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Investigation of Clustering Phenomena Considering Density of Chaotic Circuits

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1. Introduction

Clustering is a prominent phenomena, widely studied and applied to business data mining, image processing and analysis of biological data. Many studies are proposed to utilize synchronization phenomena for clustering. Previously, these studies used discrete time models, however analysis of using circuit models in continuous time has not studied well.

In this study, we examine the coupled chaotic circuit networks in continuous time model. In this model, the coupling strength corresponds to the distance between the circuits. In particular, we investigate the the density of coupled chaotic circuits.

2. Circuit model

In this section, we explain the model of chaotic circuits. The single circuit model is shown in Fig. 1.

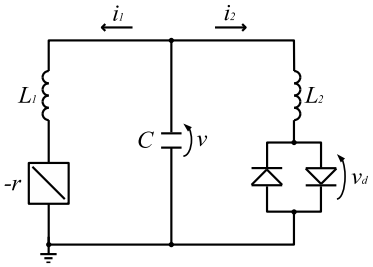


Figure 1: Chaotic circuit.

We can consider the following equations, when all circuits are coupled globally each other.

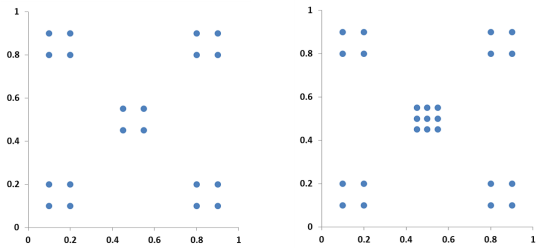
$$\begin{aligned}\frac{dx_i}{d\tau} &= \alpha x_i + z_i \\ \frac{dy_i}{d\tau} &= z_i + f(y) \\ \frac{dz_i}{d\tau} &= -x_i - \beta y_i - \sum_{j=1}^{N} \gamma_{ij}(z_i - z_j) \\ &(i, j = 1, 2, \cdots, N)\end{aligned} \tag{1}$$

where the parameter γ_{ij} represents the coupling strength between the circuits. The value of γ_{ij} reflects the distance between the circuits in an inverse way, described by the following equation:

$$\gamma_{ij} = \frac{g}{(length_{ij})^2}. \tag{2}$$

$length_{ij}$ denotes the Euclidean distance between the i-th circuit and the j-th circuit. The parameter g is a weighting or scaling parameter that determines the coupling strengths. In this study, we set the parameter as $g = 1.0 \times 10^{-4}$.

We set 2 patterns for arrangement of the circuits as shown in Fig. 2. Arrangement of Fig. 2 (a) is composed of the same number of circuits in five groups, however the number of circuits in the middle group changes in Fig. 2 (b).

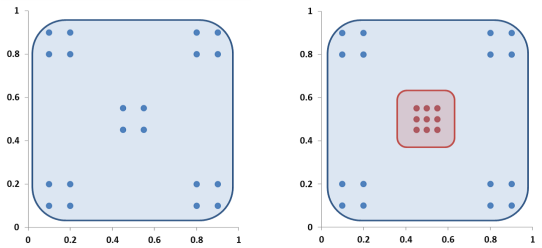


(a) Pattern I (b) Pattern Ⅱ

Figure 2: Arrangement of chaotic circuits.

3. Simulation Result

We investigate the relationship between clustering and the density of a group. In this simulation, all circuits are connected to each other by resistors and the coupling strength between two circuits is determined by Eq. (2).



(a) One cluster (b) Two clusters

Figure 3: The clustering results.

Figure 3 shows the clustering results shown in Fig. 2. Figure 3 (a) shows that, all circuits are synchronized in one cluster, however we can see that another cluster occurs from chaos synchronization between the middle group and the other groups from the result of Fig. 3 (b).

4. Conclusions

In this study, we have examined the relation of clustering to density for coupled chaotic circuits. For this investigation, we have studied the clustering phenomena when we change the number of circuits in a cluster. We showed that another cluster was occurred when the density between chaotic circuits is higher than the other groups.