Applied Mathematics and Computation 313 (2017) 37–51

Contents lists available at ScienceDirect

Applied Mathematics and Computation

journal homepage: www.elsevier.com/locate/amc

Exponential and fixed-time synchronization of Cohen–Grossberg neural networks with time-varying delays and reaction-diffusion terms[☆]

Ruoxia Li[a], Jinde Cao[a,b,*], Ahmad Alsaedi[c], Fuad Alsaadi[d]

[a] School of Mathematics, and Research Center for Complex Systems and Network Sciences, Southeast University, Nanjing 210096, China
[b] Department of Mathematics, Faculty of Science, King Abdulaziz University, Jeddah 21589, Saudi Arabia
[c] Nonlinear Analysis and Applied Mathematics (NAAM) Research Group, Faculty of Science, King Abdulaziz University, Jeddah 21589, Saudi Arabia
[d] Department of Electrical and Computer Engineering, Faculty of Engineering, King Abdulaziz University, Jeddah 21589, Saudi Arabia

ARTICLE INFO

Keywords:
Cohen–Grossberg neural network
Exponential synchronization
Fixed-time synchronization
Reaction-diffusion

ABSTRACT

This paper is devoted to the global exponential and fixed-time synchronization of delayed reaction-diffusion Cohen–Grossberg neural networks. Adaptive controllers are designed such that the addressed system can realize global exponential synchronization goal under the framework of inequality techniques, Lyapunov method as well as some suitable assumptions. Furthermore, as corollaries, the corresponding conclusion is provided to ensure the delayed Cohen–Grossberg neural networks without reaction-diffusion term can reach fixed-time synchronization goal. In addition, the settling time of fixed-time synchronization can be adjusted to desired values regardless of initial conditions, which is more reasonable. Finally, two numerical examples and its simulations are given to show the effectiveness of the obtained results.

1. Introduction

As one of the most popular and typical neural networks, Cohen–Grossberg system was initially proposed in 1983 [1], which contains some well-known neural network models as its special cases, such as cellular NNs, Hopfield NNs, and bidirectional associative memory NNs. In the past few decades, this kinds of system have received increasing interesting due to its wide application in classification, pattern formation, association memories, parallel computation and solving optimization problems. Such applications heavily rely on its dynamical behaviors, thus, the qualitative analysis of its dynamical behaviors is a necessary step for the practical design and application of neural networks [2–9].

In the course of studying neural networks, it is found that the diffusion phenomena could not be ignored in neural networks and electric circuits once electrons transport in a nonuniform eletromagnetic field. For example, the multilayer

☆ This work was jointly supported by the National Natural Science Foundation of China under Grant nos. 61573096 and 61272530, the Natural Science Foundation of Jiangsu Province of China under Grant no. BK2012741, the “333 Engineering” Foundation of Jiangsu Province of China under Grant no. BRA2015286, the “Fundamental Research Funds for the Central Universities ”, the JSPS Innovation Program under Grant KYZZ16_0115, and Scientific Research Foundation of Graduate School of Southeast University under Grant no. YBJJ1663.

* Corresponding author at: School of Mathematics, and Research Center for Complex Systems and Network Sciences, Southeast University, Nanjing210096, China.

E-mail addresses: ruoxiali1227@163.com (R. Li), jdcao@seu.edu.cn (J. Cao).

http://dx.doi.org/10.1016/j.amc.2017.05.073
0096-3003/

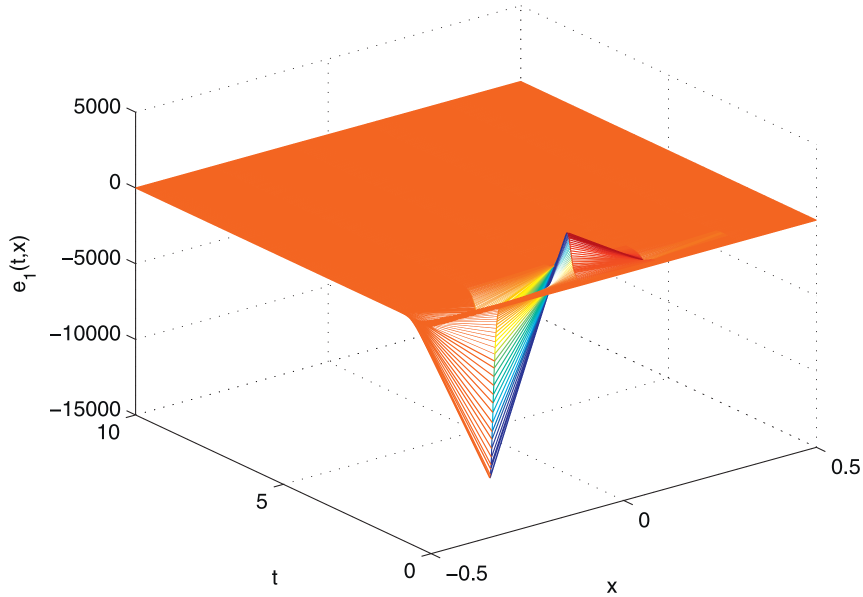

Fig. 1. Synchronization errors $e_1(t, x)$ between systems (1) and (4) under the adaptive controller (8).

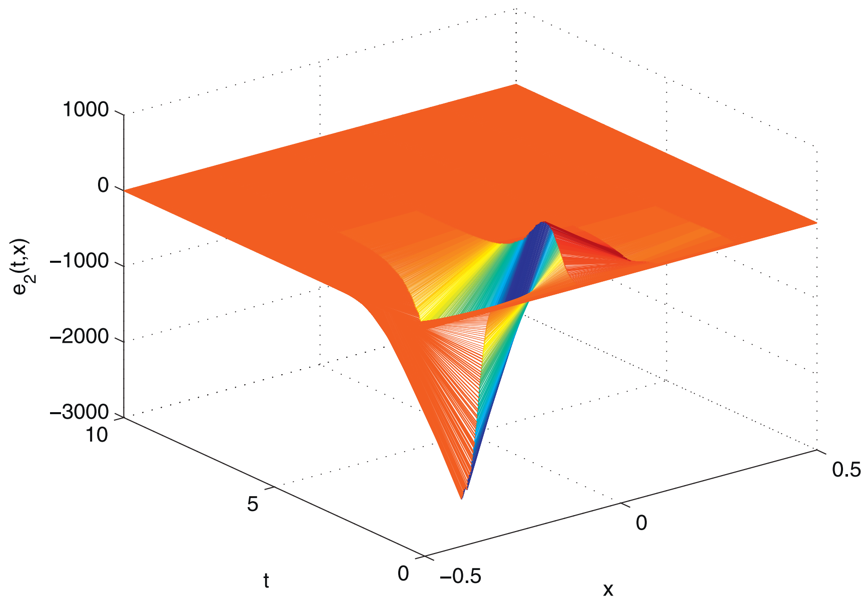

Fig. 2. Synchronization errors $e_2(t, x)$ between systems (1) and (4) under the adaptive controller (8).

cellular neural networks (MCNNs) are arrays of nonlinear and simple computing elements characterized by local interactions between cells, therefore, the paradigm are well suited to describe locally interconnected simple dynamical systems showing a lattice-like structure [10]. In other words, the whole structure and dynamic behavior of MCNNs are seriously dependent on the evolution time of each variable and its position (space), as well as its interactions deriving from the space-distributed structure of whole networks. So, it is essential to consider the state variables varying with time and space variables. On the other hand, there are a large number of reaction-diffusion phenomena in nature and many discipline fields, especially in chemistry and biology fields. Thus, it is natural to consider the states of the neurons vary in space as well as in time [11–16].

Synchronization, which means that two or more systems share a common dynamical behavior, and this common behavior can be induced by coupling or by external force. In the real word, synchronization phenomenon is very important in consideration of its potential applications in many different areas including secure communication, biology systems, optics, and information processing [17–29]. By means of impulsive control technique, the corresponding lag synchronization