Guest editorial: Cellular Internet of UAVs for 5G and beyond

1 | INTRODUCTION

Emerging unmanned aerial vehicles (UAVs) are playing an increasingly important role in military, public, and civilian applications. More recently, UAVs have become a topic of central research interest in the wireless communication community. For example, the 3rd Generation Partnership Project (3GPP) standardisation body has recently worked on a study item to facilitate seamless integration of UAVs into future cellular networks, which is called the cellular Internet of UAVs. UAVs can be exploited in different ways to enhance cellular communications. On the one hand, dedicated UAVs can be used as airborne wireless access points or relay nodes to further improve terrestrial communications, which is referred to as UAV-assisted cellular communications. On the other hand, UAVs may be exploited for sensing purposes by leveraging their advantages such as on-demand deployment, larger service coverage compared with the conventional fixed sensor nodes, and flexible spatial network architecture. We refer to this category of UAV applications as cellular-assisted UAV sensing.

Unlike terrestrial cellular networks, UAV communications have many distinctive features such as high dynamic network topologies and weakly connected communication links. Besides, they also suffer from some practical constraints such as battery power, no-fly zones, and sensing requirements. Therefore, it is essential to develop novel communication and signal-processing techniques in support of ultra-reliable and real-time sensing applications.

This special issue aims to create a platform for researchers from both academia and industry to disseminate state-of-the-art results and to advance the integration of UAVs into cellular networks. In total, 12 excellent papers were accepted after a rigorous multi-round review process. These papers can be divided into two topics: UAV-assisted cellular communications and cellular-assisted UAV sensing. In the following, we will introduce these papers and highlight their contributions.

2 | UAV-ASSISTED CELLULAR COMMUNICATIONS

In their survey paper 'A survey on unmanned aerial vehicle relaying networks', Li et al. comprehensively summarise UAV relaying communications, which is an important paradigm of UAV-assisted cellular communications, and introduce its application scenarios. Key challenges are presented and corresponding technologies to address these challenges are discussed. Furthermore, they also show the research opportunities of UAV relaying communications.

Yuan et al., in their paper 'Interference coordination and throughput maximisation in an unmanned aerial vehicle-assisted cellular: User association and three-dimensional trajectory optimisation', consider a UAV as an aerial base station (BS) to serve ground users. To reduce the interference between the UAV and terrestrial BSs, they propose a joint user association and 3D trajectory optimisation method. An improved block successive upper-bound minimisation based penalty algorithm is proposed.

In 'Age-optimal path planning for finite-battery UAV-assisted data dissemination in IoT networks', Changizi and Emadi consider using UAVs to assist wireless sensor networks to deliver information with the aim to explore the freshness of data. An UAV trajectory planning for data dissemination is proposed, taking into account both maximal use of energy and the freshness of data. The effect of limited energy for UAVs is also discussed.

In 'metaheuristic-based optimal 3D positioning of UAVs forming aerial mesh network to provide emergency communication services', Gupta and Varma study the optimal placement of UAVs to facilitate post-disaster emergency communication services. Coverage, quality-of-services, energy consumption, equal load distribution over UAVs, and fault tolerance are all considered for improving network connectivity and lifetime. Two metaheuristic-based hybrid optimisation algorithms are proposed to integrate these objectives together.

Sun et al., in their paper 'An efficient data collection framework in the sky: An affine transformation approach based on Internet of unmanned aerial vehicles', use a UAV as a data collector to collect data from sensors. An efficient data collection framework is proposed and a min-maximum data processing strategy is adopted based on data value to store the collected time-series data. Moreover, an efficient affine transformation method is proposed to improve the efficiency of the system.

3 | CELLULAR-ASSISTED UAV SENSING

In their paper 'Advanced squirrel algorithm-trained neural network for efficient spectrum sensing in cognitive radio-based air traffic control application', Eappen et al. utilise a cognitive radio
manner to establish a connection between the UAV and the ground controller. A neural network trained by Advanced Squirrel Algorithm (ASA) is proposed for efficient spectrum sensing. Simulation-based evaluation shows that the proposed method is capable of efficiently detecting the spectrum holes with high convergence rate.

In 'Blockchain-assisted secure UAV communication in 6G environment: Architecture, opportunities, and challenges', Gupta et al. investigate the security and privacy issues in UAV sensing applications. They propose an Interplanetary File System and blockchain-based secure UAV communication scheme. The proposed scheme ensures data security and privacy, reduces data storage cost, and enhances network performance.

Wu et al., in their paper 'Optimisation of virtual cooperative spectrum sensing for UAV-based interweave cognitive radio system', consider UAVs equipped with spectrum sensing for data transmission. Based on a virtual cooperative spectrum sensing model, the authors propose an energy-efficient virtual cooperative spectrum sensing with the sequential 0/1 fusion rule to reduce the average number of decisions without any loss in the detection performance. Moreover, the optimisation problem of virtual cooperative spectrum sensing for UAV-based interweave cognitive radio systems is formulated and solved.

In 'Cellular UAV-to-device communications: Joint trajectory, speed, and power optimisation', Liu et al. study two communication modes for the UAV sensing applications, that is, UAVs can transmit through the BS or to the corresponding mobile devices directly. The authors propose a joint sensing and transmission protocol to schedule UAV sensing and transmission, and formulate an energy utility maximisation problem. A joint trajectory, speed, and transmit power optimisation algorithm is proposed to obtain a suboptimal solution.

Ren et al., in their paper 'Computation offloading game in multiple unmanned aerial vehicle-enabled mobile edge computing networks', use mobile edge computing to offload the computation tasks for UAVs. To obtain the minimum computing time, the offloading percentage and the transmission power is optimised through a game theory modelling. Numerical results verify that the proposed schemes can effectively decrease the computing time and energy consumption, especially for a large number of UAVs.

In 'An enhanced genetic algorithm for unmanned aerial vehicle logistics scheduling', Yuan et al. examines a scheduling problem in consideration of the loading capacity, the maximum flight time, and the flight speed. A genetic-based algorithm framework is presented for solving the scheduling problem. Moreover, in order to reduce the search space and accelerate the execution of this algorithm, a weight-based loading method is adopted.

Finally, in their paper 'Multi-channel underdetermined blind source separation for recorded audio mixture signals using an unmanned aerial vehicle', Xie et al. apply UAVs for locating sound-emitting targets and study the source separation problem when the number of sources is more than the number of sensors. An underdetermined blind source separation algorithm to separate the multi-channel audio mixture signals recorded by an unmanned aerial vehicle is proposed. As a result, the frequency-domain sources are estimated through Wiener filtering and time-domain sources are obtained via inverse short-time Fourier transform.

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