Cooperative Control of Multiple Heterogeneous Unmanned Vehicles for Coverage and Surveillance

Peng Cheng, Vijay Kumar, Ron Arkin, Marc Steinberg, and Karl Hedrick

There are many technical barriers to the deployment of teams of cooperating heterogeneous unmanned aerial vehicles (UAVs). The assignment of multiple tasks to multiple heterogeneous assets is an unsolved problem and is further complicated by the presence of differential constraints in dynamically changing environments. The command and control of individual UAVs require real-time solutions to motion-planning problems with spatiotemporal differential constraints. The tracking and mapping of geographically distributed, dynamic sources of information requires novel approaches to the solution of cooperative pursuit-evasion problems.

This special issue brings together articles from experts in the field to address the theory and practice underlying the deployment of unmanned vehicles with a focus on algorithmic issues that arise in coverage and surveillance. The first article by Cole et al. and the second article by Tisdale et al. address the cooperative search problems with multiple unmanned vehicles, whereas the third article by How et al. focuses on the tracking of targets while searching an area. Deliberative planning approaches are discussed in two articles: one for decomposing tasks and workspaces (Pavone et al.) and the other for clearing paths (Likhachev and Stentz). The last article by Ding et al. deals with human interaction with multiple UAVs.

Cole et al. present cooperative control algorithms using a realization of the decentralized data-fusion framework. The UAVs share abstract feature-state information obtained via sensing and use this information to plan paths independently but toward a common goal. They show experimental results that demonstrate effective cooperation without centralized decision making.

Tisdale et al. address the real-time path planning problems that arise in cooperative search and localization using multiple UAVs with vision sensors. They incorporate probabilistic approach to represent the uncertainty and a receding horizon control algorithm to plan paths to maximize information gain related to search and localization.

The command and control of individual UAVs require real-time solutions to motion-planning problems with spatiotemporal differential constraints.

How et al. tackle the difficulty problem of simultaneously tracking known targets while continuing to explore the unknown environment. Their approach enables UAVs to periodically switch between the two distinct modes of operation to both reduce the uncertainty in the unexplored portions of the environment and to improve certainty of tracked targets.

Pavone et al. address the difficulty of sharing workload in dynamic environments across many unmanned vehicles. They show how a dynamic workspace can be automatically partitioned to facilitate task allocation and scheduling while establishing some optimality results.

Likachev and Stentz address the so-called path clearance problem in which vehicles must navigate to their goals without being detected by adversarial vehicles, a problem of great relevance to defense and security applications. They establish a probablistic planning approach to obtain paths in partially known environments.

Ding et al. focus on the human interaction, command and control issues with multiple UAVs. They describe two modes of operation, a completely autonomous mode and a pilot-controlled mode, to enable leader–follower formation using a receding horizon approach in a hybrid systems setting.

We hope that you enjoy this special issue dedicated to cooperation between unmanned vehicles. We are grateful to the authors, the anonymous reviewers, and the editor in chief for all the support in making this issue possible.

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