoT networks to base stations (BSs) in order to overcome the limitations of sensor devices. UAVs are effective in time-sensitive applications like disaster response tasks but face challenges in timely data delivery due to flight control and scheduling issues. The Age of Information (AoI) metric, measuring data freshness, has driven research in optimizing UAV-assisted data gathering. This paper reviews the literature on AoI minimization, identifying key design aspects such as energy management, flight trajectory, and UAV/SN scheduling. It also explores related issues and future considerations, like traffic prioritization and system optimization.

Finally, in the seventh and last contribution, Salih Safa Bacanli et al. analyze the role of UAVs in opportunistic wireless networks, especially in areas without infrastructure or with overloaded networks. However, their short battery life and need for frequent charging limit their utility. This paper addresses optimal charging station placement in UAV-aided networks using K-means, DBSCAN, and random clustering. These approaches were tested with routing protocols, namely Epidemic, Spray and Wait, and State-Based Campus Routing (SCR). Simulations showed that K-means clustering with three clusters results in a reduction in message delay and higher success rates compared to random or DBSCAN placement, regardless of the routing strategy adopted.

3. Future Perspectives

In the coming years, UAVs are expected to continue to attract attention among researchers and be applied in an expanding array of tasks across various sectors. This introduces numerous challenges in terms of system design and navigation, necessitating extensive integration efforts, diverse test environments, deployment findings, and innovative

protocols. To support these systems, communications are crucial, with software-defined radio/networks, virtualized networks, heterogeneous networks, and channel modeling emerging as pivotal elements. This is particularly pertinent given the rise of bandwidth-intensive applications like real-time video streaming for monitoring purposes. Additionally, addressing issues related to UAV security remains paramount, especially in tasks related to aerial surveillance and civil security.

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List of Contributions:

1. Wang, D.; Yuan, L.; Pang, L.; Xu, Q.; He, Y. Age of Information-Inspired Data Collection and Secure Upload Assisted by the Unmanned Aerial Vehicle and Reconfigurable Intelligent Surface in Maritime Wireless Sensor Networks. *Drones* **2024**, *8*, 267.
2. Lai, H.; Li, D.; Xu, F.; Wang, X.; Ning, J.; Hu, Y.; Duo, B. Optimization of Full-Duplex UAV Secure Communication with the Aid of RIS. *Drones* **2023**, *7*, 591.
3. Custodio, J.; Abeledo, H. Drone-Based Environmental Emergency Response in the Brazilian Amazon. *Drones* **2023**, *7*, 554.
4. Kim, B.; Han, J.; Jang, J.; Jung, J.; Heo, J.; Min, H.; Rhee, D.S. A Dynamic Checkpoint Interval Decision Algorithm for Live Migration-Based Drone-Recovery System. *Drones* **2023**, *7*, 286.
5. Li, F.; Luo, J.; Qiao, Y.; Li, Y. Joint UAV deployment and task offloading scheme for multi-UAV-assisted edge computing. *Drones* **2023**, *7*, 284.
6. Amodu, O.A.; Nordin, R.; Jarray, C.; Bukar, U.A.; Raja Mahmood, R.A.; Othman, M. A survey on the design aspects and opportunities in age-aware uav-aided data collection for sensor networks and internet of things applications. *Drones* **2023**, *7*, 260.
7. Bacanli, S.S.; Elgeldawi, E.; Turgut, B.; Turgut, D. UAV charging station placement in opportunistic networks. *Drones* **2022**, *6*, 293.

References

1. Palmieri, N.; Yang, X.S.; De Rango, F.; Santamaria, A.F. Self-adaptive decision-making mechanisms to balance the execution of multiple tasks for a multi-robots team. *Neurocomputing* **2018**, *306*, 17–36. [CrossRef]
2. Akter, R.; Doan, V.S.; Zainudin, A.; Kim, D.S. An explainable multi-task learning approach for rf-based uav surveillance systems. In Proceedings of the 2022 Thirteenth International Conference on Ubiquitous and Future Networks (ICUFN), Barcelona, Spain, 5–8 July 2022; IEEE: New York, NY, USA, 2022; pp. 145–149.
3. Naseer, A.; Shmoon, M.; Shakeel, T.; Ur Rehman, S.; Ahmad, A.; Gruhn, V. A Systematic Literature Review of the IoT in Agriculture-Global Adoption, Innovations, Security Privacy Challenges. *IEEE Access* **2024**, *12*, 60986–61021. [CrossRef]
4. De Rango, F.; Potrino, G.; Tropea, M.; Santamaria, A.F.; Fazio, P. Scalable and ligthway bio-inspired coordination protocol for FANET in precision agriculture applications. *Comput. Electr. Eng.* **2019**, *74*, 305–318. [CrossRef]
5. Ray, P.P.; Mukherjee, M.; Shu, L. Internet of things for disaster management: State-of-the-art and prospects. *IEEE Access* **2017**, *5*, 18818–18835. [CrossRef]
6. Nikhil, N.; Shreyas, S.M.; Vyshnavi, G.; Yadav, S. Unmanned aerial vehicles (UAV) in disaster management applications. In Proceedings of the 2020 Third International Conference on Smart Systems and Inventive Technology (ICSSIT), Tirunelveli, India, 20–22 August 2020; IEEE: New York, NY, USA, 2020; pp. 140–148.
7. Li, T.; Ota, K.; Wang, T.; Li, X.; Cai, Z.; Liu, A. Optimizing the coverage via the UAVs with lower costs for information-centric Internet of Things. *IEEE Access* **2019**, *7*, 15292–15309. [CrossRef]
8. Dong, P.; Wang, X.; Wang, S.; Wang, Y.; Ning, Z.; Obaidat, M.S. Internet of UAVs based remote health monitoring: An online eHealth system. *IEEE Wirel. Commun.* **2021**, *28*, 15–21. [CrossRef]
9. Majid, M.I.; Chen, Y.; Mahfooz, O.; Ahmed, W. Uav-based smart environmental monitoring. In *Employing Recent Technologies for Improved Digital Governance*; IGI Global: Hershey, PA, USA, 2020; pp. 317–335.
10. Manfreda, S.; McCabe, M.F.; Miller, P.E.; Lucas, R.; Pajuelo Madrigal, V.; Mallinis, G.; Ben Dor, E.; Helman, D.; Estes, L.; Ciraolo, G.; et al. On the use of unmanned aerial systems for environmental monitoring. *Remote Sens.* **2018**, *10*, 641. [CrossRef]
11. Santamaria, A.F.; Raimondo, P.; Tropea, M.; De Rango, F.; Aiello, C. An IoT surveillance system based on a decentralised architecture. *Sensors* **2019**, *19*, 1469. [CrossRef] [PubMed]
12. Fazio, P.; Sottile, C.; Santamaria, A.F.; Tropea, M. Vehicular networking enhancement and multi-channel routing optimization, based on multi-objective metric and minimum spanning tree. *Adv. Electr. Electron. Eng.* **2013**, *11*, 349–356. [CrossRef]

13. Spina, M.G.; De Rango, F. Lightweight, dynamic and energy efficient security mechanism for constrained IoT devices using coap. In Proceedings of the 2023 IEEE 20th Consumer Communications & Networking Conference (CCNC), Las Vegas, NV, USA, 8–11 January 2023; IEEE: New York, NY, USA, 2023; pp. 1123–1128.
14. De Rango, F.; Stumpo, D. Supporting path planning in LoRa-based UAVs for dynamic coverage for IoT devices. In Proceedings of the 2023 IEEE 20th Consumer Communications & Networking Conference (CCNC), Las Vegas, NV, USA, 8–11 January 2023; IEEE: New York, NY, USA, 2023; pp. 337–340.
15. Wei, Z.; Zhu, M.; Zhang, N.; Wang, L.; Zou, Y.; Meng, Z.; Wu, H.; Feng, Z. UAV-assisted data collection for Internet of Things: A survey. *IEEE Internet Things J.* **2022**, *9*, 15460–15483. [CrossRef]
16. Van Mulders, J.; Boeckx, S.; Cappelle, J.; Van der Perre, L.; De Strycker, L. UAV-based solution for extending the lifetime of IoT devices: Efficiency, design and sustainability. *Front. Commun. Netw.* **2024**, *5*, 1341081. [CrossRef]
17. Xia, W.; Wen, Y.; Foh, C.H.; Niyato, D.; Xie, H. A survey on software-defined networking. *IEEE Commun. Surv. Tutor.* **2014**, *17*, 27–51. [CrossRef]
18. Schwarzmann, S.; Civelek, T.E.; Iera, A.; Corujo, D.; Karetsos, G.T.; Guerzoni, R.; Abboud, O.; Valenzuela, A.M.; Trivisonno, R.; Spina, M.G.; et al. Native Support of AI Applications in 6G Mobile Networks Via an Intelligent User Plane. In Proceedings of the 2024 IEEE Wireless Communications and Networking Conference (WCNC), Dubai, United Arab Emirates, 21–24 April 2024; IEEE: New York, NY, USA, 2024; pp. 1–6.