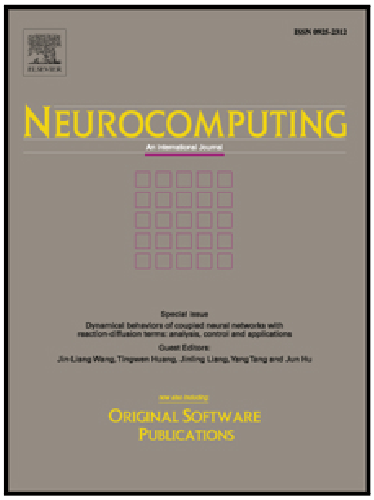

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Yiyan Han, Chuandong Li

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Second-order Consensus of Discrete-time Multi-agent Systems in Directed Networks with Nonlinear Dynamics via Impulsive Protocols

Yiyan Han[a], Chuandong Li[a,*]

[a]*Chongqing Key Laboratory of Nonlinear Circuits and Intelligent Information Processing, College of Electronic and Information Engineering, Southwest University, Chongqing 400715, PR China*

Abstract

In this paper, we discuss the second-order consensus problem of discrete-time multi-agent systems with fixed and switching topologies. New impulsive protocols are introduced for multi-agent systems with nonlinear dynamics. The consensus problem of multi-agent systems is analyzed by algebraic graph theory and matrix theory, where a connection of impulsive control methods and network topologies is established. Our main results indicate that the second-order consensus of multi-agent systems can be achieved if the topology graphs are balanced and strongly connected under suitable conditions. Numerical simulations are presented to support the theoretical results.

Keywords: Impulsive protocols, Discrete-time multi-agent systems, Second-order consensus, Nonlinear dynamics

1. Introduction

Recently, the consensus problem of multi-agent systems has been studied intensively. A general multi-agent system is always composed of many agents, in which each agent can refer different individual with its own dynamics. Nowadays, the consensus problem becomes attractive for its promising applications in flocking, rendezvous, complex networks and so on[1–3].

In multi-agent systems, each agent shares information with its neighbors to reach an agreement. Existing researches mainly focus on the first-order consensus problem[4–6]. Recently the consensus problem of second-order multi-agent systems[7–9] with states of both position and velocity draws more attention, in which distributed consensus problem was consider in both undirected and directed cases. And because non-linear phenomena is every where in real-world, many studies[10–12] have been done with the non-linear dynamics of multi-agent systems in first-order and second-order multi-agent systems. Paper[13] studied the adaptive leader-following consensus of second-order multi-agent systems with a time-varying non-linear dynamics by a fully distributed algorithm. Moreover, high-order multi-agent systems also attracted researchers. In [14], consensus of a third-order multi-agent systems with non-linear dynamics was investigated and some sufficient conditions were given. And the high-order case was also studied by [15], in which the authors introduced a distributed protocol to achieve the consensus of non-linear multi-agent systems. However, in some certain circumstances, discrete-time dynamics are more suitable for analyzing real problems. There are also many researches[16–19] on consensus of discrete-time second-order and high-order multi-agent systems.

Meanwhile, impulsive control systems are paid more attention in recent years in that an evolution of a system may encounter sudden changes in real circumstances. To get closed to the reality, impulsive control method is established because it is an efficient tool to model multi-agent systems with high-robustness and low-cost. Impulsive control had been widely applied to the synchronization and consensus problems[20–22] with kinds of complex networks over last decade. The authors in[23] investigated the consensus problem of multi-agent systems with each agent described by impulsive dynamics under directed communication network topology. By impulsive control method, several conditions are built for synchronization and consensus with switching topology[24]. In[25], the convergence speed depended on the consensus algorithms via impulsive control was investigated. Recently, the consensus problem of second-order multi-agent systems was also combined with impulsive systems, on which may deserve more researches[26, 27]. Paper[28] investigated the consensus problem of second-order multi-agent systems via impulsive control using only position information with communication delays. Static consensus of second-order multi-agent systems was investigated[29] by using impulsive algorithm and the author further considered the case with communication time-delays. Many researches emphasized on the second-order multi-agent systems with linear or simple dynamics, some focused on the non-linear dynamics case. In[30], consensus criteria of second-order multi-agent systems were delivered based on algebraic graph theory via impulsive protocols with nonlinear velocity dynamics in switching network topology, but the protocol needs feedback on both position and velocity. Paper[31] proposed protocols which permit that all the feedbacks are only on velocity in communication interval. If the interval were only a

*Corresponding author

Email addresses: yiyanhan@email.swu.edu.cn (Yiyan Han), cdli@swu.edu.cn). (Chuandong Li)