Preface

Up to date, many researchers have devoted much effort to dynamical behaviors for coupled neural networks (CNNs) because of their wide applications in different fields. For instance, the CNNs have been triumphantly applied to harmonic oscillation generation, chaos generators design, secure communication, the electronic circuits, and memorizing and reproducing complex oscillatory patterns. Moreover, the research about synchronization of CNNs is a significant step to comprehend brain science. On the other hand, it is well known that neural networks are implemented by electric circuits, and the diffusion phenomena inevitably appear in electric circuits once electrons transport in a nonuniform electromagnetic field. Obviously, it is extremely necessary to consider the diffusion phenomena in coupled neural networks. Therefore, the investigation of dynamical behaviors about coupled reaction-diffusion neural networks (CRDNNs) has both practical and theoretical significance.

The aim of this book is to introduce recent research work on analysis and control of the passivity and synchronization for CRDNNs. This book is organized as follows:

Chapter 1: The background of reaction-diffusion neural network and CRDNNs is introduced as well as the organization of this book, and some important definitions, useful lemmas, and some basic knowledge about graph are also provided in this chapter.

Chapter 2: Two types of CRDNNs are proposed in this chapter. In the first one, the nodes are coupled through their states. In the second one, the nodes are coupled through the spatial diffusion terms. The synchronization of the first model is investigated by utilizing Lyapunov functional method and pinning control technique. In addition, considering that the theoretical coupling strength required for synchronization may be much larger than the needed value, we propose an adaptive strategy to adjust the coupling strength for achieving suitable value. For the latter, we establish a criterion for synchronization by using the designed pinning controllers. It is found that the CRDNNs with state coupling under the given linear feedback pinning controllers can realize synchronization when the coupling strength is very large, which is contrary to CRDNNs with spatial diffusion coupling.

Moreover, a general criterion for ensuring network synchronization is derived by pinning a small fraction of nodes with adaptive feedback controllers.

Chapter 3: This chapter is concerned with a directed CRDNNs. Based on the Lyapunov functional method and the pinning control technique, some sufficient conditions are obtained to guarantee the synchronization of the proposed network model. In addition, an adaptive strategy is proposed to obtain appropriate coupling strength for achieving network synchronization. Furthermore, the pinning adaptive synchronization problem is also investigated in this chapter, and a general criterion for ensuring network synchronization is established.

Chapter 4: This chapter applies the impulsive control method to achieve the synchronization of CRDNNs with time-varying delay. By combining the Lyapunov functional method with the impulsive delay differential inequality and comparison principle, a few sufficient conditions are derived to guarantee the global exponential synchronization of coupled neural networks with reaction-diffusion terms. Especially, the estimate for the exponential convergence rate is also given, which relies on time delay, system parameters, and impulsive interval.

Chapter 5: Two types of CRDNNs are proposed and the adaptive synchronization of these two types of CRDNNs is, respectively, investigated in this chapter. Based on local information of node dynamics, some novel adaptive strategies to tune the coupling strengths among network nodes are designed. By constructing appropriate Lyapunov functionals and utilizing inequality techniques, several sufficient conditions are given for reaching synchronization by using the designed adaptive laws.

Chapter 6: This chapter proposes a model of CRDNNs with hybrid coupling, which is composed of spatial diffusion coupling and state coupling. By utilizing the Lyapunov functional method combined with the inequality techniques, a sufficient condition is given to ensure that the proposed network model is synchronized. In addition, when the external disturbances appear in the network, a criterion is obtained to guarantee the $\mathcal{H}_\infty$ synchronization of the network. Moreover, some adaptive strategies to tune the coupling strengths among network nodes are designed for reaching synchronization and $\mathcal{H}_\infty$ synchronization. Some criteria for synchronization and $\mathcal{H}_\infty$ synchronization are derived by using the designed adaptive laws.

Chapter 7: A CRDNNs consisting of N linearly and diffusively coupled identical RDNNs is proposed in this chapter. By utilizing some inequality techniques, a sufficient condition ensuring the output strict passivity is derived for the proposed network model. Then, we reveal the relationship between output strict passivity and synchronization of the proposed network model. Moreover, based on the obtained passivity result and the relationship between output strict passivity and synchronization, a criterion for synchronization is established.

Chapter 8: This chapter is concerned with the passivity problem of a model of CRDNNs with adaptive coupling. In order to ensure the passivity of the CRDNNs, some adaptive strategies to tune the coupling strengths among network nodes are designed. By utilizing some inequality techniques and the designed adaptive laws, several sufficient conditions ensuring passivity are obtained. In addition, we reveal the relationship between passivity and synchronization of the CRDNNs. Based on the obtained passivity results and the relationship between passivity and synchronization, a global synchronization criterion is established.

Chapter 9: This chapter considers two CRDNNs with different dimensions of input and output. The only difference between them is whether time-varying delay is incorporated in the mathematical model of network. We, respectively, analyze dissipativity and passivity of these CRDNNs. Firstly, for the systems with different dimensions of input and output vectors, two new passivity definitions are proposed. Then, by exploiting some inequality techniques, several dissipativity and passivity criteria for these CRDNNs are established. Furthermore, we analyze stability of passive CRDNNs.

Chapter 10: This chapter studies a CRDNNs consisting of N identical neural networks with reaction-diffusion terms. Firstly, several passivity definitions for the systems with different dimensions of input and output are given. By utilizing some inequality techniques, several criteria are presented, ensuring passivity of the CRDNNs under the designed adaptive law. Then, we discuss the relationship between synchronization and output strict passivity of the proposed network model. Furthermore, these results are extended to the case when topological structure of the network is undirected.

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