6G Vision in Developing Swarms of Collaborative Robotics

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Abstract

Effective collaborative robotic swarms (e.g. swarms of autonomous aerial/ground vehicles) need ultra-low latency communication to increase the efficacy of collaboration, massive connectivity per km to support a large number of nodes, high bandwidth to exchange large volumes of data/information/knowledge/wisdom/insights, prompt decision making with insights while transferring large volumes of sensor data using AI-instilled networking by prioritising the security, privacy and ethics. By promising these aforementioned abilities, 6G has the potential to completely transform robotics, especially in the area of cooperative swarms. 6G will usher in a new era of intelligent, networked, and self-governing robotic systems by providing previously unheard-of speeds, latency, and connectivity.

6G communication technologies, at the expense of increased complexity, consider not only delivering another 1000x increase in data rates, but also diving into self-sustaining networks and dynamic resource utilisation; 6G will also put an end to smartphone-centric networks, introducing new system paradigms (e.g., human-centric services). 6G, not only promises to connect things with URLLC (1-microsecond latency) leading to no delay in real time, but also promises to connect things intelligently with ultra-high-density connections (i.e., over 100 devices per cubic metre). 6G, by i) offering significantly higher bandwidth and lower latency compared to 5G, ii) integrating sensing and communication, allowing for simultaneous data collection, large volumes of processed data transmission, and continuous and timely bidirectional updates iii) being integrated with AI, enabling real-time data processing and decision-making, iv) improving the efficacy of responsiveness of the individual robots to realise swarm group goals, v) supporting larger numbers of immersive devices, and vi) enabling remote monitoring and control of remote entities with human-in-the-loop (HITL) systems with the development of efficient live digital twins (DT), have the potential to significantly impact the development of collaborative robotics swarms.

This talk, by pointing out the shortcomings of 5G, despite its ultra-reliable low-latency communication (URLLC) abilities, in robotic swarm applications, aims to help visualise how 6G communication technologies, with an ability to exploit geo-distributed intelligence, but, with increased design complexities, would impact the efficacy and design requirements of robotic collaborative swarms.

Index Terms— 6G, 5G, artificial Intelligence, cybernetics, immersive devices. human-in-the-loop (HITL), human–vehicle coactivity, collaborative swarms, robotic swarm applications, autonomous vehicles

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