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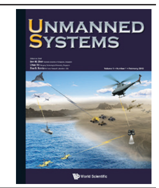

Editorial: Special Issue on New Advances on Formation Control of Autonomous Vehicles

Multi-robot cooperative systems have attracted extensive research attention in recent years due to their great potential in military and civilian applications. As a specific yet important problem in this area, cooperative formation control has been studied from both theoretical and practical perspectives. Formation control is extremely challenging to analyze if practical constraints such as complex agent dynamics, motion constraints, and imperfect measurements are incorporated. The purpose of this special issue is to report the latest high-quality research results on distributed formation or cooperative control. In this special issue, both theoretical and practical research works are presented. We would like to highlight the key contributions of these works as follows.

The work by Xiao *et al.* studies the challenging problem of time-varying formation control of general linear multi-agent systems with switching interaction topologies and time-varying delays. A consensus-based formation control protocol is constructed using local information of the neighboring agents. An algorithm with three steps is presented to design the proposed formation control protocol. Based on linear matrix inequality technique and common Lyapunov–Krasovskii stability theory, sufficient conditions for general linear multi-agent systems with switching topologies and time-varying delays to achieve time-varying formation are given together with a time-varying formation feasibility condition.

The paper by Zhang *et al.* investigates the distributed formation tracking control problem of heterogeneous multi-agent systems where the multiple targets have unknown inputs with finite-dimensional Fourier decompositions and each target's measurement output is only available to partial agents. A distributed observer-based formation tracking control algorithm is proposed. The distributed observers are based on the consensus protocol and designed to estimate the inputs and states of all targets from the available measurement outputs and neighborhood information. The tracking controller is a state feedback based on the estimated state center of the targets. It is proved that the estimation errors of all agents converge to zero, if and only if each target node in the extended topology is reachable from each agent node and the consensus gain is larger than the certain value. It is further proved that under the formation tracking control algorithm, the agents can asymptotically achieve predesigned formation and encircle the targets.

The work by Wang *et al.* studies the formation control problem in multi-quadrotor systems, where each quadrotor has limited access to its neighbors' information due to communication constraints. In this work, the dynamical model of each quadrotor is first linearized using Newton–Euler method. A new distributed formation control law is then designed and its stability is analyzed. An experimental platform is built with three Parrot Bebop drones and an indoor motion capture system. It is worth noting that both numerical and experimental results are provided to verify the effectiveness of the proposed algorithms.

The work by Onuoha *et al.* presents novel affine formation control algorithms and implementations in different scenarios. The agents in affine maneuver control are capable of producing required geometric shapes and can simultaneously accomplish desired maneuvers such as shearing, rotation, translation and scaling. In many practical situations, the inter-agent communication may be limited to periodic intervals of time, and a wide range of systems are governed by complex dynamics described with higher-orders. This paper presents two novel algorithms based on triple-integrator agent dynamics. Four implementation cases comprising of two scenarios each studied in both continuous-time and sampled-data cases are considered. Under the proposed algorithms, the collection of agents are capable of tracking time-varying targets which are affine transforms of the reference formation, if the leaders have the knowledge of the required formation maneuvers.

The work by Hafez and Kamel studies the problems of cooperative task assignment and trajectory planning for

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teams of cooperative unmanned aerial vehicles (UAVs). A novel approach of hierarchical fuzzy logic controller (HFLC) and particle swarm optimization (PSO) is proposed. Initially, teams of UAVs move in a pre-defined formation covering a specified area. When one or more targets are detected, the teams send a package of information to the ground station (GS) including the target's degree of threat, degree of importance, and the separating distance between each team and each detected target. Based on the gathered information, the ground station assigns the teams to the targets. HFLC is implemented in the GS to solve the assignment problem ensuring that each team is assigned to a unique target. Next, each team plans its own path by formulating the path planning problem as an optimization problem. The objective in this case is to minimize the time to reach their destination considering the UAVs dynamic constraints and collision avoidance between teams. A hybrid approach of control parametrization and time discretization (CPTD) and PSO is proposed to solve this optimization problem.

The work by Douthwaite *et al.* presents a critical analysis of some of the most promising approaches to geometric collision avoidance in multi-agent systems, namely, the velocity obstacle (VO), reciprocal velocity obstacle (RVO), hybrid-reciprocal velocity obstacle (HRVO) and optimal reciprocal collision avoidance (ORCA) approaches. Each approach is evaluated with respect to increasing agent populations and variable sensing assumptions. An intensive 1000-cycle Monte Carlo analysis is used to assess the performance of the selected algorithms in the presented conditions. The ORCA method is shown to yield the most scalable computation times and collision avoidance likelihood in the presented cases. The HRVO method is shown to be superior to the other methods in dealing with obstacle trajectory uncertainty for the purposes of collision avoidance.

Lastly, we would like to take this opportunity to thank all the authors who contributed to the special issue and all the reviewers for their time and effort in evaluating these papers.

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