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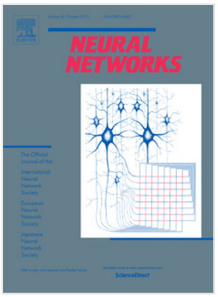

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Controller design for global fixed-time synchronization of delayed neural networks with discontinuous activations

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Abstract

This paper addresses the controller design problem for global fixed-time synchronization of delayed neural networks (DNNs) with discontinuous activations. To solve this problem, adaptive control and state feedback control laws are designed. Then based on the two controllers and two lemmas, the error system is proved to be globally asymptotically stable and even fixed-time stable. Moreover, some sufficient and easy checked conditions are derived to guarantee the global synchronization of drive and response systems in fixed time. It is noted that the settling time functional for fixed-time synchronization is independently on initial conditions. Our fixed-time synchronization results contain the finite-time results as the special cases by choosing different values of the two controllers. Finally, theoretical results are supported by numerical simulations.

Keywords: Delayed neural networks, discontinuous activations, global fixed-time synchronization, adaptive control, state feedback control

1. Introduction

Synchronization is a foundation to cognize an unknown dynamical system via another well-known dynamical system since it generally indicates the state trajectories of two systems are in accord with each other as time varies. Recently, synchronization of DNNs has been a hot topic for its potential applications in secure communication and signal processing. Lots of asymptotic and exponential synchronization results have been obtained under varied control approaches, such as linear state feedback control (Wang et al., 2013b; Wen & Zeng, 2013; Wu & Zeng, 2012; Zhang et al., 2013), adaptive control (Wang et al., 2015; Zhang et al., 2007), delay control (Karimi & Gao, 2010; Wang & Shen, 2015b), sample data control (Wu et al., 2012) and intermittent control (Zhang et al., 2015).

As is well known, the neuron activation function plays an important role in the dynamical analysis of DNNs. As the extension of continuous activations, discontinuous activations can be better applied to the DNNs model when the gain of the neuron amplifiers is very high (Forti & Nistri, 2003). Moreover, DNNs with discontinuous activations possess potential applications in impacting machines, power circuits and optimization problem (Chandrasekar et al., 2015; Forti & Nistri, 2003; Forti et al., 2005; Guo & Huang, 2009; Liu et al., 2011, 2014; Wang et al., 2009; Yang et al., 2015). Therefore, it is of great significance to consider the discontinuous activations in DNNs.

Finite-time convergence has attracted increasing attentions since it satisfies the time response in some reality circumstances (Bhat & Bernstein, 2000; Efimov et al., 2014; Moulay et al., 2008). Finite-time convergence offers the state convergence with finite settling time to the equilibrium state, thus it is better than the asymptotical or exponential convergence with infinite settling time. For the finite-time stability or synchronization of neural networks, lots of criteria have been established by using different control methods (Abdurahman et al., 2015; Hu et al., 2014; Huang et al., 2014; Jiang et al., 2015; Liu et al., 2014; Mei et al., 2013; Shen & Cao, 2012; Velmurugan et al., 2016; Wang et al., 2016; Wang & Shen, 2015a; Yang et al., 2015). Based on the delayed feedback control, the finite-time convergence of DNNs was studied with continuous activations in Abdurahman et al. (2015); Hu et al. (2014) and with discontinuous activations in Wang et al. (2016), respectively. Under discontinuous activations and controller, Liu et al. (2014) addressed the finite-time stabilization problem of neural networks via nonsmooth analysis. Mei et al. (2013) designed an effective feedback control with an updated law to actualize the synchronization in finite time between two chaotic neural networks. Under the nonlinear controller, the finite-time stabilizability problem was discussed for memristive DNNs in Wang & Shen (2015a).

The settling time for finite-time convergence heavily depends on the initial conditions, which gives rise to different convergence times under different initial conditions. As the extension of finite-time convergence, the fixed-time convergence implies the settling time is bounded by some positive constant (Polyakov, 2012; Polyakov et al., 2015). In other words, the settling time is independent of initial conditions and then is not under the influence of initial conditions. The fixed-time

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