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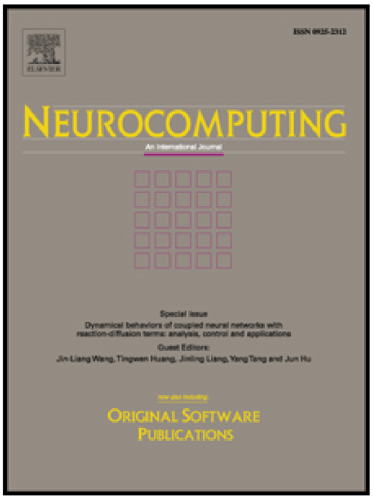

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Robust input-to-state stability of neural networks with Markovian switching in presence of random disturbances or time delays

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Abstract

This paper establishes input-to-state stability (ISS) and robust ISS of neural networks with Markovian switching (NNwMS). The M matrix algebraic condition for stochastic NNwMS is given; the result is then extended to stochastic time varying delays NNwMS. From the ISS condition of stochastic delayed NNwMS, we get robust ISS of NNwMS in two cases: delay perturbation in diffusion and delay perturbation in drift, respectively. These ISS criteria are readily to be checked only from the parameters of the NNwMS and also ensure exponential stability without input term. The results presented here include neural networks without Markovian switching as special cases. Two numerical examples are given to show the effectiveness of theoretical criteria.

Keywords: Neural networks, Input-to-state stability, Robustness, Time delay, Markov chain.

1. Introduction

Neural networks have been successfully developed and applied in various areas, such as detection of moving objects, associate memories, pattern recognition, optimization problems, robotics and control. In such applications, a key factor is stability properties of equilibrium points of the designed networks. Therefore, stability analysis is important for neural networks. In reality, in electronic implementation of neural networks, finite switching speed of amplifiers is often occur as a time delay, which may leads to undesirable dynamical network behaviors, such as instability and oscillations [1-3]. There are many different analysis methods to get the stability of neural networks, such as Lyapunov stability theory, Lasalle invariant set theory, nonsmooth analysis, Razumikhin theorems, comparison principle of delay differential systems, and so on. Many sufficient or necessary conditions have been derived to the stability by algebraic inequality [4-6], M-matrix [7], matrix norm [8], linear matrix inequality (LMI) [9-13], free weight matrix [14-15], spectral radius [16], matrix measure [17], transcendental equations [18-20] and the references cited therein. Recently, Zhang, Wang, & Liu given a comprehensive review of the research on stability of continuous time recurrent neural networks [21].

In applications of neural networks, it is common for connection weights and biases of neural networks change abruptly due to designed switching rule [22], where neural networks model can be treated as a switching systems in a set of parametric configurations as a given Markov chain. Meanwhile, due to using the statistics method and large scale integration chips to obtain the interconnection weights, so the estimating errors and parameter fluctuation may exist in modeling artificial neural networks. Stability and related to this topic of NNwMS becomes an important research topic since 2006 [23-29]. In [23-24], H-infinity filtering and robust exponential stability of delayed neural networks with Markovian switching are obtained in terms of LMI. In [25], stability conditions of neutral-type Markovian jumping neural networks are derived. In [26-27], explicit characterization of the desired estimator of state for jumping neural networks and its stochastic form are obtained. The problem of Synchronization control of Markovian switching neural networks are investigated in [28-29].

In addition, neural networks are often disturbed by external noise and input. Thus, it is significant and meaningful to guarantee neural networks is input-to-state stability. ISS is firstly introduced in [30], it stated the equivalence between input-output approach and state space approach of analyzing nonlinear systems stability, and also can be derived from dissipativity, robust margins and Lyapunov methodology [31-32]. ISS characterizes the dependence of system state trajectories on the measurement of external input. In [33], a Razumikhin type theorem on pth moment ISS of stochastic retarded systems with Markovian switching is derived to cope with the large, fast varying and non differential time delays. Boundedness of nonlinear Markovian switching stochastic delay system without

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