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Consensus of second-order delayed nonlinear multi-agent systems via node-based distributed adaptive completely intermittent protocols

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ABSTRACT

The paper discusses second-order consensus problem of nonlinear multi-agent systems with time delay and intermittent communications. Basing on local intermittent information among the agents, an effective control protocol is proposed by node-based distributed adaptive intermittent information, which a time-varying coupling weight to each node in the communication, some novel criteria are derived in matrix inequalities form by resorting to the generalized Halanay inequality. It is proved that second-order consensus can be reached if the measure of communication is larger than a threshold value under the strongly connected and balanced topology. Moreover, consensus problem is also considered for second-order non-delayed nonlinear multi-agent systems. Finally, a simulation example is presented to illustrate the theoretical results.

1. Introduction

Over the last few years, the coordination problem of multi-agent systems has attracted considerable attentions due to their extensive application in many field, such as sensor networks, spacecraft formation flying, power grid and so on [1,2]. The consensus problem plays an important role in the area of cooperative control and has been investigated from various perspectives [3–7], where the main task is to design an appropriate protocol based on the local relative information to achieve consensus [8–18].

In the aforementioned literature, many results are based on the assumption that each individual agent is governed by first-order dynamics [8–11], however, second-order consensus algorithms will contribute to the study of more complicated dynamics, where all the agents are governed by position and velocity states, thus helping engineering implement the consensus algorithms in many real-world networked multi-agent systems. Therefore, there is a growing interest focusing on the second-order consensus problem. In [12], some sufficient conditions are obtained for achieving second-order consensus under directed communication topology. It is shown that second-order consensus may fail to be reached even if the communication topology has a spanning tree, and some additional conditions should to be satisfied for achieving second-order consensus [18–23], which are somewhat different from those in multi-agent systems with first-order dynamics. Recently, it can be seen that the real and imaginary parts of the eigenvalues of the Laplacian matrix play key roles in reaching con-

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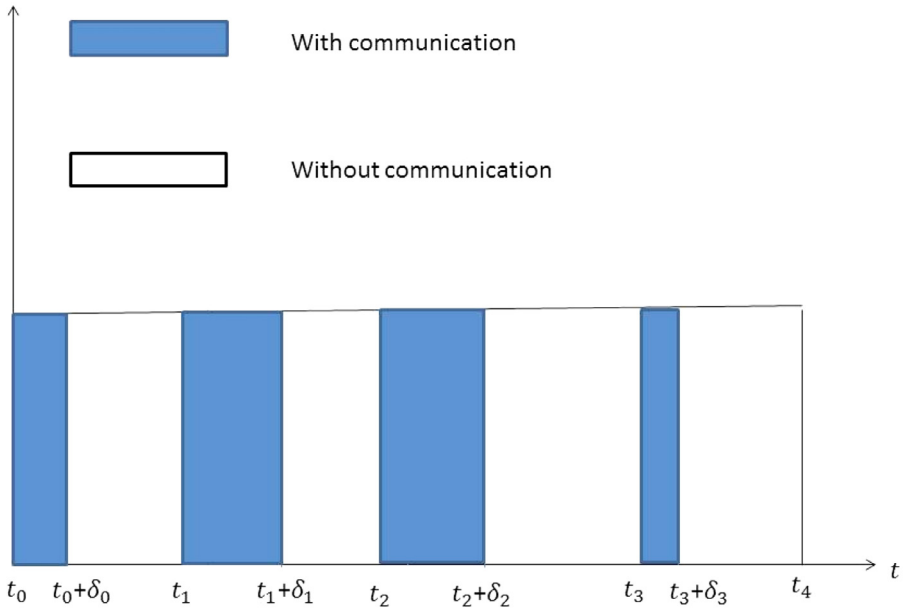

Fig. 1. Illustration for aperiodic intermittent communication.

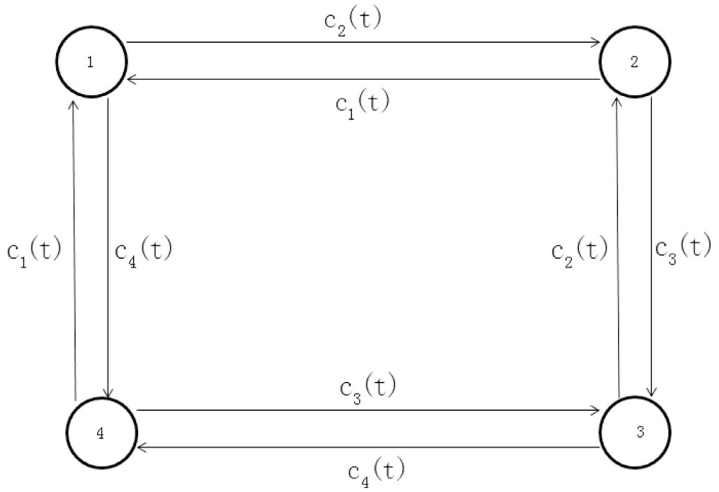

Fig. 2. Node-based adaptive protocol.

sensus [5,22,24–26]. Firstly, there is a common assumption in the existing literature that each agent can receive the state's information between its neighbors and itself all the time, which is not always appropriate in some real situations due to the unreliability of communication channels, failure of physical devices and recovery of the sensing devices from failures, thus it is reasonable to assume that each agent can sense its neighbors only in intermittently [27–33], where the consensus for the first-order and second-order multi-agent systems is investigated with intermittent information transmissions, which is shown that consensus can be reached if the communication time duration is larger than their corresponding threshold value. Due to the intermittent information transmissions, as a discontinuous control, intermittent control is introduced and activated during certain nonzero time intervals, but is off during other time intervals, which has been widely used in engineering fields for its practical and easy implementation [34–38], such as manufacturing, transportation and communications. Secondly, adaptive strategies to appropriately tune the strengths of the interconnections among network nodes have been proposed [39–41]. The synchronization of complex topologies using coupling of time-varying strength is numerically investigated and made a comparison between fixed and varying coupling strength [40], it can be seen that the fixed coupling strength is larger than those needed in practice. The strength is given in advance to guarantee the performance of a network in the worst cases, but the worst cases are seldom happen in practical systems [42], therefore, it may be conservative, adaptive strategies are proposed and can effectively overcome these shortcomings, which can appropriately tune the