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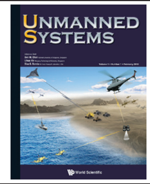

Editorial: Special Issue on Advanced Air Mobility: Enabling Technologies and Applications

In recent years, a trend has been witnessed that unmanned aerial vehicles (UAVs) will become an integral part of future smart cities. To ensure the safety of airspace and ground properties, advanced air mobility (AAM) envisions a transformative aviation transportation system that can safely and efficiently integrate UAVs into the airspace. However, enabling such a system requires addressing many new challenges. For example, small UAVs are usually constrained in their sensing, control, communication, computing, and energy capabilities, making them sensitive to environmental disturbances, prone to attacks, and harder to stabilize. Moreover, UAVs operate in a highly uncertain three-dimensional (3D) space with the presence of various uncertainties such as winds, birds and other vehicles. This special issue aims to report recent research works that develop innovative technologies and solutions to address these challenges, enabling safe and efficient AAM. After peer review, eight high-quality research papers have been collected in this special issue and are summarized as follows.

Path planning is an essential facet of UAV operations, directly tied to the safety of the UAV and the airspace. The work by Li *et al.* [1] studies the path planning problem and presents a significant enhancement of the popular Rapidly-exploring Random Tree (RRT) algorithm by introducing a Deep Q-Network to guide node exploration. The innovative exploration mechanism leverages environmental feedback, formulated within a Markov Decision Process framework, to direct the growth of the RRT. This integration enables the algorithm to make more informed node expansion decisions, thereby increasing efficiency in terms of convergence speed, reducing search redundancy, and enhancing overall path quality. Simulations validate the approach's superiority over standard RRT in terms of rapid convergence and reliable obstacle avoidance, proving its potential in yielding significantly fewer collisions with obstacles.

By considering the dynamic constraints imposed on UAVs, guaranteeing the flyability of the planned path is also crucial. The work by Li *et al.* [2] on UAV 3D trajectory planning tackles the challenge of efficiently generating a collision-free and maneuverable trajectory for UAV navigating in a 3D space. Their method begins by reducing the 3D planning problem to two-dimensional by extracting a flight surface. By using the A* algorithm based on free space method, they acquire a collision-free trajectory, which is then optimized to comply with UAV flight constraints such as climb rate, normal overload, and minimum turning radius. Simulations demonstrate that this method outperforms the traditional A* algorithm in both the efficiency and quality of the resulting trajectory, while meeting flight constraints without significantly increasing computational complexity.

Contrary to aforementioned location-based control methods that generate waypoints for UAVs, the research by Sabzekar *et al.* [3] delves into acceleration-based control for UAV navigation in 3D spaces. Their novel approach utilizes continuous acceleration control, facilitating nuanced UAV velocity and altitude adjustments. Importantly, the inclusion of air resistance — a factor often overlooked — adds a layer of realism to their UAV modeling. The Deep Deterministic Policy Gradient algorithm is employed for training, equipping UAVs with target tracking and obstacle avoidance abilities. Additionally, they introduce an innovative inner product-based reward function to enhance policy performance. Experimental results demonstrate the superior performance of the trained UAV in tracking the target and avoiding obstacles, even within congested environments.

The work by Deniz *et al.* [4] introduces a novel game-theoretic approach for UAVs to navigate safely in 3D airspaces. Compared with the path planning methods, game-theoretic methods provide a systematic framework to capture multi-agent interactions. In this work, the authors formulate the collision avoidance problem into a repeated normal-form game and integrate rule-based cognitive information to determine the optimal decisions efficiently. By designing payoff functions that consider both safety and efficiency for actions taken, and employing Nash

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equilibrium for optimal decision-making, the paper offers an innovative approach to UAV traffic management. Simulation studies validate the efficacy of the proposed approach in various multi-UAV scenarios.

Wu *et al.*'s [5] work addresses UAV navigation safety by introducing a new concept called probabilistic geofence. This geofence is defined as a bounded area where the probability of a UAV being located within this area exceeds a predetermined confidence level. Identifying such a geofence facilitates the creation of collision-free paths, assuring that the probability of potential conflicts between UAVs is bounded under data-driven uncertainties. To approximate probabilistic geofences, the authors first employ Kernel Density Estimation (KDE) optimized with Fast Fourier Transform (FFT) to model data-driven uncertainties. After obtaining KDE values, they propose a heuristic algorithm based on the optimization framework of Integer Linear Programming to efficiently approximate the geofence with a parallelogram box. The numerical results validate the algorithms' effectiveness and efficiency, potentially enhancing real-time operational safety in AAM.

When multiple UAVs cooperate to accomplish various tasks, effective task assignment becomes crucial for ensuring efficient resource allocation. Lu *et al.*'s [6] work introduces a novel reinforcement learning (RL)-based method for multi-agent pursuit–evade games, distinguishing itself by incorporating practical factors such as UAV heterogeneity, nonlinear UAV dynamics, parameter uncertainties, external disturbances, and the influence of neighboring UAVs. The authors present a mathematical model based on local position error dynamics to capture the interactions between vehicles. Based on this model, they design a position controller to achieve target trajectory tracking and introduce a Min-Max strategy to decouple the interaction effects of neighbors within the model. Subsequently, an RL-based algorithm is presented to deduce the optimal solution for the task assignment problem based on the Hamilton–Jacobi–Bellman equation. The method's effectiveness is demonstrated through simulation results, showcasing its potential to enhance cooperative multi-task assignment in complex multi-agent system scenarios.

Reliable wireless connectivity with ground control systems is also essential for the safe operation of UAVs. In situations where line-of-sight communication is obstructed, cellular networks are a viable option for enabling beyond visual line-of-sight communications. Kamal *et al.*'s [7] research delves into this subject by analyzing the throughput performance of UAVs in a sub-urban setting through actual received signal strength measurements. The findings reveal that while cellular networks can feasibly support UAV communication at altitudes below 40 m, the presence of UAVs at higher altitudes can degrade overall network throughput. Importantly, the study distinguishes between the throughput performances of aerial and terrestrial users, contributing novel insights that could aid network planners and UAV operators in optimizing communication strategies.

Small UAVs traditionally faced constraints in onboard computing capacity due to size and payload limitations, depending on ground systems for complex tasks. With technological advancements, powerful single-board computers can now be integrated into UAVs, substantially boosting their onboard computing capabilities and enhancing core UAV functions. These capabilities can be expanded further through resource sharing between UAVs. In this context, Zhang *et al.* [8] introduce a realistic ROS-based simulator and a cutting-edge hardware testbed to facilitate research in the emerging field of networked airborne computing (NAC). Their work examines crucial factors influencing NAC performance and uses comprehensive simulations and hardware experiments to uncover system design challenges, providing valuable insights for future enhancements.

In closing, we are hopeful that the research presented in this special issue offers innovative insights into AAM, providing new solutions for path and trajectory planning, collision avoidance, task assignment, as well as UAV communication and NAC. We extend our deepest gratitude to all the authors and reviewers whose dedication and meticulous efforts have significantly contributed to the quality and depth of the content within this special issue. We also wish to express our special appreciation to co-editors-in-chief, Professors Lihua Xie and Ben M. Chen, for their unwavering support throughout this enriching journey.

Special Issue Editors
Junfei Xie
San Diego State University, San Diego, CA 92182, USA
jxie4@sdsu.edu

Yan Wan
University of Texas at Arlington,
Arlington, TX 76019, USA

Hao Liu
Beihang University, Beijing 100191, P. R. China

Publisher's Note

The papers referred to in the editorial have been added as references for reader clarity.

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