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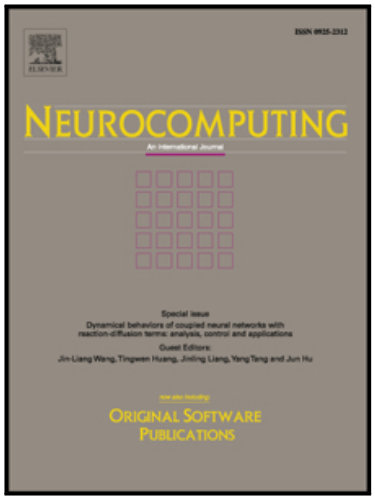

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Consensus of linear multi-agent systems via reduced-order observer

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Abstract

This paper is concerned with the consensus problem for continuous time linear multi-agent systems with directed communication topology. An estimation error dynamic is proposed to design the reduced-order observer for dealing with unknown coefficient matrices. To guarantee the consensus, control protocols based on the reduced-order observer are designed to utilize the relative outputs of neighboring agents whose communication topology contains a directed spanning tree. Then the algorithms are extended to the model reference consensus case, where the case of zero control input for reference node is not assumed. Numerical examples are given to illustrate the effectiveness of proposed approaches.

Keywords:
Multi-agent system; Reduced-order observer; Consensus; Model reference consensus; Directed topology.

1. Introduction

Cooperative control of a group of agents has received considerable attention from various control communities due to their wide applications, such as spacecraft formation flying, sensor networks, and formation control of underwater vehicles and mobile robots[1][2][3]. A critical issue arising from the cooperative control is to design a control protocol to enable the common states of the agents to reach an agreement, which is called the consensus problem. Consensus problems have been widely investigated by the researchers from various aspects see ([4], [5], [7], [8], [9], [11], [17], [18], [21]). In [6], it is shown that if and only if the directed communication topology has a spanning tree, the multi-agent systems can reach the consensus.

The above-mentioned discussions are based on the state feedback. However, for some practical systems, full state information of an agent is not always available, and only the output of its neighbors can be obtained. Meanwhile, compared with the traditional control systems utilizing relative states between the neighboring agents, the relative outputs are most available and realistic. So the consensus by feedback of relative outputs are more feasible than the traditional state feedback control in practice. The method to achieve consensus by output feedback is quite limited, see [10]. An alternative way to achieve the consensus is based on the full-order observer output feedback. In [25], an observer-based consensus law by only the relative output of neighboring agents are proposed. In [6], the optimal design for synchronization based on observer design and output feedback control is addressed. In [27], the distributed observer and optimal regulator design for multi-agent systems is introduced. Moreover, in [20] the authors considered the consensus problem for single-integrator agents with heterogeneous output saturation. More results can be found in [27][28]. Recently, a reduced-order observer-based protocols has been proposed by [14] with directed communication topologies . The author in [15] extended the results of [14], where the agents are only accessible to the relative output information between the neighboring agents. Unfortunately, the reduced-order observers mentioned above are both based on the solvability of Sylvester equation, which may immerse in solving the feasible solutions of the observer matrices. In [16], the authors propose a new observer which only needs to satisfy the condition (A, C) is detectable, and the matrix T is only required to guarantee $[C^T, T^T]^T$ is non-singular. However, the results are limited to the consensus control problems, meanwhile the reduced-order observers are based on the absolute output of the original system, which is not practical since the absolute output measurement is not available in many cases.

Motivated by the above works, especially by [15] and [16], this paper investigates the consensus and model-reference consensus control with reduced-order observer-based protocol for multi-agent systems. The main contribution of this paper will be presented in the following aspects: (i) a noval generalized reduced-order observer is proposed, which can also be extended to the linear parameter-varying systems; (ii) by the transformation of original model we consider the relative state error dynamic, based on which we design the reduced-order observer, then the consensus problem considered is simplified to the traditional output feedback control with reduced-order observer. Meanwhile, the Sylvester equation is not needed to be solved. Moreover, the states of observer are asymptotically stable though the consensus common state runs to infinity, while in [16] it is divergent. It is proved that the obtained consensus controller is more feasible and practical. Finally, the results are

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