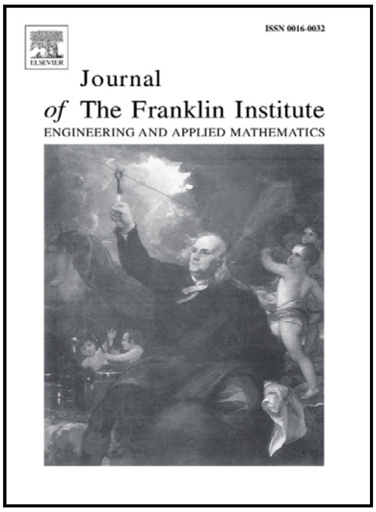

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Stochastic synchronization of neural networks with multiple time-varying delays and Markovian jump

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***Abstract*—This paper addresses the stochastic synchronization problem for a class of neural networks with multiple time-varying delays and Markovian jump. By choosing a non-negative function, M-matrix technique and stochastic analysis approach, several sufficient conditions are obtained to guarantee that the error system is stable. Moreover, the update laws of the gain matrix are derived to ensure stochastic synchronization for multiple time-varying delayed drive system and response system. In particular, the M-matrix associates with the Markovian chain generated by transmission rate matrix. And the condition of M-matrix can be verified conveniently in practice. In the end, the effectiveness and potential value of the results addressed are tested by a simulation example.**

***Index Terms*—Stochastic synchronization; multiple time-varying delays; stochastic neural networks; M-matrix; Markovian jump.**

I. INTRODUCTION

DURING the past decades, a large number of work has been devoted to various neural networks (NN) due to their wide range of applications, such as combinatorial optimization, signal processing, automatic control, fault diagnosis, associative memory, image processing, biological science, fixed-point computations, pattern recognition, solving nonlinear algebraic equations and so on (see, e.g., [1]−[7]). These widely applications base heavily on the wonderful properties of various neural networks, such as the stability of trivial solution (or equilibrium point) and the synchronization control of neural networks, and therefore, the design of the controller for the synchronization control has been a significant research topic. What's more, various synchronous conditions and the methods of study have been exhibited (see, e.g., [8]−[18], [20]−[22], [30], [32]−[37] and the references therein).

In the real world, due to the error of model, environment being destroyed or changed, the external random fluctuation, and other probabilistic causes often lead to time-delays that can cause poor performances of neural networks, such as oscillatory behaviors or network instability. There are two types of the time-delays, one is called constant time-delay and the other is called time-varying delay. It should be pointed out that, more than the time-varying delay, the multiple time-varying delays can also appear in various networks that include the neural networks. This kind of multiple time-varying delays often encounter in a lot of applications in practice such as chemical reactors, partial element equivalent circuits in very large scale integration systems, transmission lines and Lotka-Volterra systems [16]. The neural networks with multiple time-varying delays have aroused some attention in the past few years [17], [19].

On the other hand, due to the repairs of network components, changes in the interconnections of network nodes and encountering the multiple time-varying delays etc. in the neural networks, which lead to change of the mode of the system. However this kind of random mode jump can be governed by a Markovian chain. So-called Markovian jump, that is, the jump system will switch from one mode to another in a stochastic pattern, and the modes are managed by a continuous-time Markovian chain with a finite state space $S = \{1, 2, \cdots, N\}$. Moreover, the Markovian jump stochastic neural networks have attracted a great number of research interest in the past decade (see, e.g., [1], [10], [15], [23], [24], [28], [29]−[31], [34]). For instance, in [10], the adaptive exponential synchronization problem was studied extensively for pth moment of neutral-type neural networks with time delays and Markovian switching. In [23], the authors considered the exponential stability of stochastic neural networks with both Markovian jump parameters and mixed time delays, in which the main results were obtained by the approach of linear matrix inequality (LMI). Yang and Cao [30] discussed the problem of synchronization of randomly coupled neural networks with Markovian jumping and time-delay.

It is worth pointing out that an important and interesting topic in chaotic systems (see [38], [39]) is the synchronization which the original concept dates back to the 1980s after the theory of deterministic chaos has been developed. In the past few years, a lot of study work for synchronization has been devoted to various stochastic neural networks (see, e.g.,[8]−[10], [15], [30], [32]−[37]). For example, in [15], the authors discussed the adaptive synchronization for stochastic T-S fuzzy neural networks with time-delays and Markovian jumping parameters. Very recently, the work in [36] has studied the adaptive almost surely asymptotically synchronization for stochastic delays neural networks with Markovian

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