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SYNCHRONIZATION OF MASTER-SLAVE MARKOVIAN SWITCHING COMPLEX DYNAMICAL NETWORKS WITH TIME-VARYING DELAYS IN NONLINEAR FUNCTION VIA SLIDING MODE CONTROL*

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Abstract In this article, a synchronization problem for master-slave Markovian switching complex dynamical networks with time-varying delays in nonlinear function via sliding mode control is investigated. On the basis of the appropriate Lyapunov-Krasovskii functional, introducing some free weighting matrices, new synchronization criteria are derived in terms of linear matrix inequalities (LMIs). Then, an integral sliding surface is designed to guarantee synchronization of master-slave Markovian switching complex dynamical networks, and the suitable controller is synthesized to ensure that the trajectory of the closed-loop error system can be driven onto the prescribed sliding mode surface. By using Dynkin's formula, we established the stochastic stablity of master-slave system. Finally, numerical example is provided to demonstrate the effectiveness of the obtained theoretical results.

Key words Markovian switching; complex dynamical networks; Lyapunov-Krasovskii method; sliding mode control; Linear Matrix Inequality

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1 Introduction

A complex network is a large set of interconnected nodes, where the nodes and connections can be anything, and a node is a fundamental unit having specific contents and exhibiting

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dynamical behavior. Many natural and technological systems can be modeled as complex networks: cellular neural networks, wireless communication networks, World Wide Web, electric power grids, internet, and metabolic networks etc. Over the past two decades, complex networks have been studied intensively in various disciplines, such as sociology, biology, physics, mathematics, and engineering [1–3]. In turn, analysis and possibly control of complex behaviors in complex networks have become a very hot topic across several sciences also including fields of engineering sciences (For example [4–6], and references therein).

Time delay can be found in many systems, such as nuclear reactors, population dynamic models, aircraft stabilization, biological systems, chemical engineering systems, and ship stabilization and so on . The existence of time delay can make system instable and degrade its performance. In recent decades, considerable attention has been devoted to the time delay systems due to their extensive applications in practical systems including circuit theory, chemical processing, bio engineering, complex dynamical networks [7], and automatic control etc. Some results on time-delay systems were provided in [8–10]. Especially, the characteristic of time-delayed coupling often occurs in biological and physical systems such as gene regulatory networks, biological neural networks, epidemiological models, wireless communication networks, and power grids etc [11–13].

In the implementation of complex dynamical networks, time-varying delay is unavoidably encountered due to the finite speed of signal transmission over the link and the network traffic congestions [14–17]. Synchronization, the most important collective behavior of complex dynamical networks (CDNS), has received much of the focus; see [18–21] and references therein. Synchronization of coupled oscillators can explain well many of the natural phenomena. Thus, synchronization of dynamical nonlinear nodes in complex dynamical networks has been the subject of great research interests recently. As we know now, some complex network can be synchronized by itself, but the general case is that the whole network cannot synchronize by itself [22]; from the perspective of control theory, designing controllers is an effective method, and one natural idea is to assign controllers to all nodes of the controlled complex dynamical network [23–26]. In past few decades, synchronization and control problems in complex networks have been widely studied from various fields of science and engineering [27].

Recently, many control schemes are adopted to design effective controllers, such as adaptive control [28], intermittent control [29], impulsive control [30], pinning control [31], sampling data control [32], and sliding mode control [33] and so on. Sliding mode control is able to deal with uncertainty and nonlinearity [34, 35]. There exist parameter uncertainties, nonlinearities, and external disturbance in the systems under consideration. In the design of sliding surface, a set of specified matrices are employed to establish the connections among sliding surfaces corresponding to every mode. For sliding mode controller, Lyaponov stability method is applied to keep the nonlinear system under control. In the sliding mode control theory, control dynamics have two sequential modes; the first is the reaching mode and the second is the sliding mode. In addition, the effect of Markovian switching is further coped with the proposed sliding mode control law composed of the transition rates of modes (For example, [36–38]). It is shown that the state trajectories of the resultant sliding mode control system can be driven onto the specified sliding surfaces for each mode in finite time, and then the sliding motion along the sliding surface for each mode is stochastically stable [39].