Guest Editorial
Introduction to the Special Issue on Multivehicle Systems Cooperative Control With Application

OVER the past few years, there have been significant efforts devoted to the research and the development of cooperative unmanned systems. This Special Issue is a compilation of seven research papers representing the most recent advances in control of unmanned multivehicle systems. These papers focus on solutions to known and emerging problems by means of original control techniques and developments in cooperative control engineering. The papers further illustrate an interesting mix of applications involving ground, air, and underwater vehicles.

Four of the papers address multiple airborne systems. In the paper, "Assigning Micro UAVs to Task Tours in an Urban Terrain," Shima, Rasmussen, and Gross present a cooperative real-time task assignment and path planning for multiple microaerial vehicles (MAV) launched from a small UAV to carry out fly-over task tours. A search algorithm based upon the well-known traveling salesman problem has been developed together with simulations and experimental platforms. The authors suggest that the proposed multi-MAV assignments and path planning techniques require time-constrained computing, provide fault tolerance, and comply with practical operational constraints.

In the paper, "Cooperative Tracking Using Vision Measurements on SeaScan UAVs," Campbell and Whitacre propose a distributed estimation technique for geolocation tracking. A cooperative square root-sigma point information filter (SR-SPIF) enables improved estimation of ground objects despite uncertainties associated with UAV attitude and position, noisy camera measurements, turbulences, and engine vibrations, which are realistic problems. This paper suggests the need for time-stamped data transmissions and cooperative estimation techniques to compensate for communications loss. The authors use single UAV flight test data to perform post-flight evaluation of the cooperative estimation scheme.

In the brief paper, "Cooperative UAV Formation Flying With Obstacle/Collision Avoidance," Wang, Yadav, and Balakrishnan present a strategy for obstacle and collision avoidance in UAV formation flight. The salient features of their approach, a combination of neural networks with model predictive control (MPC) for trajectory generation and tracking, are the reduced online computational effort, superior scalability, and applicability to 2-D and 3-D cases.

The brief paper, "UAV as a Reliable Wingman: A Flight Demonstration," by Waydo, Hauser, Bailey, Klavins, and Murray is an example of a contribution to the realization and operation of cooperative systems. Specifically, the authors present experimental results obtained with manned-unmanned air vehicle formation flight. The unmanned platform employs nonlinear trajectory generator and receding horizon control. The flight demonstration included a realistic failure scenario involving a temporary loss of the high-rate data link. Lessons learned included the importance of controllers complying with performance constraints of a vehicle in closed-loop with the available autopilot, the need for extensive simulations, and highly accurate simulation environments for the choice of receding horizon control parameters and for system identification.

Two papers focus on advanced control techniques applicable to ground, air, and underwater vehicles. In the paper, "Distributed Robust Receding Horizon Control for Multivehicle Guidance," Kuwata, Richards, Schouwenaars, and How propose a robust MPC algorithm for multivehicle trajectory optimization. In order to warrant real-time performance of MPC-based control, a robust and distributed algorithm is developed. The effectiveness of the technique is demonstrated by means of experiments performed on a multirover test bed. The paper, "Effective Coverage Control for Mobile Sensor Networks With Guaranteed Collision Avoidance," by Hussein and Stipanovic develops a coverage control strategy involving networked sensors, with each having limited capacity. Such control strategies offer considerable potential in many applications, such as search-and-rescue, aerial mapping, and underwater sampling missions. Their approach prevents collisions among sensors and ensures coverage of a given domain for both fully and partially connected networks under reasonable assumptions.

The paper, "Coordinated Transport by Multiple Biomimetric Robotic Fish in Underwater Environment," by Zhang, Wang, Yu, and Tan proposes to coordinate a group of robotic fish in an attempt to realize the goal of moving an object from one location to another. Although the topic of underwater biomimetic robotics is not new, the authors demonstrate that the combination of intelligent control with limit cycle control enables the effective transport of a sizeable object despite underwater disturbances and limited sensing capabilities.

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