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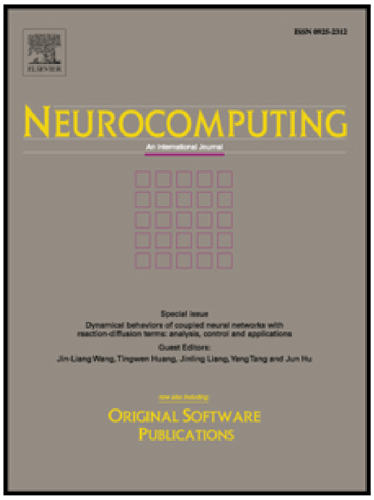

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Graph-theoretic approach to exponential synchronization of discrete-time stochastic coupled systems with time-varying delay

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Abstract

In this paper, we investigate the exponential synchronization problem for discrete-time stochastic drive-response coupled systems with time-varying delay. By employing the Lyapunov method combined with Kirchhoff's matrix tree theorem in graph theory as well as stochastic analysis technique, some novel sufficient criteria are established to guarantee the exponential synchronization of two identical delayed coupled systems with stochastic disturbances. These sufficient criteria have a close relationship with the topological property of the coupled network. Moreover, the theoretical results are applied to a coupled oscillators system to demonstrate the applicability of the proposed synchronization approaches. Finally, a numerical example is provided to illustrate the effectiveness of our theoretical results.

Keywords: exponential synchronization, discrete-time coupled systems, stochastic disturbances, time-varying delay, graph theory

1. Introduction

In the past few decades, there has been an increasing interest in coupled systems because of their extensive applications developed in physics [1, 2], neural networks [3, 4, 5, 6], biology [7, 8, 9], and engineering [10, 11]. Roughly speaking, the mathematical framework of coupled systems in the time domain can be classified into three categories (i.e. continuous time [12], discontinuous time [13] and discrete time [14]). Among them, discrete-time coupled systems have been widely investigated for their potential application prospects in biology, physics and communication networks [15, 16, 17, 18, 19]. These applications heavily depend on the dynamical behaviors such as synchronization, periodicity, bifurcation and so on. Particularly, synchronization has been regarded as one of the most effective ways to explore the collective phenomena of discrete-time coupled systems [20, 21, 22, 23, 24, 25].

In practice, time delay occurs frequently due to the finite speed of transmitting signals and traffic congestions. For example, in a multi-patch predator-prey system, a predator may need a period of time to grow up so that it is mature enough to prey. Moreover, due to the fact that time delay may lead to undesirable dynamic behaviors such as performance degradation, oscillation and even instability, the synchronization problem for coupled systems with time delay has attracted increasing research interests [26, 27]. Furthermore, time delay is usually time-varying and not identical. Hence, in order to model the real coupled systems better, we consider time-varying delay with the upper and lower bounds [28, 29]. Besides, stochastic disturbances in nature can not be

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