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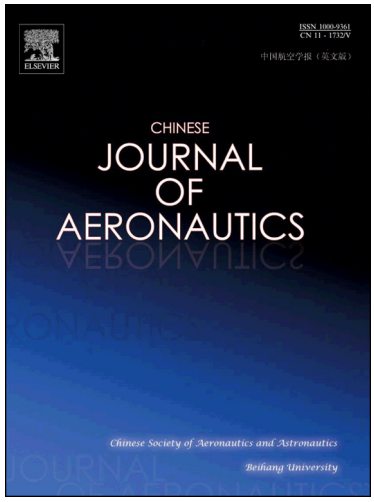

Formation tracking control for time-delayed multi-agent systems with second-order dynamics

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Abstract

In this paper, formation tracking control problems for second-order multi-agent systems (MASs) with time-varying delays are studied, specifically those where the position and velocity of followers are designed to form a time-varying formation while tracking those of the leader. A neighboring relative state information based formation tracking protocol with an unknown gain matrix and time-varying delays is presented. The formation tracking problems are then transformed into asymptotically stable problems. Based on the Lyapunov-Krasovskii functional approach, conditions sufficient for second-order MASs with time-varying delays to realize formation tracking are examined. An approach to obtain the unknown gain matrix is given and, since neighboring relative velocity information is difficult to measure in practical applications, a formation tracking protocol with time-varying delays using only neighboring relative position information is introduced. The proposed results can be used on target enclosing problems for MASs with second-order dynamics and time-varying delays. An application for target enclosing by multiple unmanned aerial vehicles (UAVs) is given to demonstrate the feasibility of theoretical results.

Keywords: Formation tracking control; Time-varying formation; Time-delayed multi-agent systems; Second-order dynamics; Multiple unmanned aerial vehicles

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1. Introduction[1]

In recent years, formation control techniques of multi-agent systems (MASs) have received lots of attention in a variety of research areas such as unmanned aerial vehicle (UAV) formation flying,[1] spacecraft formations,[2] and cooperative localization.[3] Currently, formation control techniques can be classified into different categories, the most representative of which are formation tracking control,[4] formation enclosing control,[5] and formation-containment control.[6]

Consensus-based formation control approaches have been widely used in solving the MASs problems. Ref.[7] introduced leader-follower, virtual structure, and behavior-based formation control methods as typical consensus-based approaches, and a series of distributed consensus-based formation control methods were presented for MASs with second-order dynamics. A finite-time formation control strategy for MASs with first-order dynamics was developed in Ref.[8]. Ref.[9] proposed conditions sufficient for MASs with second-order dynamics to achieve time-varying formations. Conditions necessary for first-order MASs with fixed and undirected topologies to realize a rigid formation were presented in Ref.[10]. A formation control approach that considered heteroge-

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