Digital-intelligent Twin for UAV Swarm based 5G Emergency Networks

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Unmanned aerial vehicle (UAV) based 5G networks have emerged as the promising networking paradigm, which can provide fast access in emergency situations and enhance communication services in high traffic demand. Recently, analyses and experiments on UAV based 5G networks have achieved great development [1]-[3]. [3] shows promising field trial results of the air to ground 5G network with one UAV platform. However, when it comes to UAV swarm 5G networks, the increased network complexity poses a huge challenge in network management, resource allocation, power control, and deployment solutions.

Digital twin (DT) is a virtual digital model of a physical item that truly represents its functionalists, which offers a bridge between the complex physical world and cyber computing space. The DT technology has been used to solve network problems[4-6]. [4] builds a DT of edge computing network to compute the energy consumption, delay, and packet loss probability on user association and resource allocation. [5] analyzes a graph neural network-based DT for network slicing management.

In this paper, a digital-intelligent twin (DIT) for UAV swarm based 5G emergency networks is built, aiming to model the running states of the network and to optimize the problems of resource allocation, power control and swarm deployment under diverse environments. As shown in Fig. 1, the UAV swarm carries 5G base stations, core networks and MIMO antennas, to provide fast and high-speed network access for ground users when an emergency occurs. The proposed DIT reflects the running states $s(t)$ of all network devices, which are used to build physical model of the network. Different from DT, the DIT also takes human factors $v(t)$ into consideration, and reflects behavior model of network users. The DIT further exploits deep learning to compute network optimization problem $o(t)$ expressed as Eq. 1. Theoretical analysis and simulation results show that DIT can enhance communication efficiency with less UAVs compared with an existing method, and can predict better network deployment under unseen environments.

$$o(t) = f[s(t), v(t)]. \tag{1}$$

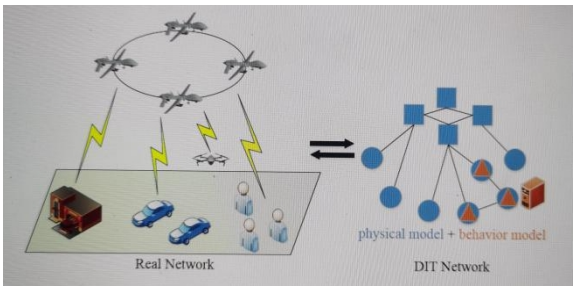

Figure 1. DIT model for UAV Swarm based 5G Emergency Networks .

References

[1] Bin Li, Zesong Fei, and Yan Zhang, "UAV Communications for 5G and Beyond: Recent Advances and Future Trends," IEEE Internet OF Things Journal, **6**, 2, April 2019, pp. 2241-2263.

[2] Yong Zeng, Qinging Wu, and Rui Zhang, "Accessing From the Sky: A Tutorial on UAV Communications for 5G and Beyond," Proceedings of the IEEE, **107**, 12, December 201, pp. 2327-2375.

[3] Yuan Gao, Jiang Cao, Ping Wang, etl., "Intelligent UAV Based Flexible 5G Emergency Networks: Field Trial and System Level Results, ", IEEE Infocom Workshop, 2019, 138-143.

[4] Rui Dong, Changyang She, Wibowo Hardjawana, etl., "Deep Learning for Hybrid 5G Services in Mobile Edge Computing Systems: Learn From a Digital Twin," IEEE Transactions on Wireless Communications,**18**, 10, October 2019, pp. 4692-4707.

[5] Haozhe Wang, Yulei Wu, Geyong Min, and Wang Miao, "A Graph Neural Network-based Digital Twin for Network Slicing Management," accepted by IEEE Transactions on Industrial Informatics, DOI: 10.1109/TII.2020.3047843.

[6] Yunlong Lu, Xiaohong Huang, Ke Zhang, etl., "Communication-efficient Federated Learning and Permissioned Blockchain for Digital Twin Edge Networks, "accepted by IEEE Internet of Things Journal, DOI:10.1109/TII.2020.3047843.