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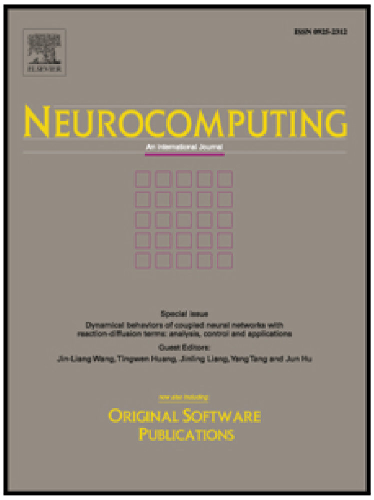

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Distributed proportion-integration-derivation formation control for second-order multi-agent systems with communication time delays

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Abstract

This paper considers the problem of distributed formation control for a second-order multi-agent system with a directed communication topology and constant communication time delays. A distributed proportion-integration-derivation (DPID) formation control law is proposed for the multi-agent system by introducing the integration information of the formation errors. A delay-independent condition and two delay-dependent conditions on the asymptotical formation stability are respectively presented under the assumption of the communication topology containing a directed spanning tree. Based on the Nyquist stability criterion, the range of the feasible time delays for asymptotical formation stability is obtained by analyzing the relationship between the Nyquist curves and the unit circle. Finally, simulations illustrate the effectiveness of the theoretical results.

Keywords: Distributed formation control, Multi-agent system, Communication time delay, Nyquist stability criterion

1. Introduction

Recently, distributed formation control has attracted considerable attention for its potential practical applications in the field of search [1], surveillance [2], and space exploration [3], etc. Consensus plays a pivot role in distributed formation control. The basic idea of consensus is that each agents updates its states by combining the information from its neighbors in order that states of all agents converge to a same value. Many typical formation control approaches such as leader-following, behavioral, and virtual structures can be regarded as special cases of distributed formation control [4].

In last two decades, large amounts of literature on distributed formation control has been published. Distributed formations for first-order integrators [5], second-order integrators [6], general linear systems [7, 8], nonlinear systems [9, 10], and stochastic systems [11, 12] have been closely studied. In [13], distributed formation control laws have been surveyed. In [14], a distributed proportion-derivation (DPD) control law was proposed to achieve time-varying formation for second-order multi-agent systems. In the paper, based on the DPD formation control law, a distributed proportion-integration-derivation (DPID) formation control law is proposed for a second-order multi-agent system by introducing the integration information of the formation errors. Compared with the DPD control law, the DPID control law is able to increase the robustness of the formation to some constant actuator or sensor faults.

In practice, many network-induced phenomena such as pockets lost, missing measurements, and quantisation effects will impact the performance of the networked systems [15, 16]. As one typical case of the network-induced phenomena, communication time delays exist widely in formation systems since information communication between agents is always influenced by environment disturbances, communication congestions, and limited bandwidth. Moreover, communication time delays will inevitably influence the formation

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