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Delayed state-feedback control for stabilization of neural networks with leakage delay ☆

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Abstract

This paper mainly deals with the problem of designing delayed state-feedback controller for neural networks with leakage delay. By constructing an appropriate Lyapunov-Krasovskii functional including double integral terms having two different exponential decay rates and utilizing linear matrix inequality (LMI) technique with the help of slack variables, some sufficient conditions for globally exponential stabilization results are obtained by designing of delayed state-feedback controller. The novelty of this paper includes: (i) although many papers dealt with dynamics of neural networks with leakage delay, there is little work on design of feedback controller. Even there is almost no result that deal with the delay-feedback controller for such delay systems, which is the main motivation of this paper; (ii) the derived delay-dependent stability criteria establish the relationship between leakage delay and time delay in the feedback term, which can be easily checked via the MATLAB LMI toolbox; (iii) we consider the general case that the control term is given in the form of Bu, where B is an $n \times m$ real matrix. Such case is more difficult to handle than the special case that B is unite matrix. It indicates that the controller can be used in all states or in some states by proper selection of the matrix B. The effectiveness of the proposed method in this paper is illustrated via numerical examples.

Key words: Neural networks; Delayed state-feedback; Leakage delay; Globally exponential stability; Linear matrix inequalities.

1. Introduction

Over the past two decades, neural networks have attracted a lot of interests and obtained a lot of developments due to its potential applications in optimization problems, signal processing, associative memory, image processing, fault diagnosis, and so on [1–5]. Indeed, various classes of neural networks such as cellular neural networks, Hopfield neural networks and Gohen-Grossberg neural networks have been widely studied in the literature [6–8]. In some other applications, the qualitative analysis of the dynamical behaviors is a key step for the practical design of the neunal networks, and many important results had been reported in literature, see [9–12] and the references therein. For example, [9] developed the passivity conditions for discrete-time switched neural networks with mixed time delay; [10] concerned the exponential stability for a class of neural networks with time-varying delay, and a less conservative exponential stability criterion for the neural networks with time-varying delay is obtained; [11] gave some delay-dependent robust stability criteria for uncertain neutral systems with mixed delays; [12] discussed the problem of lag synchronization for neural networks with time delay via impulsive control, and some delay-dependent synchronization criteria expressed in terms of linear matrix inequalities are derived. As we know, in the implementation of neural networks, time delays are unavoidably encountered [13], and it's hard to handle. What's more, the existence of time delays may destroy the stability or weaken the performance, which is harmful to the applications of neural networks. Therefore, the stability analysis of neural networks with time delays has received much attention, for example, see [13–17] and references therein.

In many practical problems, there exist a typical time delay which is quite different from the traditional time delays, called leakage delay, and it was often ignored in modeling many of models in the past. Generally speaking, the leakage delay often has a tendency to destabilize the neural networks, which was discussed in [18]. Moreover, it has been shown in [19] that the leakage delays are difficult to handle because it has quick tendency to destabilize the system performance. But like the traditional time delays, the leakage delays also have a great impact on the dynamics of different kinds of neural networks and

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