Understanding Dynamics on Network Structure
- Applying New Visualization Method to Coupled Chaotic Systems -

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Theme: Network Theory

Introduction

In this research, we apply new visualization method, which we call "Footprints of Chaos", to coupled chaotic systems. In the method, the trajectory of nonlinear dynamics can be understood as a visual pattern on two-dimensional plane, converting the value of function, like a logistic equation (R. May, *Nature*, 1976), into an angle. This method has an ability to express various patterns depending on the control parameter. Therefore it is useful to understand the shape of attractor because the generated figures show the different patterns according to the type of attractor, such as fixed, period, and chaotic area. We should emphasize that this method has an advantage to visualize the unstable periodicity in the region of the chaotic area, in which we can observe the mixture of periodic patterns and chaotic complexity.

In this presentation, we propose the method to observe the both of a network structure and internal dynamics of each elements at the same time, and show some patterns on two types of network; the coupled map lattice (CML) and globally coupled map (GCM).

Results

Our method is useful to observe the both of a network structure and internal dynamics of each nodes in the coupled map lattice (CML) and the globally coupled map (GCM). These two models, which are proposed by K. Kaneko (1993), are simplest examples of networks of chaotic elements. In the case of CML, every node is neighbors of one another and the chaotic elements interact with both neighbors function. On the other hand, GCM is completely connected network and every node has an interaction to all. On these networks, an order is emerged and evolved in time with mutual influences. In the simulation of dynamics on network, it is usually difficult to observe the both of a network structure and internal dynamics of each element at the same time. However, the proposing method enables us to observe the both at the same time.

As a result of applying the methods to CML and GCM, we can understand the generated patterns have different feature from that of one and only one chaotic function. For example, nonsymmetrical patterns are generated in the network, despite only symmetrical patterns are generated when visualizing the one and only one function. Moreover we can observe that the dynamics on the networks is influenced by the type of network.

Although our experiment is done on the static network, we think that the proposed method is powerful in the case that the structure of network is dynamically changing over time. Today, the dynamics *of* network come to attention in network science, therefore the method is useful to visualize and understand the both of dynamics *on / of* network.