Chaos, Solitons and Fractals 86 (2016) 35–49

Contents lists available at ScienceDirect

Chaos, Solitons and Fractals

Nonlinear Science, and Nonequilibrium and Complex Phenomena

journal homepage: www.elsevier.com/locate/chaos

Finite-time synchronization and identification of complex delayed networks with Markovian jumping parameters and stochastic perturbations

Qian Xie, Gangquan Si*, Yanbin Zhang, Yiwei Yuan, Rui Yao

State Key Laboratory of Electrical Insulation and Power Equipment, School of Electrical Engineering, Xi'an Jiaotong University, Xi'an, Shaanxi Province 710049, PR China

ARTICLE INFO

Article history:
Received 7 August 2015
Revised 2 February 2016
Accepted 16 February 2016
Available online 9 March 2016

Keywords:
Complex dynamical network
Finite-time synchronization
Parameters identification
Markovian jumping parameters
Time delay

ABSTRACT

In this paper, the finite-time synchronization and identification for the uncertain system parameters and topological structure of complex delayed networks with Markovian jumping parameters and stochastic perturbations is studied. On the strength of finite time stability theorem and appropriate stochastic Lyapunov–Krasovskii functional under the Itô's formula, some sufficient conditions are obtained to assurance that the complex delayed networks with Markovian switching dynamic behavior can be identified the uncertain parameters and topological structure matrix in finite time under stochastic perturbations. In addition, three numerical simulations of different situation and dimension are presented to illustrate the effectiveness and feasibility of the theoretical results.

1. Introduction

Over the past decade, various complex dynamical networks have attracted substantial numbers of interests from researchers in varied realm, such as mathematics, physics, engineering, sociology, and economic science [1,2]. With the development of society and the deepening of the study on complex dynamical networks, we know that multitudinous systems in technology and science can be described as complex dynamical networks; some common examples in real world include the electrical power grids, social relationship networks, neural networks, communication networks and World Wide Web [3–5]. As one of the typical and most important dynamical behavior of complex dynamical networks, synchronization has attracted a growing number of concern in the investigation due to its important applications in various fields comprises multi agent, secure communication, neural networks, and so forth [6,7]. Synchronization is a momentous nonlinear phenomenon of nature, discovered at the beginning of the modern age of science by Huygens in 1673 [8]. Recently, the synchronization of complex networks has been a hot topic in science and engineering, especially in the realm of control. The earlier studies mainly focused on chaos system synchronization. In recently years, it has been recognized that complex dynamical networks and those chaotic synchronization methods can be used to the synchronization of complex dynamical network either. In Ref. [9], the authors studied Generalized function projective synchronization between two different complex networks with different nodes. By using Lyapunov function method and sufficient conditions, the problem of cluster synchronization and exponential synchronization for networks were investigated in Refs. [10,11].

Because of the influence on finite signal transmission and switching speed, time delays were emerged ubiquitously in the practical process, such as long-distance information transmission [12]. In addition, time delays can bring instability and other negative effect to system, which is detrimental to realistic complex dynamical networks. Thus, the condition of time delays cannot be ignored and many investigations on synchronization and stabilization of complex networks consider time delays have been studied. In Ref. [13], H-infinity state estimation for discrete-time neural networks with interval time-varying delays and probabilistic diverging disturbances has been discussed. Under the appropriate adaptive controllers, the complex networks with time-varying coupling delay have realized synchronization was investigated in Ref. [14]. Moreover, pinning synchronization in complex networks with

* Corresponding author. Tel.: +86 2982668034; fax: +86 2982668034.
E-mail address: sigangquan@mail.xjtu.edu.cn (G. Si).

http://dx.doi.org/10.1016/j.chaos.2016.02.021
0960-0779/

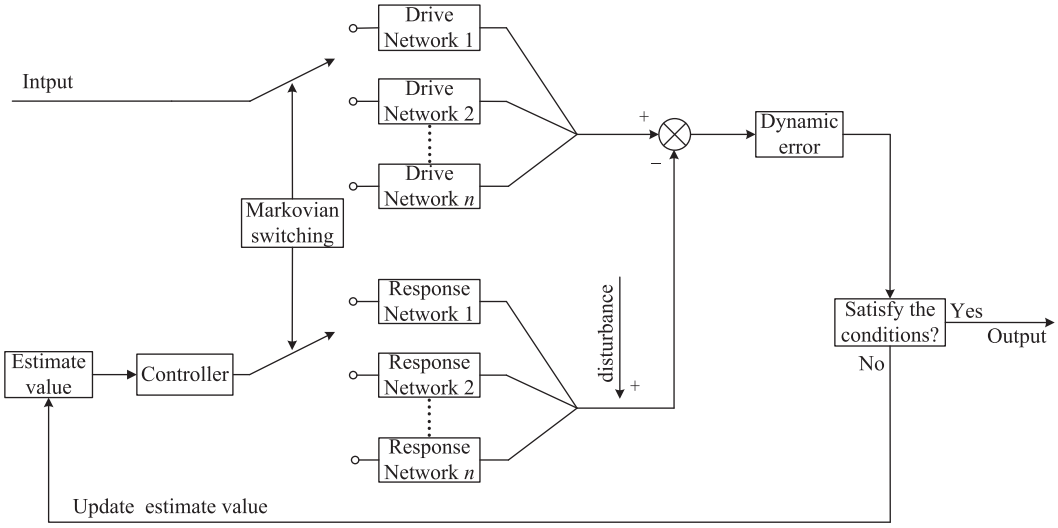

Fig. 1. The synchronization and identification scheme of the proposed problem.

variable delay couplings was studied in Ref. [15] by Lasalle's invariance principle, sufficient conditions and adaptive control method. Further, by employing suitable Lyapunov–Krasovskii functional, linear matrix inequalities and direct delay decomposition approach, Ref. [16] investigated the issue of chaotic fuzzy cellular neural networks synchronization with distributed delays and Markovian jumping parameters. Therefore, it is necessary to research the influence of time delays in network synchronization.

In practical engineering situation, it is desired to synchronize a complex dynamical network achieved in a finite time frequently. In secure communication, the range of time during which the oscillators are not synchronized corresponds to the range of time during which the encoded message cannot be recovered or sent [17]. Thus, finite-time synchronization of complex dynamical networks is taken more attractions. In order to accomplish faster synchronization in complex dynamical networks, an effective approach is adopting finite-time control methods. For instance, based on finite-time stability theory and adaptive control method, finite-time chaos synchronization of chaotic systems was investigated in Refs. [18,19], and finite-time synchronization of complex dynamical networks were studied in Ref. [20]. Furthermore, by contained the time delays, Refs. [21,22]were investigated the finite-time synchronization of complex delayed networks, the simulations were illustrated the effectiveness of the finite-time stability technique. Therefore, the finite-time stability theory have ensured better disturbance rejection and robustness against uncertainties [23].

Considering the uncertainty factor of environment in actual process, perturbation problems of complex networks are not to be neglected. Stochastic perturbations are important ingredients which are unavoidably affect the behavior of the complex dynamical networks. Within the evolving process of complex dynamical networks, stochastic perturbations are often inescapable, which even break the stability of complex dynamical networks. By using the It?'s differential rule and adaptive feedback control scheme, stochastic synchronization with time delays were investigated in Refs. [24,25]. Therefore, to study the affection of stochastic perturbations in complex network synchronization is inevitability. Withal, in realistic systems, complex dynamical networks may be submitted to parameters switching, such switching can be dependent on Markov process. Complex dynamical networks with Markovian jumping parameters have great practical influence due to random switching in their dynamical behavior, such as component failures or repairs, sudden environmental disturbance, and changing subsystem interconnections [26]. The category of these networks promptly developed and researched due to the great mathematical modeling capacity of Markov process in many situations. In Ref. [27], the authors investigated the global asymptotic stability of the Markovian jump genetic regulatory networks model with time-varying delays by using linear matrix inequalities. Ref. [28] have analysis the exponential synchronization in Markovian jump complex dynamical networks with time delays, and also stochastic synchronization problem for Markovian jump networks were investigated in Refs. [29,30]. Although, there are few researches on complex delayed dynamical networks synchronization considering Markovian jumping parameters and stochastic perturbations concurrently in finite time, thus we should take into account.

On the other hand, the system parameters and topological structure of complex dynamical networks are unknown occasionally, majority of the researches on the synchronization of complex networks consider the system parameters and topological structure as known, but in some practical situations this hypothesis is inappropriately. Then, recently complex networks parameters and topological structure identification become a significant research orientation. In Refs. [31,32], the authors have analysis the synchronization of uncertain complex dynamical networks parameters and the results identified the truth values. The finite time synchronization and identification of uncertain or unknown parameters systems were investigated in Refs. [33,34]. Moreover, that is more important to be concerned about the identification of the uncertain system parameters and topological structure in finite time complex dynamical networks synchronization considering time delays.

In this paper, we will discuss the synchronization and identification of the uncertain complex dynamical networks with Markovian switching and disturbance. Fig. 1 shows the scheme of this topic. The drive network and response network have $1, 2, \ldots, n$ states with different dynamic behaviors respectively, and the switching process between each state obeys the Markov process. We only know that in the initial state of the drive network input and output values, then the truth values of the system parameters and topological structure matrix are converged by updating the estimate values. To the best of the authors' knowledge, an