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One Direction Two-Layer Cellular Neural Networks with Switching Templates

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1. Introduction

Cellular Neural Networks (CNN) have used the concept of cellular automata. The two-layer CNN is constructed as conventional two single-layer. Two single layer have an effect on each other. In some image processing, the two-layer CNN is better than the single-layer CNN [1]. Also, CNN with switching template is better than the single-layer CNN [2]. Then, we consider the structure of two-layer CNN that has only effect the one side layer by switching template.

In this study, we propose the one-direction two-layer CNN with switching template. The proposed system has only effect from the first-layer to the second-layer. The first-layer and the second-layer are connected by switching templates. In simulation results, we show effective image processing of the proposed system.

2. Proposed System

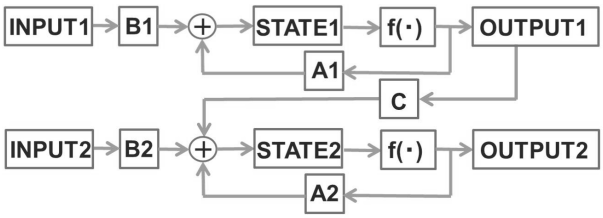


Figure 1: Block diagram of the proposed system.

In this section, we explain the algorithm of the proposed system. The structure of the proposed system is based on two-layer CNN in Fig 1. The proposed system has only one coupling template that has effect on the second-layer from the first-layer.Thus the structure of the proposed system has an effect only the one side layer. In addition, three types of coupling template are switched. The coupling template is decided by the output value of the first-layer and the input value of the second-layer. The algorithm of the proposed system is shown as follows.

Step 1 : We determine the boundary values T_1 and T_2.

Step 2 : We determine the difference value D_{ij} by the output value of first-layer and the input value of second-layer. The difference value is calculated by

$$D_{ij} = |v_{2uij}(t) - v_{1yij}(t)|. \tag{1}$$

Step 3 : The boundary value and the difference value are compared. If $|D_{ij}|$ is over T_1 and under T_2, the template of C_1 is used. On the other hand, if $|D_{ij}|$ is over T_2, the template of C_2 is used. if $|D_{ij}|$ is under T_1, the template of C_3 is used.

Step 4 : The value of each cell is updated by the state equation and the output equation. used the value of each sell to be update. The state equation and the output equation of each layer are described as follows.

State equation of the first-layer CNN :

$$\begin{aligned}\frac{dv_1xij}{dt} &= -v_{1xij} + \sum_{k=i-r}^{i+r}\sum_{l=j-r}^{j+r} A_{1(i,j;k,l)}v_{1xkl}(t) \\ &\quad + \sum_{k=i-r}^{i+r}\sum_{l=j-r}^{j+r} B_{1(i,j;k,l)}v_{1ukl}(t) + I_1. \end{aligned}\tag{2}$$

State equation of the second-layer CNN :

$$\begin{aligned}\frac{dv_2xij}{dt} &= -v_{2xij} + \sum_{k=i-r}^{i+r}\sum_{l=j-r}^{j+r} A_{2(i,j;k,l)}v_{2xkl}(t) \\ &\quad + \sum_{k=i-r}^{i+r}\sum_{l=j-r}^{j+r} B_{2(i,j;k,l)}v_{2ukl}(t) \\ &\quad + \sum_{k=i-r}^{i+r}\sum_{l=j-r}^{j+r} C_{(i,j;k,l)}v_{1ykl}(t) + I_2. \end{aligned}\tag{3}$$

Step 5 : Step 2 to Step 4 are repented every 0.005[τ].

3. Simulation Results

In this section, we show simulation results of edge detection by using the proposed method. In this simulation, T_1 and T_2 are set to 0.3 and 0.4, respectively.

Templates A, B, threshold I_1 and I_2 of each layer are assigned as follows.

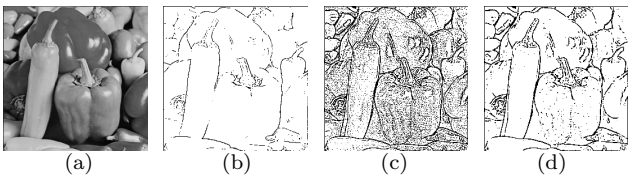
Edge detection template :

$$A_1 = A_2 = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix} \quad B_1 = B_2 = \begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix},$$
$$I_1 = -0.13,\ I_2 = -1. \tag{4}$$

Using coupling templates are described as follows.

Coupling templates:

$$C_1 = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 2 & 1 \\ 1 & 1 & 1 \end{bmatrix},\ C_2 = \begin{bmatrix} 0.5 & 0.5 & 0.5 \\ 0.5 & 0.5 & 0.5 \\ 0.5 & 0.5 & 0.5 \end{bmatrix},$$
$$C_3 = \begin{bmatrix} 0 & 1 & 0 \\ 1 & 8 & 1 \\ 0 & 1 & 0 \end{bmatrix}. \tag{5}$$



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

Figure 2: Simulation result. (a) Input image. (b) Edge detection result of the single-layer CNN. (c) Edge detection result of the first-layer CNN. (d) Edge detection result of the second-layer CNN.

In Fig. 2(a), boundary line of the vegetable of center side and the empty space is an indistinct portion. This indistinct portion is not detected by using the single-layer CNN in Fig. 2(b). The results of the proposed system are shown in Fig. 2(c) and (d). Figure. 2(c) shows the output of the first-layer. The boundary line of indistinct portion is detected by low threshold. Figure. 2(d) shows the output of the second-layer. The edge of the indistinct portion can be distinctly detected. From these results, we can say that the proposed system is more effective than the single-layer CNN for edge detection.

4. Conclusions

In this study, we have proposed the one direction two-layer CNN with switching template. The proposed system has only effect the second-layer. The first-layer and the second-layer are connected switching three types of templates. From simulation results, the proposed system could more detect than the single-layer CNN.

References

[1] Z. H. Yang, Y. Nishio and A. Ushida, “Image processing of two-layer CNNs -applications and stability-,” IEICE,Trans. Fundamentals, vol. E85-A, no. 9, pp. 2052-2060, Sept. 2002.

[2] Y. KATO, Y. UEDA, Y. UWATE and Y. NISHIO, “Cellular Neural Networks with Switching Two Types of Templates,” Proc. of IJCNN’ 11, pp. 1423-1428, Jun. 2011.