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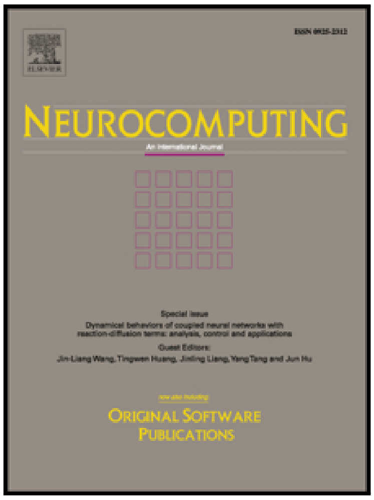

Delay-dependent and delay-independent passivity of a class of recurrent neural networks with impulse and multi-proportional delays

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Delay-dependent and delay-independent passivity of a class of recurrent neural networks with impulse and multi-proportional delays[☆]

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Abstract

The problem for passivity of a class of recurrent neural networks (RNNs) with impulse and multi-proportional delays is investigated in this paper. Several delay-dependent and delay-independent passivity criteria for the given system are obtained by establishing appropriate Lyapunov-krasovskill functionals and applying matrix inequality approach. The passivity criteria here are presented in the form of linear matrix inequalities (LMIs), which can be easily verified by Matlab Toolbox. Simultaneously, the criteria obtained here include the passivity results of RNNs without impulse or without delays as special cases and can also be extended to other RNNs with more complicated impulsive noise. Finally, two numerical examples with some simulations shows that the proposed results are effective.

Keywords: Recurrent neural networks · Proportional delay · Passivity · Impulse effect · Lyapunov-krasovskill functional · Matrix inequality

1. Introduction

Recurrent neural networks (RNNs) possess the feedback functions, which make them become excellent systems in dynamics, such as Hopfield neural networks (HNNs), Cohen-Grossberg neural networks (CGNNs), cellular neural networks (CNNs) and bidirectional associative memory neural networks (BAMNNs). In 1982, Hopfield first proposed a HNNs model for the TSP problem (NP complete traveling salesman problem). In 1983, Cohen and Grossberg proposed a generalized CGNNs model, which is mainly applied to associative memory storage. In 1988, Chua and Yang put forward originally the CNNs model which is mainly used in the fields of image processing, pattern recognition and associative memory. A BAMNNs model was proposed by Kosko in 1988, which was used in the fields of learning and memory. In 1990, Chua and Kosko proposed a class of delayed CNNs to deal with moving images. Since then, all kinds of neural networks with delays have received much attention [1, 2, 3, 4]. In fact, in the process of signal transmission, the system will produce delay, and delay can cause the system instability, chaos and turbulence phenomenon. Therefore, the study on delayed recurrent neural networks (DRNNs) accords with actual situation. In the past decades, RNNs with time delays have been studied widely and have become the focus of research. In recent years, DRNNs have been extensively and intensively studied due to their successful applications in the fields of pattern recognition, mobile image processing, associative memory, nonlinearly constrained optimization problem, etc. In these applications, various dynamic properties of DRNNs play many important roles.

The passivity is also one of the important dynamical properties of the RNNs. The passivity theory was firstly proposed in the circuit analysis and has obtained extensive attentions in the analysis and design of dynamic systems consisting of linear system, nonlinear system and so on [5, 6]. Usually, the passive system refers that the energy received from external environment is higher than the energy dissipated within the dynamic system, in other words the passive properties of a system can keep internal stability [7]. Furthermore, the passivity theory plays an important role in many different areas, such as continuous singular system, chaotic system, fuzzy control system, energy management and so on [8, 9, 10, 11, 12]. At present, the passivity theory has been applied to DRNNs and a great deal of criteria were proposed [14, 15, 16, 17, 18, 19]. In [14], by employing an improved free-weighting matrix approach and Lyapunov-Krasovskii functional method, passivity was dealt with for neural networks (NNs) with both time-varying delays and norm-bounded parameter uncertainties. In [15], the delay-dependent passivity was studied by use of the delay partitioning method for the singular Markov jump system with time-varying delays. In the sense of Filippov solutions, the passivity of a class of memristor-based RNNs with time-varying delays was discussed by constructing appropriate Lyapunov-Krasovskii functionals/Lyapunov functionals, using the characteristic function techniques and inequality techniques in [16, 17, 18]. In [19], the delay-dependent passivity of impulsive NNs with time-varying delays was studied by applying Lyapunov-Krasovskii functionals and matrix inequality approach.

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