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Stability of Delayed Markovian Switching Stochastic Neutral-type Reaction-diffusion Neural Networks*

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Abstract This paper is concerned about exponential stability in mean square of Markovian switching delayed reaction-diffusion neutral-type stochastic neural networks (RNSNNs). By Lyapunov function method, several novel stability criteria on exponential mean square stability of Markovian switching RNSNNs with time-varying delays are obtained. In the end, two examples are given to verify the feasibility of our findings.

Keywords Markovian switching, Neutral-type, Neural network, Reaction-diffusion system.

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1. Introduction

Many practical systems are often disturbed by various kinds of noise. When a system is affected by some random factors in the environment, the phenomenon can no longer be described by definite differential equations, so the stochastic differential equation appears. For example, the change of stock price in financial market and conservative mechanical system can be described by stochastic differential equations. Based on G-Lyapunov functional method, the criteria of quasi-surely exponential stability and finite-time stability of stochastic reaction-diffusion systems driven by G-Brownian motion have been established [18]. [17] aimed to design feedback control based on past state to stabilize a class of nonlinear stochastic differential equations driven by G-Brownian motion. The stability of stochastic differential equations driven by G-Brownian motion via feedback control based on discrete time state observation has been studied [25].

In the last decades, a growing number of scholars have been inclined to the study of stochastic partial differential equations (SPDEs). SPDEs have been used to describe a large number of mathematical models in many subjects such as biology and physics. Kao et al., explored the stability of coupled SRDSs on networks

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with Markovian switching by constructing the Lyapunov function [10]. Kao et al., employed Itô formula studying the stability in mean of SRDSs with Markovian switching [11]. By using Leary Schauder fixed point theorem and Lyapunov method, the existence of solutions and the global Mittag-Leffler stability criterion for fractional coupled reaction-diffusion NNs with delay without strong connectivity have been given [2]. Applying Lyapunov-Krasovskii (LK) functional, stochastic analysis technology and LMIs technique, reaction-diffusion statistic CGNNs (RDSCGNNs) with mixed time delays have been discussed [9, 27] respectively. The global existence, uniqueness, uniform boundedness and asymptotic behavior of solutions for a weakly coupled reaction-diffusion systems have been studied [5].

In addition, there are many structurally mutated systems in the real world, such as computer control system, chemical process and communication system, which can be described by Markovian jumping system. Markovian switching system is a hybrid system consisting of discrete time state and continuous time state. The delay-dependent stabilization problem for a class of stochastic Markov systems with event-triggered feedback control was studied [39]. Exponential stability and instability of Markovian switching impulsive stochastic functional differential equations (SFDSs) were discussed by Lyapunov direct method [13]. Mean square exponential stability of Markovian jumping time-varying delayed reaction-diffusion HNNs with uncertain transition rates by Lyapunov-Krasovskii functional method and linear matrix inequality [30].

In the real world, stochastic differential equations with time delay have important applications in biological engineering, ship stability control and other fields. If a system depends not only on the present state and the past state, but also on the rate of state change in the past period of time, delayed neutral stochastic differential equation is used to describe the system. The delayed neutral stochastic differential equation has certain application value in the fields of economics, biology, mechanics and electronics. Mean square exponential stability criteria of mixed delayed impulsive fuzzy RDSCGNNs were derived mainly by "M-cone" approach and LMI techniques [32]. A low conservative criterion for asymptotic stability of a class of fractional neutral-type delayed NNs with Riemann-Liouville meaning have been considered [38]. The problem of distributed event-triggered control for nonlinear stochastic multi-agent systems with external disturbance and time delay have been discussed [29]. The exponential synchronization problem of time-varying delayed coupled stochastic reaction-diffusion NNs were studied [37]. Global exponential stability and instability criteria of impulsive SFDSs have been obtained [4]. Besides, stability of impulsive stochastic systems have been studied [35, 36] respectively. Furthermore, many efforts have been done in this area. Some results on the global stochastic exponential stability, almost sure exponential stability, mean value exponential stability and mean square exponential stability have been obtained, and please refer to [1, 22, 31, 34]. However, very few results have been reported on mean square exponential stability of time-varying delayed Markovian switching reaction-diffusion neutral-type stochastic neural networks.

Based on the above concerns, we discuss stability criteria for time-varying delayed RNSNNs with Markovian switching as follows. Section 2 introduces several lemmas and definitions. Section 3 presents exponential mean square stability criteria of Markovian switching time-varying delayed RNSNNs. Section 4 illustrates the effectiveness of our findings. Finally, a conclusion is presented.

Notation: We assume that $G = \{x||x_l| < d_l, l = 1, \cdots, n\}$ is a bounded set of $\mathbb{R}^n$