17-64

Output Characteristics of Cellular Neural Networks Using Mixtured Template

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1. Introduction

Cellular Neural Networks (CNN) were introduced by Chua and Yang in 1988. The idea of the CNN was inspired from the architecture of the cellular automata and the neural networks. The CNN has local connectivity property. Since the structure of the CNN resembles the structure of animals' retina, the CNN can be used for various image processing applications. Wiring weights of the cells are established by parameters called the template. If the templates of the cells in the CNN are identical, the system is called space-invariant system, or if not identical, space-varying system. Typically, space-invariant system is mainly used in the studies of CNN, because the cost to implementation is cheap price but on the flip side, this system holds the fault that the performance is limited eminently. In this study, we propose the mixtured templates system as one of the space-varying template system. In this system, distributions of templates are completely random. In this article, we get an interesting performance that by mixtured two types of templates system.

2. Proposed CNN Model

The basic circuit unit of CNN is called a cell. It contains linear and nonlinear circuit elements. The CNN is an array of cells. Each cells are connected to neighboring cells.

The state equation of the cell is shown as follows.

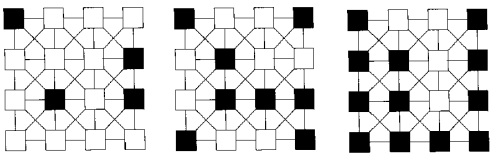
State equation:

$$\frac{dv_{xij}}{xt} = -v_{xij} + \sum_{k=i-r}^{i+r}\sum_{l=j-r}^{j+r} A_{(i,j;k,l)}v_{ykl}(t) + \sum_{k=i-r}^{i+r}\sum_{l=j-r}^{j+r} B_{(i,j;k,l)}v_{ukl}(t) + I \quad (1)$$

Output equation:

$$v_{yij}(t) = \frac{1}{2}(|v_{xij}(t) + 1| - |v_{xij}(t) - 1|) \quad (2)$$

v_x, v_y and v_u represent a state, an output and an input of cell, respectively. In the equation (1), A is the feedback template and B is the control template, these and bias I are collectively called template.



(a) (b) (c)

Figure 1: Examples of mixtured template. (a) white : black=75 : 25. (b) white : black=50 : 50. (c) white : black=25 : 75.

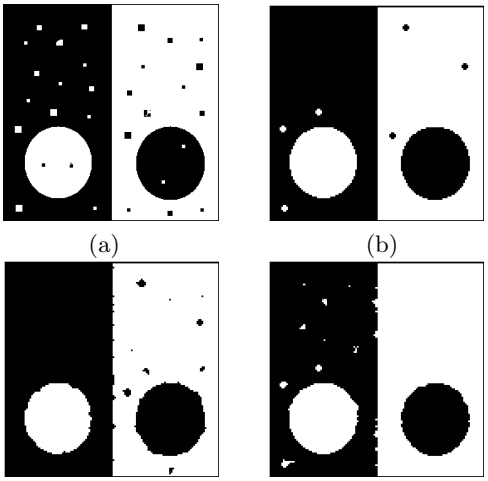
Figure 1 shows examples of the mixtured template. Black cells and white cells have different templates. Mixture method is completely random.

3. Simulation and Results

Figure 2 shows the simulation results using the mixtured template which mixed "small object remover" (3) and "patch maker" (4) or (5). The Size of CNN is 128 × 128. Template (3) can put out small objects from binary images. Template (4) can extends black objects, and template (5) can extends white objects.

$$A = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 2 & 1 \\ 1 & 1 & 1 \end{bmatrix}, B = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}, \quad I = 0. \quad (3)$$

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 1 & 2 & 1 \\ 0 & 1 & 0 \end{bmatrix}, B = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix}, \begin{cases} I = 4.5. \ (4) \\ I = -4.5. \ (5) \end{cases}$$



(a) (b) (c) (d)

Figure 2: Simulation results. (a) Input image. (b) Only template (3). (c) Result using mixtured template. (3) : (4) = 90 : 10. (d) (3) : (5) = 90 : 10.

Figure 2 (b) shows the result using template (3). Figures 2 (c) and (d) show the results using mixtured template which template (3) and template (4) or (5) are mixed at a rate of 9:1.

In the result (c), characteristic to the left area was improved. In the result (d), characteristic to the right area was improved.

4. Conclusions

In this study, we proposed the mixtured two types of templates system as one of the space-varying templates systems. We investigated characteristic of proposed system by simulation. As a result, we clarified that characteristic of CNN can be improved by proposed system.

Reference

[1] L. O. Chua and L. Yang, "Cellular Neural Networks:Theory" IEEE Trans. Circuits & Syst., vol. 32, pp. 1257-1272, Oct. 1988.