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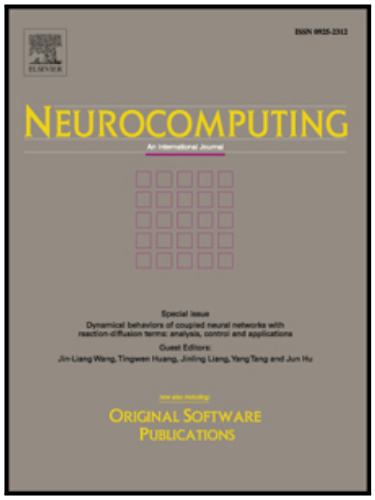

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Distributed consensus of linear MASs with an unknown leader via a predictive extended state observer considering input delay and disturbances

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Abstract

The problem of disturbance rejection/attenuation for constant-input delayed linear multi-agent systems (MASs) with the directed communication topology is tackled in this paper, where a classic model reduction technique is introduced to transform the delayed MAS into the delay-free one. First, when the leader has no control input, a novel adaptive predictive extended state observer (ESO) using only relative state information of neighboring agents is designed to achieve disturbance-rejected consensus tracking. The stabilization analysis is presented via the Lyapunov function and sufficient conditions are derived in terms of linear matrix inequalities. Then the result is extended to disturbance-attenuated case where the leader has bounded control input which is only known by a portion of followers. Finally, two numerical examples are presented to illustrate the effectiveness of proposed strategies. The main contribution focuses on the design of adaptive predictive ESO protocols with the fully distributed property.

Keywords: Input delay, consensus control, multi-agent systems, extended state observer, linear matrix inequality.

1. Introduction

Distributed cooperative control has gained increased research attention due to its widely potential applications such as the unmanned aerial vehicle formation, complex networks synchronization [1], satellite clusters and so on. Among different kinds of cooperative control formats, consensus control, which aims at controlling all agents to achieve the same objective, has been investigated tremendously thanks to the impressive framework-building works [2–4]. After that, many consensus results have been presented from the undirected to directed communication topology concerning different dynamics, for instance, fractional-order [5], first-order [6], double integrator [7, 8], second-order, general linear [9, 10] and nonlinear dynamics. Particularly, Li [11] presented a unified framework by expanding conventional observers to distributed observers, which is a significant breakthrough to solve the consensus problem and synchronization of complex networks. Then, the fully distributed consensus control design, which needs no global information like the minimum eigenvalue of Laplacian matrix of communication topology, was proposed in [12]. It is worth noting that the fully distributed property in the consensus controller is very meaningful as it is nearly impossible for each agent to know the Laplacian matrix for the eigenvalue calculation when the number of agents is very large. Except the work [3] with first-order dynamics and the work [7, 8] with double integrator dynamics, which dealt with time-delay consensus problem , all the works above do not cover the disturbance or time-delay issues.

The external disturbance is widely existed in the industrial control process and thus has been researched for decades. One of the fundamental ideas is to design an observer mechanism to estimate the disturbance, and then incorporate the designed observer into input controller to compensate the effect of disturbance. Readers are recommended to survey papers [13, 14] about ESOs for the disturbance attenuating and rejecting issues. In this paper, we

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