18-12

Relationship between Oscillatory Phenomena and Template Parameter in Two-Template CNN with Periodic Boundary Condition

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1. Introduction

Cellular Neural Networks (CNNs) were introduced by chua and yang in 1988 [1]. There have been many studies on CNN and many kinds of modified CNNs have been proposed. In our previous study [2], Two-Template CNN was investigated in some conditions of templates and boundaries. As a result, oscillatory phenomena were observed.

In this study, we investigate a relationship between parameters of templates and oscillatory phenomena in Two-Template CNN with a periodic boundary condition.

2. Two-Template CNN

Figure 1 shows an architecture of Two-Template CNN. Two-Template CNN is defined by the following equations.

1: The case that $i+j$ is an even number.

$$\frac{dx_{ij}}{dt} = -x_{ij} + I_\alpha + \sum_{c(k,l)} A_\alpha(i,j;k,l)y_{kl} + \sum_{c(k,l)} B_\alpha(i,j;k,l)u_{kl} \tag{1}$$

2: The case that $i+j$ is an odd number.

$$\frac{dx_{ij}}{dt} = -x_{ij} + I_\beta + \sum_{c(k,l)} A_\beta(i,j;k,l)y_{kl} + \sum_{c(k,l)} B_\beta(i,j;k,l)u_{kl} \tag{2}$$

$A_{\{\alpha\beta\}}(i,j;k,l)$, $B_{\{\alpha\beta\}}(i,j;k,l)$ and $I_{\{\alpha\beta\}}$ are called as the feedback coefficient, the control coefficient and the bias current, respectively. The output equation of the cell is given as follows:

$$y_{ij} = f(x_{ij}). \tag{3}$$

where

$$f(x) = 0.5(|x+1| - |x-1|). \tag{4}$$

The variables u and y are the input and output variables of the cell, respectively.

3. Computer Simulation

We carried out computer simulations by using the following conditions. A boundary condition is set as a periodic boundary condition as shown in Fig. 2. Initial state values are set as random values. The number of cells is fixed as 8 × 8. The template set as follows.

$$\boldsymbol{A}_\alpha = \begin{pmatrix} -u & v & -u \\ v & w & v \\ -u & v & -u \end{pmatrix}, \quad \boldsymbol{A}_\beta = \begin{pmatrix} u & -v & u \\ -v & -w & -v \\ u & -v & u \end{pmatrix}, \tag{5}$$

$$\boldsymbol{B}_\alpha = 0, \quad \boldsymbol{B}_\beta = 0, \quad I_\alpha = 0, \quad I_\beta = 0.$$

Figure 3 shows one of the computer simulation results. We obtained the relationship between oscillatory phenomena and a template parameter as shown in Table 1. Additionally, as increasing $|u|$, offset values of oscillations of groups α_1 and α_2 increase.

Table. 1: Relationship between parameters and oscillation frequencies or amplitudes.

Quadrant	By increasing v	By increasing u
First	Freq. High	Freq. Low, Amp. High
Second	Freq. Low	Freq. Low, Amp. High
Third	Freq. Low	Freq. High, Amp. Low
Fourth	Freq. High	Freq. High, Amp. Low

4. Conclusions

In this study, we have investigated and have revealed relationship between oscillatory phenomena and parameters in a Two-Template CNN with periodic boundary conditions.

References

[1] L. O. Chua and L. Yang, "Cellular Neural Networks: Theory," *IEEE Trans. Circuits Syst.*, vol. 35, no. 10, pp. 1257–1272, 1988.

[2] J. Fujii, Y. Hosokawa and Y. Nishio, "Oscillatory Phenomena in Cellular Neural Networks Using Two Kinds of Templates," *Proc. of NOLTA'08*, pp. 688–691, 2008.

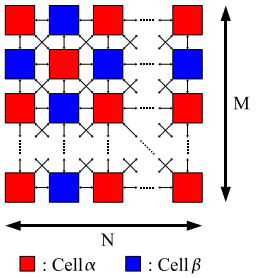

Fig. 1: Structure of Two-Template CNN.

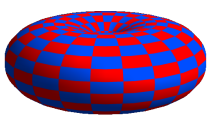

Fig. 2: A periodic boundary conditions.

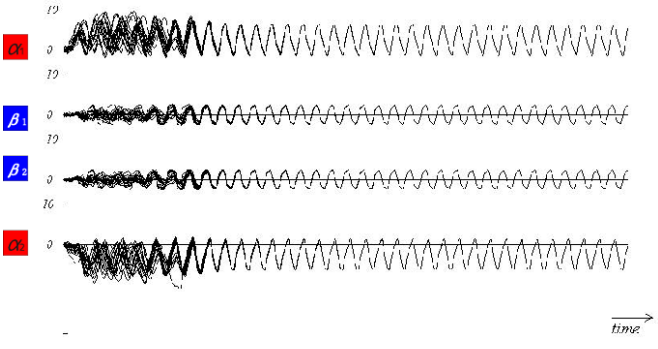

Fig. 3: One of the computer simulation results. $u = 2.0$, $w = 1.0$ and $v = 5.0$.