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Asymptotic bounded consensus tracking of multi-agent systems with a bounded-acceleration target via sampled-data control

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Abstract

This paper is concerned with the asymptotic bounded consensus tracking problems of single-integrator multi-agent systems with an asymptotically-unbounded-velocity and bounded-acceleration target via sampled-data control. An improved sampled-data consensus tracking protocol is proposed to guarantee that single-integrator multi-agent systems track an asymptotically-unbounded-velocity and bounded-acceleration target available to only a portion of agents. The augmented matrix method and the eigenvalue analysis method are employed for deriving the necessary and sufficient conditions given in the form of the allowable scopes of the constant feedback gain and the sampling period. Comparison simulations numerically illustrate the effectiveness of the proposed protocol.

1. Introduction

During the past decade, distributed coordination control of multi-agent systems has received considerable attention due to its broad applications such as swarming, flocking, rendezvous, formation, time synchronization and coverage control of distributed sensor networks, distributed and parallel computation, and so on. As a basic issue in distributed coordination control, consensus is to design a proper distributed control input called consensus protocol for guaranteeing that all agents eventually converge to a common value. For most of the existing

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consensus protocols, the final common value to be achieved is a function of initial states of all agents and is inherently a prior unknown constant. This is the so-called χ-consensus [1], one of important forms of which is the average consensus [2–7]. However, in many real applications, it is required that all agents communicating with their local neighbors track a moving target available to only a portion of agents. This is the so-called consensus tracking. Due to the ineffectiveness of χ-consensus protocols to directly deal with consensus tracking, we need to design proper consensus tracking protocols for guaranteeing multi-agent systems to achieve consensus tracking. Till now, many consensus tracking protocols have been proposed for guaranteeing single-integrator multi-agent systems to achieve consensus tracking [8–18]. Ren proved that the proportional-like continuous-time consensus tracking protocol cannot guarantee all agents to track a moving target available to only a portion of agents, whereas the proportional and derivative-like continuous-time consensus tracking protocol can do [9]. Further, in Refs. [19–22], three discrete-time versions of the proportional and derivative-like continuous-time consensus tracking protocol in Ref. [9] were presented and the conditions for the asymptotic or stochastic bounded consensus tracking were obtained in the discrete-time domain.

In the above literature [8–18], continuous-time consensus tracking protocols were used for guaranteeing consensus tracking of single-integrator multi-agent systems. However, due to the application of digital sensors and controllers, in many cases, though the system itself is a continuous process, only sampled-data at discrete sampling instants is available for the synthesis of control laws. Thus, it is important to study the consensus tracking problems of single-integrator multi-agent systems based on sampled-data. Up to now, there have been some results about the consensus tracking problems of single-integrator multi-agent systems based on sampled-data [23–26]. Now we review Refs. [23–26] to raise the main topic in this paper.

In Ref. [23], Wu et al. demonstrated that choosing a proper sampling period can guarantee single-integrator multi-agent systems with measurement noises and a bounded-velocity moving target, using the proposed sampled-data consensus tracking protocol, to achieve the mean square bounded consensus tracking under the assumption that the network topology is fixed, undirected, and connected and at least one agent has access to the moving target. Further, in Refs. [24,25] Wu et al. extended the results of Ref. [23] to the cases of the sampled-data with small and general sampling delay, respectively, and the similar results were obtained. By revising the proof process of main results in Ref. [23], we can prove that choosing a proper sampling period can guarantee single-integrator multi-agent systems without measurement noises and with a bounded-velocity moving target, using the free-noise version of the sampled-data consensus tracking protocol proposed in Ref. [23], to achieve the asymptotic bounded consensus tracking under the assumption that the network topology composed of agents and the moving target is fixed and undirected, the moving target is available to only a portion of agents, and there is a path from the moving target to each agent. However, in the passive consensus tracking, the moving target to be tracked is beyond the control of the designer of multi-agent systems. For example, in the target tracking of wireless sensor networks, the designer can utilize multiple sensors for obtaining the real-time trajectory of a moving body but cannot control the moving body. For another example, in the target intercepting of multi-missile systems, the designer can employ multiple missiles for intercepting the enemy missile but cannot control the enemy missile before intercepting the enemy missile successfully. Due to the uncontrollability of the moving target in the passive consensus tracking, the velocity of the moving target might be asymptotically unbounded and its acceleration might be bounded. Therefore, we wonder whether single-integrator multi-agent systems without measurement noises and with an asymptotically-unbounded-velocity and bounded-acceleration moving target, using the free-noise version of the sampled-data consensus