Connected Swarms: Joint Orchestration of Networking and Control Strategies for Swarm Autonomy

Kamesh Namuduri, Professor, Electrical Engineering, University of North Texas

Swam autonomy is expected to play a significant role in urban warfare. Researchers envision swarms of several tens or even hundreds of autonomous vehicles –Unmanned Aircraft Systems (UAs) and Unmanned Ground Vehicles (UGVs) – to gather information and assist troops in an urban environment where line-of-sight and satellite-based communication might be obstructed by buildings. The information the swarms collect can help keep the troops and civilians in the battle areas safer. Swarm autonomy has many aspects including deployment strategies, intelligence gathering, human-machine interaction, and security.

The central theme of this research presentation is joint orchestration of control and networking strategies for swarm autonomy. This systems view of swarm autonomy enables the development of the theory and algorithms for control of large autonomous teams with varying capability levels of sensing, computing, and autonomy. This presentation first reviews the classical control strategies for formation control such as consensus building, particle swarm optimization, as well as networking strategies such as mesh networking. Then, it presents strategies for jointly addressing networking and control strategies. In order to illustrate the need for jointly addressing networking and control strategies, a swarm of UAs making maneuvers for surveillance and data gathering will be considered. In this problem, the trajectories of UAs need to be chosen such that they form the desired flying patterns as early as possible. Classical strategies address this problem as a consensus building or formation control. In order for the nodes to avoid collisions, the trajectories need to be estimated such that the nodes maintain a minimum distance from one another. At the same time, in order for the UAs to be connected and be able to share information, every node must be within the communication range of at least another node. From a networking perspective, the swarm forms an elastic layer of UAs. The joint problem requires us to develop formation control strategies with collision avoidance as one constraint from control perspective and connectivity as another constraint from networking perspective. The connected swarm problem formulation and solutions will be discussed during the presentation.

Speaker's Bio:

Kamesh Namuduri serves as the director for Autonomous Systems Laboratory at the University of North Texas. He has a long-standing collaboration with the Air Force Research Laboratory. His current research interests include UAV Networks and Communications, Wireless Sensor Networks, and Public Safety Communications Research. Namuduri is a co-editor of the book "UAV Networks and Communications" published by the Cambridge University Press in 2017. He is serving as the Chair for the IEEE 1920.1 Working Group that is currently developing standards for aerial communications and networks. He is also serving as the chair for the ad hoc committee on drone connectivity recently created by the IEEE Vehicular Technology Society. He is an active member of UAS Traffic Management (UTM) working group, National Public Safety Telecommunication Council (NPSTC), and Aircraft Engineering Association Committee (AEEC) among others. He is leading an action cluster for the project "Deployable Communication Systems" in partnership with the government, public and private organizations. This action cluster demonstrated the proof of concept for "Flying Cell Towers" for emergency communications in May 2017 and showcased this project during the Global City Team Challenge exhibition hosted by NIST in August 2017. The details of this demonstration are published in the September 2017 issue of IEEE Spectrum magazine.