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A distributed event-triggered transmission strategy for exponential consensus of general linear multi-agent systems with directed topology ☆

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Abstract

In this paper, exponential consensus problem of general linear multi-agent systems is investigated over directed topology with distributed event-triggered strategy. Firstly, a distributed event-triggered controller is designed, so that the controller updates for each agent only trigger at its own triggering time instants. Then, a sufficient condition is presented to guarantee the exponential consensus. It is shown that by utilizing only the information of neighbors, which is transmitted by neighbors at their own triggering time instants, exponential consensus can be achieved and Zeno behavior can be excluded. Finally, simulation examples are presented to verify the theoretical results.

1. Introduction

Numerous contributions have been made in the research of distributed cooperative control of multi-agent systems (MAS) due to its wide applications in cooperative control of mobile robots, formation

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control of unmanned vehicles, etc., [1,2]. The consensus problem, as a special case, has been investigated in several papers [3–8]. An important aspect in the implementation of distributed control is the design of communication and control strategy [6–11]. A widely used method is time-triggered sample-date control [6–8]. However, in many practical MAS, the bandwidth of the communication network and the power source of the agents are inevitably constrained. To lower the cost, each agent may equip with a small embedded microprocessor with limited energy resources and computing capabilities, which motivates researches to develop event-triggered control strategies [12,13], that is more efficient in resource utilization.

Later, event-triggered control has been proposed as an alternative to time-triggered control [14,15]. The distinct feature of event-triggered control is that control tasks are triggered only when some specific events occur. It has been originally used for the control of discrete-event systems, finite state machines and Petri Nets. Compared with time-triggered control, event-triggered strategy can lower the control cost and save resources in resource-limited control systems. For example, the application of the event-triggered control strategy in physically distributed sensor/actuator networks [16] can lower the power consumption and prolong the lifetime of the networks.

Since the pioneering work reported in paper [12], event-triggered control has been widely studied in networked control systems [17] and sensor/actuator networks [16]. Recently, it has been extended to study consensus of MAS. With event-triggered control, in [18–22], the dynamics of integrator MAS are studied, and in [23–25], the dynamics of general linear multi-agent systems are considered, which is much more complicated.

In most of literatures mentioned above, the Laplacian matrix of communication topology must be symmetric [18–21,24], so that the information between two agents can be transmitted bidirectional. However, in coordination applications, information flow may often be directed, either due to heterogeneity, nonuniform communication powers, or sensing with a limited field of view. The case of directed interaction is much more challenging than that of undirected interaction. In [25], the event-triggered consensus problem of general linear multi-agent systems has been investigated with directed graph. However, agents need to sample the information of neighbors as well as to broadcast its own information to neighbors at triggering time instants.

Another limitation of the existing event-triggered strategy is the fact that each agent is required to be triggered at the neighbors' event time [18,20], which leads to higher frequency of controller updates. Although a combinational measurement approach is proposed [19] to solve this problem, continuous communication between neighboring agents is required. In [25], a novel event-based control approach is applied to consensus problem, and continuous communication between neighboring agents can be avoided with more controller updates.

Motivated by the above discussions, the event-based exponential consensus problem of general linear MAS is investigated in this paper. Different from [24,25], directed communication topology is investigated and sufficient condition for exponential consensus is presented. Besides, continuous communication among neighboring agents is avoided without increasing controller updates. The contributions of this paper are as follows: (i) A novel distributed event-triggered transmission strategy is proposed for general linear MAS with directed communication topology, that is, the information transmission for directed edges is unidirectional between agents. (ii) A totally distributed controller is designed, where each agent is triggered independently, and continuous communication between neighboring agents is avoided. (iii) Guaranteed exponential consensus is achieved asymptotically.

The rest of this paper is organized as follows. Section 2 contains preliminaries as well as the model description. In Section 3, the event-triggered function is designed. The main result of