UAV Networks and Communications

Edited by Kamesh Namuduri, Serge Chaumette, Jae H. Kim, and James P.G. Sterbenz

The first book to focus on the communications and networking aspects of UAVs, this unique resource provides the fundamental knowledge needed to pursue research in the field. The team of authors covers the foundational concepts of the topic, as well as offering a detailed insight into the state-of-the-art in UAVs and UAV networks, discussing the regulations, policies, and procedures for deployment (including analysis of risks and rewards) along with demonstrations, test-beds, and practical real-world applications in areas such as wildlife detection and emergency communications. This is essential reading for graduate students, researchers, and professionals in communications and networking.

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Dedicated to
Our Teachers

Preface

Aviation authorities around the world have been making progress towards integrating UAVs (unmanned aerial vehicles) into their national airspaces. In parallel, private industry has been developing innovative UAV-based applications, such as drone-based package delivery, medicine delivery, pipeline monitoring systems, and disaster-area aerial surveys. However, before UAVs can become integrated into the civilian airspace and such real-world applications become reality, there are several technical, societal, and regulatory challenges that need to be addressed by the research community. The most important among them is the need for enhanced situational awareness of UAVs in the airspace.

Three different, yet complementary, paradigms emerged to address enhanced situational awareness of UAVs: satellite communications, cellular-communications, and aerial communications and networks. This book focuses on the third strategy, i.e., enhanced situational awareness through self-organized aerial networking of UAVs. It provides the necessary knowledge for students, researchers, and professionals to gain an understanding of the research challenges in UAV networks and communications. Collaborating with several eminent research scholars and subject matter experts, the editors developed nine chapters that take the reader from the foundations to active research topics in this exciting domain.

The first chapter, "Introduction to UAV Systems," introduces the reader to UAV types and missions. It provides the background and context for UAVs and UAV networks with a focus on their civilian applications. It also discusses the state-of-the-art in engineering and technology aspects of UAV networks and the benefits of deploying such networks.

The second chapter, "Air-to-Ground and Air-to-Air Data Link Communication," provides the background on wireless communication used in manned aviation. It discusses the technologies proposed for L-band Digital Aeronautical Communication. It provides the fundamental insights relevant for aerial communication on unmanned and small UAVs, learned from experience with the advanced terrestrial mobile broadband communication extrapolated to the aerial case.

The third chapter, "Aerial Wi-Fi Networks," provides the characteristics of aerial links in three-dimensional space (3D). Aerial networks differ from other wireless networks, such as mobile ad hoc networks or vehicular ad hoc networks. It discusses the communication requirements for aerial network applications in terms of throughput, delay, data

exchange frequency, etc. It defines different levels of autonomy in aerial networks from the perspective of communication needs.

The fourth chapter, "Disruption-Tolerant Airborne Networks and Protocols," presents an architecture and protocol suite suitable for the aeronautical environment: highly dynamic, high-velocity multi-hop networks that require the greatest change to past networking architectures, with comparisons to traditional end-to-end transport and routing protocols.

The fifth chapter, "UAV Systems and Networks: Emulation and Field Demonstration," discusses the design, implementation, and deployment of a UAV network for the purpose of transmitting video surveillance data amongst nodes. It presents a heterogeneous network consisting of multiple stationary and mobile ground-based nodes, as well as multiple autonomous aerial vehicles. It presents a design process to enable emergent system safety through appropriate integration of critical subsystems and collaboration across multiple UAVs.

The sixth chapter, "Integrating UAVs with NAS – Regulatory, Technical, and Research Challenges," provides the background and context for integrating UAVs within a civilian airspace system. This chapter will cover regulatory concerns, social issues, and technical challenges with respect to integration efforts for UAVs.

The seventh chapter, "Safety, Security, and Privacy Aspects in UAV Networks," discusses the challenges in terms of safety, security, and privacy, which are the three dimensions for integrating UAVs in the civilian airspace and for designing real-world applications.

The eighth chapter, "Collaboration Between Autonomous Drones and Swarming," addresses some of the major issues that should be solved if swarms are to be used in the field. It explains why swarming can significantly increase the possibilities of a mission. It then outlines and dives into a number of challenges and research directions that need to be explored further.

The ninth chapter, "Real-World Applications," reviews two of the many applications of UAVs and UAV networks that researchers are currently pursuing: (1) wildlife detection and (2) emergency communications. These examples showcase the unique value and innovation that UAVs can bring to the real-world applications.

The editors sincerely believe that these nine chapters will guide aspiring students, researchers, and professionals to gain a broad understanding of this emerging topic of UAV networks and communications.

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