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.

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

2: The case that \( i + j \) is an odd number.

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

\( A_{(\alpha,\beta)}(i,j;k,l) \), \( B_{(\alpha,\beta)}(i,j;k,l) \) 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:

\[
y_{ij} = f(x_{ij}).
\]

where

\[
f(x) = 0.5(|x + 1| - |x - 1|).
\]

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 \( 8 \times 8 \). The template set as follows.

\[
A_{\alpha} = \begin{pmatrix} -u & v & -u \\ v & w & v \\ -u & v & u \end{pmatrix}, \quad A_{\beta} = \begin{pmatrix} u & -v & u \\ -v & -w & -v \\ u & -v & u \end{pmatrix}
\]

\[
B_{\alpha} = 0, \quad B_{\beta} = 0, \quad I_{\alpha} = 0, \quad I_{\beta} = 0.
\]

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 \( \alpha_1 \) and \( \alpha_2 \) increase.

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

<table>
<thead>
<tr>
<th>Quadrant</th>
<th>By increasing ( v )</th>
<th>By increasing ( u )</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>Freq. High</td>
<td>Freq. Low, Amp. High</td>
</tr>
<tr>
<td>Second</td>
<td>Freq. Low</td>
<td>Freq. Low, Amp. High</td>
</tr>
<tr>
<td>Third</td>
<td>Freq. Low</td>
<td>Freq. High, Amp. Low</td>
</tr>
<tr>
<td>Fourth</td>
<td>Freq. High</td>
<td>Freq. High, Amp. Low</td>
</tr>
</tbody>
</table>

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
