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Nonlinear Spring Model of Self-Organizing Map Arranged in Rectangular Grid and its Chaotic Behaviors

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1. Introduction

The Self-Organizing Map (SOM) is a subtype of artificial neural networks [1] and is a model simplifying self-organization process of the brain. However, SOM is still far away from the realization of the brain mechanism. In order to realize more powerful and more flexible mechanism, it is important to propose new models of the brain mechanism and to investigate their behaviors.

This study proposes $N \times M$ SOM model connected by the nonlinear spring. The proposed model consists of $N \times M$ neurons located at a rectangular grid.

2. Nonlinear Spring Model of SOM Arranged in $N \times M$

In this study, we propose the nonlinear spring model of SOM with a rectangular structure. The proposed model consists of neurons located at $N \times M$ rectangular grid, and the neurons are connected by the nonlinear spring. The model is shown in Fig. 1.

The input vectors are given to the 4 corners of the model, and the neuron nearest to the input becomes a winner. Therefore, the Neuron 11, $1M$, $N1$ or NM, becomes the winner, and it is attracted to the input. The other neurons always do not receive the direct effect from the input vector and are influenced only by the restoring force of the nonlinear spring from the neighboring neurons. The input pattern is that the input vectors are given to the corner of the model near the Neuron 11, $1M$, NM and $N1$ in rotation.

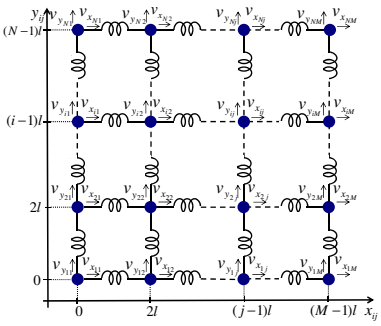
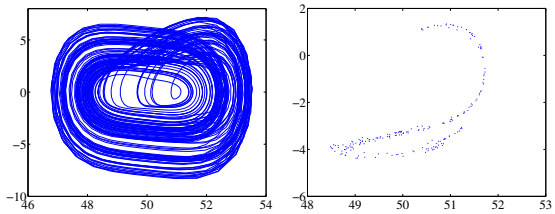


Figure 1: Nonlinear spring model of SOM with $N \times M$ rectangular shape.

3. Computer Simulation Results

We show computer calculation results obtained by using Runge-Kutta method. We set the initial states of the positions to its own physical location on the 2-D grid and the initial states of the velocities to 0.

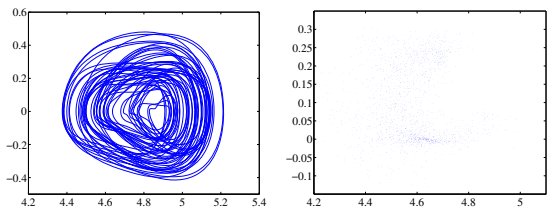
First, we consider the 2×2 model ($N = M = 2$). The projections of attractor onto x_{12}–$v_{x_{12}}$ and its Poincaré map are shown in Fig. 2. We can confirm that the orbit of attractor looks chaos. Poincaré map is folded and has the shape like strange attractors.



(a) (b)

Figure 2: Projection of attractor onto x_{12}–$v_{x_{12}}$ plane and its Poincaré map of 2×2 with $B = 15$, $l = 50$ and $k = 0.31$. (a) Attractor. (b) Poincaré map.

Furthermore, we consider the nonlinear spring model with 5×5 neurons ($N = M = 5$). The projections of attractor onto x_{53}–$v_{x_{53}}$ and its Poincaré map are shown in Fig. 3. We can see that the attractor and Poincaré map are more complex than the 2×2 model.



(a) (b)

Figure 3: Projection of attractor onto x_{53}–$v_{x_{53}}$ plane and its Poincaré map of 5×5 with $B = 0.89$, $l = 2$ and $k = 0.15$. (a) Attractor. (b) Poincaré map.

4. Conclusions

We have proposed the SOM model whose neurons are arranged in 2-dimensional array and connected by the nonlinear spring. We have considered the models arranged 2×2 and 5×5 array and have investigated their chaotic behaviors.

Reference

[1] T. Kohonen, *Self-organizing Maps*, Berlin, Springer, vol. 30, 1995.