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Synchronization Phenomena of Coupled Chaotic Circuits with Different Network Structure

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1. Introduction

Complex networks of chaotic circuits have been studied. However, many researchers have not been researched more about synchronization phenomena in complex networks of coupled chaotic circuits which compare degree distribution. In this study, we investigate synchronization phenomena of chaotic circuits of different network structures in the same degree distribution by changing the coupling strength.

2. System Model

The chaotic circuit model is shown in Fig. 1. This circuit consists of a negative resister, two capacitors, an inductor and dual-directional diodes.

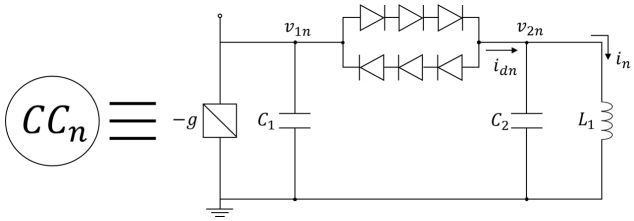

Figure 1: Circuit model.

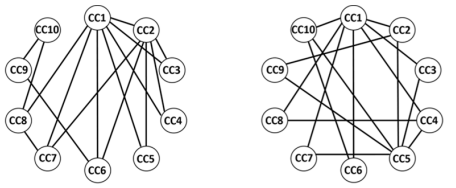

Figure 2: Network model.

Figure 2 shows network of coupled chaotic circuits which are connected by resistors. The number of nodes is fixed at 10 and the number of edges is fixed at 16. The path length of network model (a) is 1.822 and that of network model (a') is 1.689. Furthermore, both network models created based on scale free network in the same degree didstribution. The normalized circuit equations of each network are given as follows:

$$\begin{cases} \dfrac{dx_n}{d\tau} = z_n \\ \dfrac{dy_n}{d\tau} = \alpha\gamma y_n - \alpha\beta f(y_n - z_n) - \alpha\delta \displaystyle\sum_{k\in S_n} (y_n - y_k) \\ \dfrac{dz_n}{d\tau} = \beta f(y_n - z_n) - x_n, \\ \qquad\qquad (n = 1, 2, \cdots, N), \end{cases} \tag{1}$$

where $n = 1, 2, 3, ..., 10$ and S_n is set of nodes which are connected to CC_n. The parameter δ corresponds the coupling strength between the circuits. The nonlinear function $f(y)$ corresponds to the $i-v$ characteristics of the nonlinear resistors consisting of the diodes and are given as follows:

$$f(y_n - z_n) = \begin{cases} y_n - z_n - 1 & (y_n - z_n > 1) \\ 0 & (|y_n - z_n| \le 1) \\ y_n - z_n + 1 & (y_n - z_n < 1). \end{cases} \tag{2}$$

3. Simulation results

We observed the synchronization phenomena of coupled chaotic circuits and measured synchronization rate by changing the coupling strength. Definition of synchronization in this study is determined by a voltage difference. We define synchronization as the following Eq. (3).

$$|z_j - z_i| < 0.15, \qquad (i, j = 1, 2, \cdots, 10). \tag{3}$$

Synchronization rate of network model (a) and (a') is shown in Fig. 3. The vertical axis is synchronization rate and the horizontal axia is the coupling strength δ. Although both network models are created from the same degree distribution, network model (a) gets high synchronization rate.

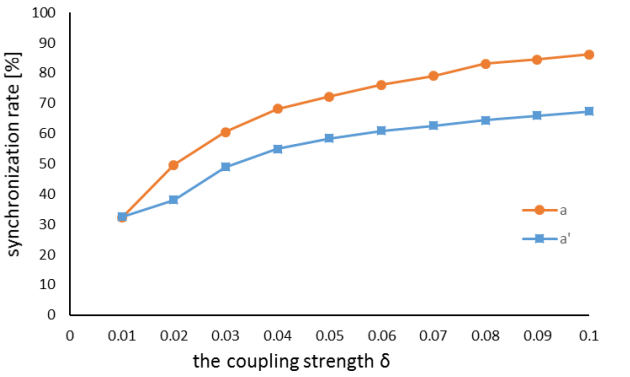

Figure 3: Synchronization rate.

3. Conclusion

In this study, we investigated synchronization rate of networks which have different network topology structures in the same degree distribution and compare them.

In this result, we have confirmed synchronization rate of one network model get high rate. This result is related to the network structure. We analyzed that network structure including connection between nodes with many coupling is an important structure.