Chapter 24
Delay-Range-Dependent Robust Stability for Uncertain Stochastic Neural Networks with Time-Varying Delays

Wei Feng
Chongqing University and Chongqing Education College, China

Haixia Wu
Chongqing University and Chongqing Education College, China

ABSTRACT

This paper is concerned with the robust stability analysis problem for uncertain stochastic neural networks with interval time-varying delays. By utilizing a Lyapunov-Krasovskii functional and conducting stochastic analysis, the authors show that the addressed neural networks are globally, robustly, and asymptotically stable if a convex optimization problem is feasible. Some stability criteria are derived for all admissible uncertainties, and these stability criteria are formulated by means of the feasibility of a linear matrix inequality (LMI), which can be effectively solved by some standard numerical packages. Five numerical examples are given to demonstrate the usefulness of the proposed robust stability criteria.

INTRODUCTION

The dynamics of neural networks has been extensively investigated in the past two decades because of their great significance for both practical and theoretical purposes. At the same time, neural networks have been successfully applied in many areas such as combinatorial optimization, signal processing, pattern recognition and many other fields (Wang, 2009, pp. 41-48; Chen, 2010, pp. 345-351; Mingo, 2009, pp. 67-80). However, all successful applications are greatly dependent on the dynamic behaviors of neural networks. As is well known now, stability is one of the main

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properties of neural networks, which is a crucial feature in the design of neural networks. On the other hand, axonal signal transmission delays often occur in various neural networks, and may cause undesirable dynamic network behaviors such as oscillation and instability. Up to now, the stability analysis problem of neural networks with time-delays has been attracted a large amount of research interest and many sufficient conditions have been proposed to guarantee the asymptotic or exponential stability for the neural networks with various type of time delays such as constant, time-varying, or distributed. (Forti, 1994, pp. 491-494; Arik, 2000, pp. 1089-1092; Liao, 2002, pp. 855-866; Mou, 2008, pp. 532-535; Liu, 2008, pp. 823-833; Feng, 2009, pp. 414-424; Feng, 2009, pp. 2095-2104).

It is worth noting that the synaptic transmission is a noisy process brought on by random fluctuations from the release of neurotransmitters and other probabilistic causes in real nervous systems. It has also been known that a neural network could be stabilized or destabilized by certain stochastic inputs (Blythe, 2001, pp. 481-495). Hence, the stability analysis problem for stochastic neural networks becomes increasingly significant, and meantime some results related to this problem have recently been published (Liao, 1996, pp. 165-185; Wan, 2005, pp. 306-318; Wang, 2007, pp. 62-72; Zhang, 2007, pp. 1349-1357). On the other hand, the connection weights of the neurons depend on certain resistance and capacitance values that include uncertainties. When modeling neural networks, the parameter uncertainties (also called variations or fluctuations) should be taken into account, and therefore the problem of stability analysis for neural networks emerges as a research topic of primary importance (Kim, 2005, pp. 306-318; Huang, 2007, pp. 93-103; Liu, 2007, pp. 455-459).

Recently, a special type of time delays in practical engineering systems, i.e., interval time-varying delays, is identified and investigated (He, 2006, pp. 1235-1239; Jiang, 2006, pp. 1059-1065; Yue, 2005, pp. 999-1007; Yue, 2006, pp. 658-664). Interval time-varying delay is a time delay that varies in an interval in which the lower bound is not restricted to be zero. A typical example of dynamical systems with interval time-varying delays is networked control systems (NCSs) (Yue, 2006, pp. 658-664; Tian, 2007, pp. 103-107). As far as we know, there are systems which are stable with some nonzero delays, but they are unstable without delays (Gu, 2001, pp. 479-504; Zhao, 2004, pp. 399-407; Gu, 2001, pp. 737-744). Therefore, it is important to perform the stability analysis of systems with nonzero delays (Yue, 2005, pp. 999-1007; Tian, 2001, pp. 544-559; Jiang, 2005, pp. 2099-2106), and the nonzero delays can be placed into a given interval. This paper will address uncertain stochastic neural networks with interval time-varying delays.

In most published papers, the stochastic analysis problems and the robust stability analysis problems have been treated separately. There are few results considering the global stability analysis problem for uncertain stochastic neural networks with interval time-varying delays, a well-known inequality was used repetitively, which may lead some conservative results. Therefore, to the best of the authors' knowledge, the robust stability analysis problem for uncertain stochastic neural networks with interval time-varying delays has not been fully investigated, which still remains important and challenging.

Based on the above discussion, a class of uncertain stochastic neural networks with interval time-varying delays is considered in this paper. The main purpose of this paper is to study the global robust stability in the mean square for uncertain stochastic neural networks with interval time-varying delays. The parameter uncertainties are assumed to be norm bounded. A stability criterion is developed by using the Lyapunov stability theory and the LMI technique. The LMI condition can be efficiently solved by Matlab LMI Control Toolbox, and no tuning of parameters is required (Boyd, 1994). Numerical examples are given to