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Ratio of Chaotic Propagation in Scale Free Network by Changing Clustering Coefficient

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1. Introduction

In this study, in order to research the spread of chaotic behavior in various complex networks, we investigate the ratio of chaotic propagation in scale-free network with coupled chaotic circuits. The scale-free network is composed of coupled chaotic circuits when one circuit is set to generate chaotic attractor and the other circuits are set to generate three-periodic attractors. By using computer simulations, we investigate the ratio of propagation by changing the initial chaos position. Moreover, the initial position of chaotic attractor changes according to the clustering coefficient in each node.

2. Proposed method

The chaotic circuit is shown in Fig. 1. This circuit consists of a negative resistor, two inductors, a capacitor and dual-directional diodes. This chaotic circuit is called Nishio-Inaba circuit.

Figures 2 shows the proposed scale-free network. In our proposed network model, each chaotic circuit is coupled by one resistor R. Moreover, proposed system model uses 49 coupled chaotic circuits and 84 edges.

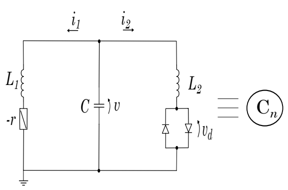

Figure 1: Chaotic circuit.

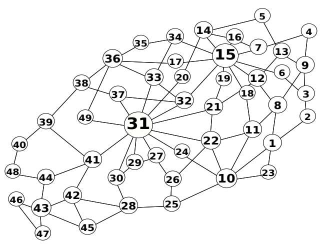

Figure 2: System model.

Topological structures in complex networks of N nodes and E edges can be evaluated by the typical three types structural metrics (degree, path length and clustering coefficient). First, degree (k) is the number of edges which is connected on a node. Second, path length(L) shows the shortest path in the network between two nodes. Third, clustering coefficient (C) shows the number of actual links between neighbors of a node divided by the number of possible links between those neighbors. These are given as follows;

$$L = \frac{2}{N(N-1)} \sum_{m=1}^{N-1} \sum_{n=m+1}^{N} l(m,n). \tag{1}$$

$$C = \frac{1}{N} \sum_{n=1}^{N} C_n = \frac{1}{N} \sum_{n=1}^{N} \frac{2E_n}{k_n(k_n-1)}. \tag{2}$$

Furthermore, average degree is 2.720, average path length is 3.503 and average clustering coefficient is 0.112 in the proposed system model.

3. Simulation results

We investigate the ratio of chaotic propagation in proposed system model. First, in the initial state of each node, one circuit is set to generate chaotic attractor and the other circuits are set to generate three-periodic attractors. Next, we change the initial chaos position according to the clustering coefficient C.

Figure 3 shows the simulation results of ratio of propagation according to clustering coefficient in each node. For example, in Fig. 3, when the clustering coefficient C in the initial chaos position is 0.044, we set the chaotic attractor in 15th node. Also, when the clustering coefficient C in the initial chaos position is 1.000, we set the chaotic attractor in 23th, 46th or 47th node. In addition, we investigate the ratio of propagation in the static state when we fix coupling strength as $\gamma = 0.001, 0.005$.

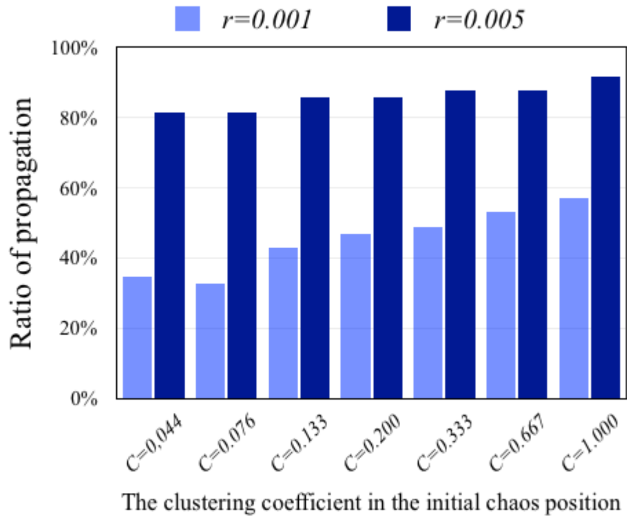

Figure 3: Ratio of chaotic propagation according to clustering coefficient in each node.

From the result, as the coupling strength become larger, the three-periodic attractors are easily affected from the chaotic attractor in each initial chaos position. Moreover, as the clustering coefficient in the initial chaos position become larger, the chaos propagation become to more easy.

4. Conclusions

In this study, we have investigated the ratio of chaotic propagation by changing the initial chaos position according to clustering coefficient. By the computer simulations, we confirmed that the three-periodic attractors are affected from the chaotic attractors when the coupling strength increases. From the above results, we confirm that ratio of propagation in scale-free network is easily affected from the chaotic behavior by increasing clustering coefficient.