applied sciences

MDPI

Editorial

Special Issue on Unmanned Aerial Vehicles

Sylvain Bertrand [1,*] and Hyo-Sang Shin [2,*]

[1] Traitement de l'Information et Systèmes, ONERA, Université Paris-Saclay, 91123 Palaiseau, France
[2] Centre for Autonomous and Cyber-Physical Systems, Cranfield University, Cranfield MK43 0AL, UK
* Correspondence: sylvain.bertrand@onera.fr (S.B.); h.shin@cranfield.ac.uk (H.-S.S.)

1. Introduction

Unmanned Aerial Vehicles (UAVs) are recognized as very useful tools to replace, help, or assist humans in various missions, such as inspection and monitoring, surveillance, search and rescue, exploration, logistics and transportation, etc. Practical uses for such missions in both civilian and defense contexts have experienced a significant growth thanks to recent technological progresses. Nevertheless, some challenges and open issues remain to ensure a full operational use of UAVs.

This Special Issue aims to present recent advances in technologies and algorithms to improve the levels of autonomy, reliability, and safety of UAVs. Different topics are addressed in this Special Issue, covering vehicle design and characterization (aerodynamics, flight dynamics, design optimization, communications), algorithms for autonomy (guidance and control, path planning, machine learning, computer vision, perception), traffic and risk management (Unmanned Traffic Management, reliability, risk assessment). Open issues related to new missions such as precision agriculture or telecommunication relays are also considered.

A total of twenty papers (nineteen research papers and one review paper) are presented in this Special Issue.

2. Vehicle Design and Characterization

Fight mechanics and aerodynamics studies can be done to derive accurate dynamical models of UAVs. When dealing with specific configurations of UAVs, these model can be useful for performance evaluation and vehicle design, control algorithm synthesis, etc.

In [1], aerodynamic characterization of a coaxial tri-rotor Micro Air vehicle (MAV) is performed, with particular attention to the influence of wind effect. Another type of MAV configuration, namely a strake-wing MAV, is considered in [2], where bifurcation theory is applied to study the open loop flight dynamics of the vehicle.

Actuators design and characterization also plays an important role in performance analysis and design of the vehicle and control algorithms. Regarding characterization of propellers (efficiency, thrust coefficient), an approach is proposed in [3] to validate a wind tunnel propeller dynamometer. The choice of the number and types of actuators, and how they are used in the vehicle design may improve its robustness wrt to faults. In [4], an optimization framework is presented to design a novel actuator fault-tolerant multrirotor MAV.

Optimization of the vehicle configuration can also be considered to account for specific requirements of the mission. Optimized for long hover and long-range missions, a new tandem-wing quadplane UAV configuration is proposed in [5].

3. Algorithms for Autonomy

Navigation, guidance and control of Unmanned Aerial Vehicles rely on different types of algorithms that must realize automatic/autonomous functions of perception, decision making, path planing, motion control, etc.

check for updates

Citation: Bertrand, S.; Shin, H.-S. Special Issue on Unmanned Aerial Vehicles. *Appl. Sci.* **2023**, *13*, 4134. https://doi.org/10.3390/app13074134

Received: 6 March 2023
Accepted: 10 March 2023
Published: 24 March 2023

Copyright: © 2023 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

Machine Learning algorithms are now widely used in perception and computer vision, especially for classification and decision making. In [6], a light-weight deep neural network architecture is proposed for real-time object classification, considering mission specific input data augmentation techniques. In [7], a classifier is designed for aerial images via deep transfer learning for UAV networks.

Reinforcement learning algorithms are proposed in [8] for solving the position control problem of a quadrotor. In case of wind, a robust controller is developed in [9] through Reinforcement Learning and disturbance compensation.

In the case of multiple vehicles, distributed cooperative control laws are proposed in [10] for the problem of interception of static and maneuvering targets by several UAVs. In [11], a distributed formation controller is presented using specific index patterns and chain rules of visual references among the vehicles of the fleet, resulting in a good robustness wrt losses of vehicle(s).

When moving in cluttered environments, collision-free reference trajectories are to be sought, to be followed by the vehicles. As path planing can be computationally demanding, a new light-weight planner is developed in [12] based on relative position of detected obstacles that can be used in real-time in a perception and control loop. Another approach is proposed in [13] that exploits obstacle geometry information to give priority to search in sub-spaces where a solution can be found quickly.

4. Traffic and Risk Management

When operating in real world environments, reliability and safety requirements have to be satisfied for the UAV and the operation to ensure mitigation of risks wrt third parties: other manned or unmanned platforms in the airspace, people at ground, etc.

The work in [14] proposes a method to design reliable UAV architectures accounting for modeling of emergency situations such as collision risk avoidance behaviors.

Regarding Unmanned aerial system Traffic Management (UTM), an open source software architecture is presented in [15] to track aerial operations an monitor the airspace during in real time. Furthermore, the system is capable of in-flight emergency management and tactical deconfliction. For low-altitude UTM, a 3D flight volumization algorithm along with path planning solutions is presented in [16] for definition and management of geofenced airspaces that would contain compatible UAV trajectories and ensure avoidance of no-fly zones.

To deal with risk wrt third parties at ground, a method based on Importance Sampling is proposed in [17] to generate reliable ground impact footprints that contains a high percentile of the drone impact points.

5. New Missions for UAVs

Unmanned Aerial Vehicles offer new capabilities that can be employed for innovative usages. Acting as communication relays is one type of new missions that can be envisaged for UAVs. Classification of routing protocols for Flying Ad-Hoc networks is proposed in [18], along with a comparison of several protocols for WiFi technology. Regarding UAVs as relays to be integrated in the future 6G cellular network, the work in [19] proposes a method to detect the directions of arrival of each UAV relay in a network supporting an uplink non-orthogonal multiple access cellular system.

Precision agriculture is another type of mission for which UAVs are at the center of the attention. In this context, aerial electrostatic spray is a technology of interest for reducing environmental pollution from application of pesticides. A review on the development of such a technology in China is presented in [20].

Acknowledgments: We would like to thank all the authors for their valuable contributions to this Special Issue 'Unmanned Aerial Vehicles' as well as peer reviewers for their hard work and valuable comments to the authors. Thanks to the dedicated editorial team of *Applied Sciences*, all the staff and people involved in this Special Issue.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Lei, Y.; Ye, Y.; Chen, Z. Horizontal Wind Effect on the Aerodynamic Performance of Coaxial Tri-Rotor MAV. *Appl. Sci.* **2020**, *10*, 8612. [CrossRef]
2. Nowakowski, M.; Sibilski, K.; Sibilska-Mroziewicz, A.; Żyluk, A. Bifurcation Flight Dynamic Analysis of a Strake-Wing Micro Aerial Vehicle. *Appl. Sci.* **2021**, *11*, 1524. [CrossRef]
3. Jdiobe, M.; Rouser, K.; Paul, R.; Rouser, A. Validation of a Wind Tunnel Propeller Dynamometer for Group 2 Unmanned Aircraft. *Appl. Sci.* **2022**, *12*, 8908. [CrossRef]
4. Debele, Y.; Shi, H.; Wondosen, A.; Kim, J.; Kang, B. Multirotor Unmanned Aerial Vehicle Configuration Optimization Approach for Development of Actuator Fault-Tolerant Structure. *Appl. Sci.* **2022**, *12*, 6781. [CrossRef]
5. Okulski, M.; Ławryńczuk, M. A Small UAV Optimized for Efficient Long-Range and VTOL Missions: An Experimental Tandem-Wing Quadplane Drone. *Appl. Sci.* **2022**, *12*, 7059. [CrossRef]
6. Endale, B.; Tullu, A.; Shi, H.; Kang, B. Robust Approach to Supervised Deep Neural Network Training for Real-Time Object Classification in Cluttered Indoor Environment. *Appl. Sci.* **2021**, *11*, 7148. [CrossRef]
7. Alotaibi, S.S.; Abdullah Mengash, H.; Negm, N.; Marzouk, R.; Hilal, A.; Shamseldin, M.; Motwakel, A.; Yaseen, I.; Rizwanullah, M.; Zamani, A. Swarm Intelligence with Deep Transfer Learning Driven Aerial Image Classification Model on UAV Networks. *Appl. Sci.* **2022**, *12*, 6488. [CrossRef]
8. Jembre, Y.; Nugroho, Y.; Khan, M.; Attique, M.; Paul, R.; Shah, S.; Kim, B. Evaluation of Reinforcement and Deep Learning Algorithms in Controlling Unmanned Aerial Vehicles. *Appl. Sci.* **2021**, *11*, 7240. [CrossRef]
9. Pi, C.; Ye, W.; Cheng, S. Robust Quadrotor Control through Reinforcement Learning with Disturbance Compensation. *Appl. Sci.* **2021**, *11*, 3257. [CrossRef]
10. Jiang, Z.; Ge, J.; Xu, Q.; Yang, T. Terminal Distributed Cooperative Guidance Law for Multiple UAVs Based on Consistency Theory. *Appl. Sci.* **2021**, *11*, 8326. [CrossRef]
11. Qiao, R.; Xu, G.; Cheng, Y.; Ye, Z.; Huang, J. Simulation and Analysis of Grid Formation Method for UAV Clusters Based on the 3×3 Magic Square and the Chain Rules of Visual Reference. *Appl. Sci.* **2021**, *11*, 11560. [CrossRef]
12. Tullu, A.; Endale, B.; Wondosen, A.; Hwang, H. Machine Learning Approach to Real-Time 3D Path Planning for Autonomous Navigation of Unmanned Aerial Vehicle. *Appl. Sci.* **2021**, *11*, 4706. [CrossRef]
13. Majeed, A.; Hwang, S. Path Planning Method for UAVs Based on Constrained Polygonal Space and an Extremely Sparse Waypoint Graph. *Appl. Sci.* **2021**, *11*, 5340. [CrossRef]
14. Gromada, K.; Stecz, W. Designing a Reliable UAV Architecture Operating in a Real Environment. *Appl. Sci.* **2022**, *12*, 294. [CrossRef]
15. Capitán, C.; Pérez-León, H.; Capitán, J.; Castaño, Á.; Ollero, A. Unmanned Aerial Traffic Management System Architecture for U-Space In-Flight Services. *Appl. Sci.* **2021**, *11*, 3995. [CrossRef]
16. Kim, J.; Atkins, E. Airspace Geofencing and Flight Planning for Low-Altitude, Urban, Small Unmanned Aircraft Systems. *Appl. Sci.* **2022**, *12*, 576. [CrossRef]
17. Morio, J.; Levasseur, B.; Bertrand, S. Drone Ground Impact Footprints with Importance Sampling: Estimation and Sensitivity Analysis. *Appl. Sci.* **2021**, *11*, 3871. [CrossRef]
18. Guillen-Perez, A.; Montoya, A.; Sanchez-Aarnoutse, J.; Cano, M. A Comparative Performance Evaluation of Routing Protocols for Flying Ad-Hoc Networks in Real Conditions. *Appl. Sci.* **2021**, *11*, 4363. [CrossRef]
19. Pierucci, L. Hybrid Direction of Arrival Precoding for Multiple Unmanned Aerial Vehicles Aided Non-Orthogonal Multiple Access in 6G Networks. *Appl. Sci.* **2022**, *12*, 895. [CrossRef]
20. Zhang, Y.; Huang, X.; Lan, Y.; Wang, L.; Lu, X.; Yan, K.; Deng, J.; Zeng, W. Development and Prospect of UAV-Based Aerial Electrostatic Spray Technology in China. *Appl. Sci.* **2021**, *11*, 4071. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.