Chapter XXIV
Fuzzy Chaotic Neural Networks

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ABSTRACT

An understanding of the human brain’s local function has improved in recent years. But the cognition of human brain’s working process as a whole is still obscure. Both fuzzy logic and dynamic chaos are internal features of the human brain. Therefore, to fuse artificial neural networks, fuzzy logic and dynamic chaos together to constitute fuzzy chaotic neural networks is a novel method. This chapter is focused on the new ways of fuzzy neural networks construction and its application based on the existing achievement in this field. Four types of fuzzy chaotic neural networks are introduced, namely chaotic recurrent fuzzy neural networks, cooperation fuzzy chaotic neural networks, fuzzy number chaotic neural networks and self-evolution fuzzy chaotic neural networks. Chaotic recurrent fuzzy neural networks model is developed based on existing recurrent fuzzy neural networks through introducing chaos mapping into the membership layer. As it is a dynamic system, the input of neuron not only processes the information of former monument but also contains chaos maps information which is provided by dynamic chaos. Cooperation fuzzy chaotic neural network is proposed on the basis of simplified T-S fuzzy chaotic neural networks and Aihara chaotic neuron. It realizes fuzzy reasoning process by a neural network structure in which the rule inference part is realized by chaotic neural networks. Then enlightened by fuzzy number neural networks we propose a fuzzy number chaotic neuron, which is obtained by blurring the Aihara chaotic neuron. Using these neurons to construct fuzzy number chaotic neural networks, the mathematical model and weight updating rules are also given. At last, a self-evolution fuzzy chaotic neural network is proposed according to the principle of self-evolution network, which unifies the fuzzy Hopfield neural network constitution method.
INTRODUCTION

There is appreciable understanding of some partial functions of the human brain. The researches of perceptrons, visual processing network, and memory and so on, have attained certain levels of success. Unfortunately despite these successes the overall function of the human brain remains a real challenge to understand. At present scientists have already accumulated massive knowledge of basic and essential facts about brain composition, brain contour and cerebrum function, but are still unable to explain substantively, the question of brain information processing.

But the integrated function is in no way a simple combination the partial function. The consciousness and cognition process of the brain involves a complex dynamic system to carry on the massive neuron activity. The fact that people do not have a complete understanding of the human brain and work process, underscores a need for qualitative leap in this research (Zhu, D.Q., 2004).

It is well known, that neural network is an attempt to simulate the human brain’s structure and primary function. Fuzziness is a remarkable characteristic of human brain. The synergy of neural network and the fuzzy theory helps to address more complex questions in wider application domains with a solution model usually called the fuzzy neural network.

Chaos has been discovered to be a characteristic of the dynamics present in the brain. In the cranial nerve system, from the microscopic neuron and neural network, to the macroscopic brain wave and the brain magnetic wave, chaos were discovered in two aspects (Huang, R. S., 2000; Wang, Y. N, Yu, Q. M., & Yuan, X. F., 2006). Chaos theory could help understand certain irregular activities in the brain, thus the chaos dynamics provide people a new turning point to study the neural network. The chaos phenomenon is inherently a non-linear dynamics, and the neural network is also a highly non-linear dynamics system, so that both have a close correlation.

At present, the fuzzy neural network technology have been well developed, and widely applied in many kinds of domains. The chaos dynamics and the chaos neural network technology is an exciting emerging research area which yielded encouraging results from theory to application. From the existed literature, it can be seen that the proposed fuzzy neural network models (whether the static or dynamic models) do not consider the chaos characteristic of actual biological neural network (Liu, C. J., Liao, X. Z., & Zhang, Y. H. 2000; Juang, C. F., 2004; Yang, G., & Meng, J. E., 2005; Abdulhamit, S., 2006; Theocharis, J. B., 2006; Gu, L. L., & Deng, Z. L., 2006; Shashi, K., Sanjeev, K., Prakash, Ravi, S., Tiwari, M. K., & Shashi B. K., 2007). The chaotic neural network technology stems from chaos dynamic do not consider the fuzzy characteristic of actual biological neural network, and cannot process the fuzzy information. From the exist literature, the research of fuse fuzzy logic, chaos and artificial neural networks is extremely few at present.

There is an emerging interdisciplinary science that combines fuzzy logic, chaos dynamics and artificial neural networks paradigms. These three sciences individually reflect some aspects of the human brain information processing mechanism. From the existing literature however, a synergized approach which combines fuzzy logic, chaos and artificial neural networks is extremely few at present. Such a hybrid facilitates an overlapping of individual capabilities to establish a more robust system that has fuzzy reasoning ability, auto-adaptation ability, and chaos search ability.

The structure of the chapter is organized as follows: Backgrounds and Previous Research Work provides a detailed review and a background of the existing fuzzy, chaos, and neural networks theory development. The Main Thrust of the Chapter consists of four types of fuzzy chaotic neural networks. Concluding Remarks concludes the whole chapter with the special emphasis on the advantage of the four models. Finally, the future directions are addressed in Future Research Directions. The terms and definitions, as well as an additional reading list, can be found at the end of the chapter.

BACKGROUND AND PREVIOUS RESEARCH WORK

The fuzzy logic and the neural network study human’s cognition question from the different angle respectively. Fuzzy neural network is developed based on neural network and fuzzy system. Complimenting neural network and
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