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Exponential stability of complex-valued memristor-based neural networks with time-varying delays☆

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ABSTRACT

In this paper, we propose a new type of complex-valued memristor-based neural networks with time-varying delays and discuss their exponential stability. Firstly, by using a matrix measure method, the Halanay inequality and some analytic techniques, we derive a sufficient condition for the global exponential stability of this type of neural networks. Then, we build a Lyapunov functional and utilize the Halanay inequality to establish several criteria for the exponential stability of such networks with time-varying delays. Finally, we show two numerical simulations to demonstrate the theoretical results.

1. Introduction

In recent years, the dynamical attributes of complex-valued neural networks motivated more and more research interest because this kind of neural networks have many applications in optimization of wireless communication, electromagnetic imaging, signal processing, pattern recognition, and so on [1–6]. Actually, complex-valued neural networks can solve some problems which cannot be solved by real-value neural networks, such as the XOR problem and the detection of symmetry [7].

Since 1971, memristor was coined and reported by Chua [8]. In 2008, some other researchers declared the invention of practical memristor device [9,10]. As is well known now, memristor has memories and can be made in nano-scale sizes. Even from earlier works, it has been realized that memristors have similar characteristics as neurons in the biological brain. Thanks to this special feature, memristor device can be applied to construct a novel class of complex-valued neural networks to imitate the brain.

In the literature, there are many reports on memristor-based neural networks [11–23] and complex-valued neural networks [24–36]. But noticeably not so many were devoted to studying complex-valued memristor-based neural networks, except a few. In [25], finite-time stability of fractional-order complex-valued memristor-based neural networks was discussed based on fractional-order differential inclusion theory, Mittag–Laffler functions theorem and a generalized Gronwall inequality. In [24–26], the dissipativity and passification of complex-valued memristor-based neural networks were investigated,

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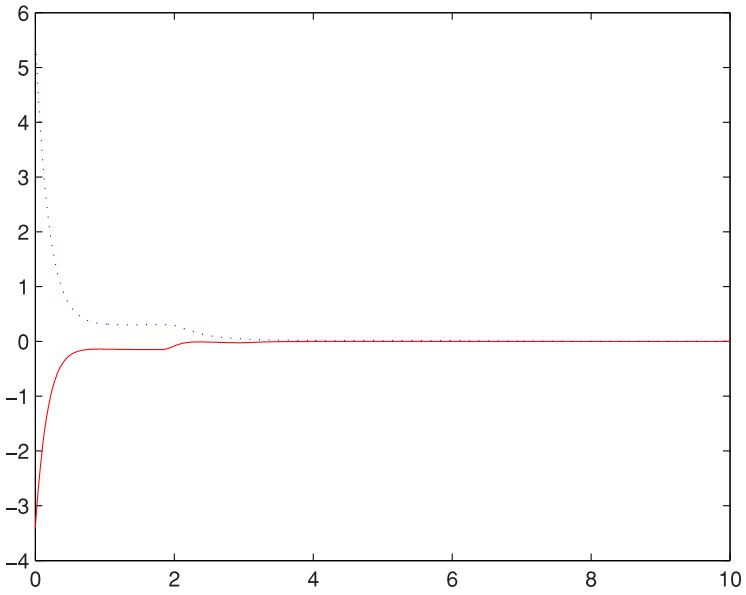

Fig. 1. Phase trajectories of the real parts $x(t)$ in Example 1.

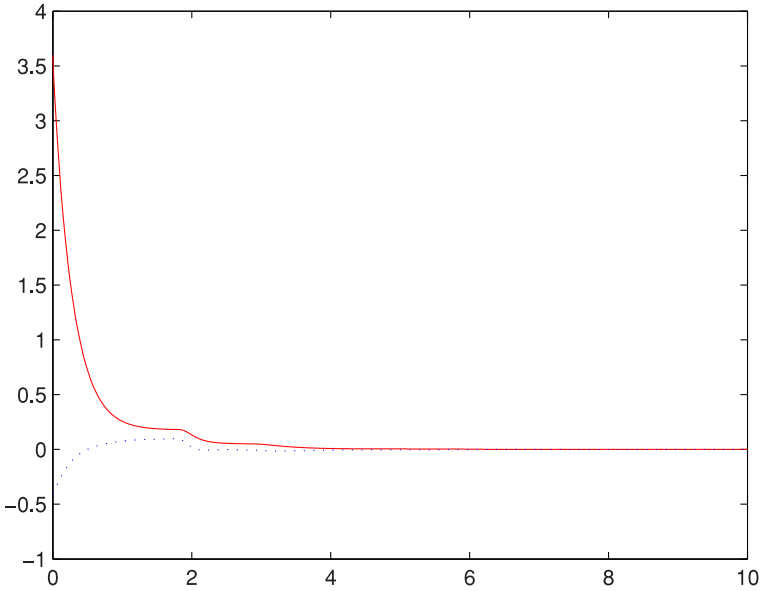

Fig. 2. Phase trajectories of the state variables of the imaginary parts $y(t)$ in Example 1.

specifically the existence and uniqueness of a new kind of complex-valued memristive recurrent neural networks proposed in [27], where several sufficient conditions on the exponential stability were obtained by using the M-matrix theory and Lyapunov functions.

Inspired by the above analysis and discussions, we propose a new type of complex-valued memristor-based neural network with time-varying delays in this paper, and discuss its exponential stability. In Section 2, the model of the complex-valued memristor-based neural networks with time-varying delays, as well as some preliminaries, will be given. In Section 3, some sufficient conditions will be derived for the global exponential stability of this type of neural networks. In Section 4, several numerical simulations will be given to demonstrate the theoretical results. The last section concludes the paper.