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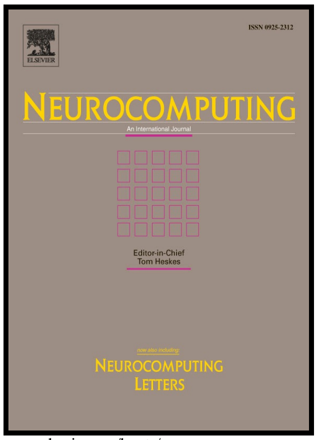

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State Estimation for Recurrent Neural Networks with Unknown Delays: a Robust Analysis Approach

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Abstract

In this paper, the state estimation problem is investigated for recurrent neural networks with unknown delays both in state equation and output equation. By constructing the Taylor series and linear matrix inequality (LMI) technique, the sufficient conditions of state estimation for a kind of recurrent neural networks with unknown delays are presented, therefore, the error system is globally asymptotically stable with L_∞ performance. The design observer can attenuate the effect of the unknown delays on a pre-defined performance output, and the observer gain can be obtained by solving a set of linear matrix inequalities. Some remarks and examples are given to show the effectiveness of the proposed method in comparison with some existing results.

Keywords: Recurrent neural networks, state estimation, unknown delay, L_∞ stable, global asymptotic stability, performance index

1. Introduction

In the past few decades, delayed recurrent neural networks have been applied successfully in many areas such as signal processing, pattern recognition, associative memories, parallel computation, and optimization solvers. In such applications, the qualitative analysis of the dynamical behaviors is a necessary step for the practical design of neural networks [1, 2, 3]. Some results on the dynamical behaviors have been reported for delayed neural networks, for example, most works for delayed neural networks have focused on the stability analysis [4, 5, 6, 7, 8, 9, 10, 11, 12].

Recently, it has been witnessed a growing interest in investigating recurrent neural networks(RNNs) owing to its potential applications such as signal processing, pattern recognition, static image processing, associative memory, and combinatorial optimization. When designing a neural network to handle complicated nonlinear problems, time delay can be frequently encountered in the neural networks. It is frequently encountered due to the finite signal propagation time in biological networks and the finite switching speeds of the amplifiers. Therefore, the problem of stability of delayed neural networks is important in both theory and practice. On the other hand, the neuron states in relatively large scale neural networks are not often completely available in the network outputs. Thus, in many applications, one often needs to know the information about the neuron states and then use the estimated neuron states to achieve certain objectives such as state feedback control. Based on the discussion, the state estimation problem for delayed neural networks is thus of great importance and practical significance from the point of view of theory and engineering [14, 15, 16, 17, 18, 19, 20, 21, 22, 23].

In the network outputs of large-scale neural networks, neuron state estimation problem has been gaining considerable attention, where the estimated neuron state can used to achieve certain practical performances, such as system

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