Application of Chaotic Neural Model Based on Olfactory System on Pattern Recognitions

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Abstract. This paper presents a simulation of a biological olfactory neural system with a KIII set, which is a high-dimensional chaotic neural network. The KIII set differs from conventional artificial neural networks by use of chaotic attractors for memory locations that are accessed by, chaotic trajectories. It was designed to simulate the patterns of action potentials and EEG waveforms observed in electrophysioloical experiments, and has proved its utility as a model for biological intelligence in pattern classification. An application on recognition of handwritten numerals is presented here, in which the classification performance of the KIII network under different noise levels was investigated.

1 Introduction

In recent years, the theory of chaos has been used to understand the mesoscopic neural dynamics, which is at the level of self-organization at which neural populations can create novel activity patterns [1]. According to the architecture of the olfactory neural system, to simulate the output waveforms observed in biological experiments with EEG and unit recording, the KIII model, which is a high dimensional chaotic network, in which the interactions of globally connected nodes lead to a global landscape of high-dimensional chaotic attractors, was built.

In this paper we present two application examples of the KIII network for recognitions of image patterns and handwriting numerals [2].

2 Chaotic Neural Model Based on Olfactory System

The central olfactory neural system is composed of olfactory bulb (OB), anterior nucleus (AON) and prepyriform cortex (PC). In accordance with the anatomic architecture, KIII network is a multi-layer neural network model, which is composed of heirarchichal K0, KI and KII units. Fig.1 shows the topology of KIII model, in which M, G represent mitral cells and granule cells in olfactory bulb. E, I, A, B represent excitatory and inhibitory cells in anterior nucleus and prepyriform cortex respectively.

L. Wang, K. Chen, and Y.S. Ong (Eds.): ICNC 2005, LNCS 3610, pp. 378 – 381, 2005.

3 Application on Image Pattern and Handwriting Numeral Recognitions

Pattern recognition is an important subject of artificial intelligence, also a primary field for the application of Artificial Neural Network (ANN). KIII network is a more accurate simulation of the biological neural network than conventional ANN.

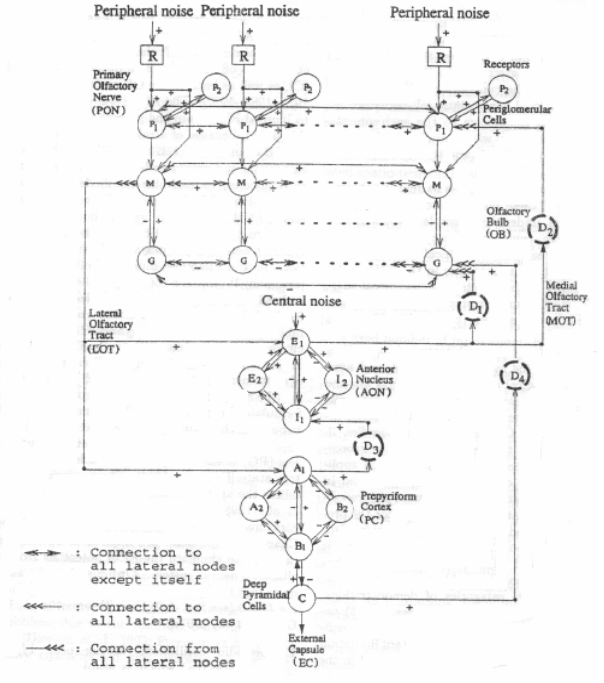

Fig. 1. Topology of the KIII network (Adapted from Chang & Freeman [3].)

Derived from the study of olfactory system, the distributed KIII-set is a high dimensional chaotic network, in which the interactions of globally connected nodes lead to a global landscape of high-dimensional chaotic attractors. After reinforcement learning to discriminate classes of different patterns, the system forms a landscape of low-dimensional local basins, with one basin for each pattern class [4]. The output of the system is controlled by the attractor, which signifies the class to which the stimulus belonged [5].

3.1 Classification of Image Patterns

In this article, we used the KIII model to classify image patterns. The parameters involved in our simulation in this paper were taken from the document [3].

First, the KIII model learned the desired patterns --- the 8*8 binary bitmap image of circle and isosceles triangle. Both patterns were learned for three times in turn. Second, the novel input images need to be preprocessed before classification: image segmentation, image zooming, edge detection, etc. Finally, we input the preprocessed