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Synchronization stability of memristor-based complex-valued neural networks with time delays

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Abstract

This paper focuses on the dynamical property for a class of memristor-based complex-valued neural networks (MCVNNs) with time delays. By constructing the appropriate Lyapunov functional and utilizing the inequality technique, sufficient conditions are proposed to guarantee exponential synchronization of the coupled systems based on drive-response concept. The proposed results are very easy to verify, and they also extend some previous related works on memristor-based real-valued neural networks. Meanwhile, the obtained sufficient conditions of this paper may be conducive to qualitative analysis for some complex-valued nonlinear delayed systems. A numerical example is given to demonstrate the effectiveness of our theoretical results.

Keywords: Complex-valued neural networks, Exponential synchronization, Memristor, Time delays.

1. Introduction

Memristor is known as the fourth fundamental passive circuit element besides the resistor, capacitor and inductor in circuitry. It was firstly postulated theoretically by Chua (Chua, 1971), whereafter, scientists had spent nearly 40 years to develop the practical memristor device. Until 2008, the prototype of memristor was successfully realized based on nanotechnology by scientists of a research team at Hewlett-Packard Laboratories and the finding was published in Nature (Strukov, Snider, Stewart, & Williams, 2008; Tour, & He, 2008). Memristor has a lot of properties, such as low power, high density, and good scalability. As a result of these properties, increasing interest from various fields has been paid to memristor, such as low-power computation, booting free computer, brain-like computer and nonvolatile memory storage (Itoh, & Chua, 2008; Itoh, & Chua, 2009; Pershin, & Di, Ventra 2011; Corinto, Ascoli, & Gilli, 2011). More importantly, the value (memristance) of memristor is not fixed and it depends on the voltage applied to the corresponding state. Therefore, memristors are used to replace resistors as synaptic weights in artificial neural networks, which can better emulate the human brain (Adhikari, Yang, Kim, & Chua, 2012; Sharifi, & Banadaki, 2010; Zhang, Xu, Li, Yu, Liu, & Zhu, 2012).

For the past few decades, the dynamical behaviors of a variety of nonlinear systems have been widely investigated (Fu, Ma, & Chai, 2015; Zhang, Mou, Lam, & Gao, 2009; Zhu, Yang, & Shen, 2016; Wang, Gao, Qiu, & Ahn, 2016; Liu, Zhou, Liang, & Wang, 2017; Zhou, Wu, & Shi, 2016; Wei, Qiu, & Karimi, 2017a, 2017b; Wei, Qiu, Karimi, & Wang, 2014; Wei, Qiu, Karimi, & Wang, 2015). For example, in Fu et al. (2015), global finite-time stability for a class of switched nonlinear systems with the powers of positive odd rational numbers has been investigated. The piecewise-affine memory $\mathcal{H}_\infty$ filtering problem for nonlinear systems with time-varying delay in a delay-dependent framework has been studied in Wei et al. (2017b). New passivity criteria for neural networks have been proposed in Zhang et al. (2009). With the extensive applications of memristor, memristor-based connection weights have been taken into consideration in neural networks to construct a class of memristor-based neural networks (MNNs). Different from the conventional neural networks, MNNs are a class of state-dependent switched nonlinear dynamical systems. Thus, the dynamical analysis for MNNs has received much attention from various areas, such as the global exponential stability (Zhang, Shen, Yin, & Sun, 2013; Zhang, Shen, & Sun, 2012; Sheng, Shen, & Zhu, 2016), input-to-state stability (Zhong, Yang, & Zhu, 2016), Lagrange stability (e.g. Wu, & Zeng, 2014), synchronization (Zhang, & Shen, 2013; Wu, Wen, & Zeng, 2012; Zhang, & Shen, 2014), anti-synchronization (Zhang, Shen, & Wang, 2013; Wu, & Zeng, 2013), and passivity analysis (Wen, Zeng, Huang, & Chen, 2013; Guo, Wang, & Yan, 2014; Wang, & Shen, 2014).

At present, most of the dynamical analyses for nonlinear systems are discussed in real number domains, which can not satisfy some requirements in engineering applications and hardware implementations, that is because some problems can not be solved in real number domains, they can only be solved in complex number domains. For instance, the detection of symmetry problem and XOR

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