18-32

Cellular Neural Networks with Switching Template for Edge Detection

Yoshihiro KATO Yasuhiro UEDA Masakazu KAWAHARA
Yoko UWATE Yoshifumi NISHIO
(Tokushima University)

1. Introduction

Cellular Neural Networks (CNN) were introduced by Chua and Yang in 1988 [1]. The idea of the CNN was inspired from the architecture of the cellular automata and the neural networks. The CNN has local connectivity property. Wiring weights of the cells are established by parameters called the template.

In the conventional CNN, using edge detection template of 3×3 matrix, the edge of the indistinct portion has not been detected. On the other hand, using edge detection template of 5×5 matrix, detected edge becomes bold line.

In this study, we propose CNN with switching template for edge detection. The template of our proposed method is switched by the output value of the corresponding cell. We show effective edge detection from simulation results.

2. Proposed Method

In this section, we explain the algorithm of the proposed method. In our method, 2 types of template are switched by the value of cell.

Step1 : First, we determine the boundary values D_1 and D_2. If V_i is over D_1 and under D_2, the template of 5×5 matrix is used. On the other hand, if V_i is under D_1 or over D_2, the template of 3×3 matrix is used.

Step2 : The state equation and the output equation are described as follows.

State equation with the template of 3×3 matrix :

$$\frac{dv_{xij}}{dt} = -v_{xij} + \sum_{k=i-r}^{i+r}\sum_{l=j-r}^{j+r} A_3(i,j;k,l)v_{xkl}(t) + \sum_{k=i-r}^{i+r}\sum_{l=j-r}^{j+r} B_3(i,j;k,l)v_{ukl}(t) + I. \quad (|i-k| \le 1 \ , \ |j-l| \le 1). \tag{1}$$

State equation with the template of 5×5 matrix :

$$\frac{dv_{xij}}{dt} = -v_{xij} + \sum_{k=i-r}^{i+r}\sum_{l=j-r}^{j+r} A_5(i,j;k,l)v_{xkl}(t) + \sum_{k=i-r}^{i+r}\sum_{l=j-r}^{j+r} B_5(i,j;k,l)v_{ukl}(t) + I. \quad (|i-k| \le 2 \ , \ |j-l| \le 2). \tag{2}$$

Output equation :

$$v_{yij}(t) = \frac{1}{2}(|v_{xij}(t)+1| - |v_{xij}(t)-1|). \tag{3}$$

Then, state values and output values are updated.

Step3 : After Step2, the proposed CNN switches the template to 3×3 matrix or 5×5 matrix according to the output value of the corresponding cell.

We carry out Step2 and Step3 every 0.5[τ].

3. Simulation Results

In this section, we show a simulation result using our proposed method. In this simulation, D_1 and D_2 are set to −0.3 and 0.1, respectively.

Edge detection template of 3×3 *matrix* :

$$A_3 = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix}, \ B_3 = \begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}, \ I = -1. \tag{4}$$

Edge detection template of 5×5 *matrix* :

$$A_5 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix},$$

$$B_5 = \begin{bmatrix} -1 & -1 & -1 & -1 & -1 \\ -1 & 0 & 0 & 0 & -1 \\ -1 & 0 & 16 & 0 & -1 \\ -1 & 0 & 0 & 0 & -1 \\ -1 & -1 & -1 & -1 & -1 \end{bmatrix}, \ I = -1. \tag{5}$$

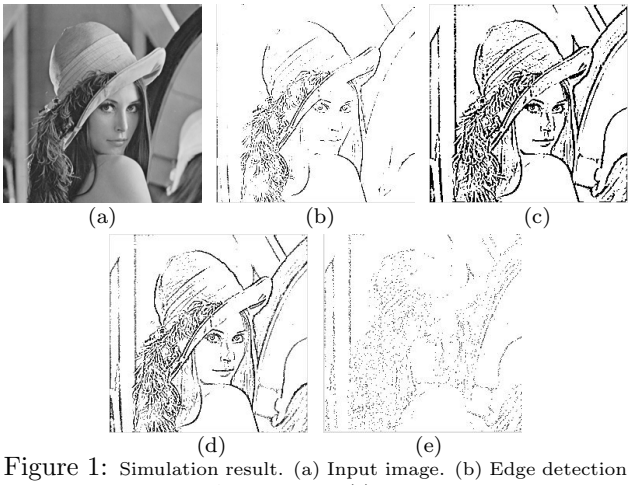

Figure 1: Simulation result. (a) Input image. (b) Edge detection result using template of 3×3 matrix. (c) Edge detection result using template of 5×5 matrix. (d) Edge detection result using CNN with switching template. (e) Distribution of template of 5×5 matrix and template of 3×3 matrix.

The pillar on the left side in the background is an indistinct portion in Fig. 1(a). This indistinct portion is not detected using the conventional CNN in Fig. 1(b). Although, the edge of the indistinct portion is detected in Fig. 1(c), the detected edge becomes bold line. In our proposed method, the edge of the indistinct portion can be detected more clearly than using the template of 3×3 matrix. Also, the detected edge is more fine line than using the template of 5×5 matrix. In Fig. 1(e), black points show the cells using the template of 3×3 matrix and white points show the cells using the template of 5×5 matrix. From Fig. 1(e), distinct parts are processed by the template of 3×3 matrix. On the other hand, indistinct parts are processed by the template of 5×5 matrix. From these results, we can say that our proposed method is more effective than the conventional CNN.

4. Conclusions

In this study, we have proposed CNN with switching template for edge detection. In our proposed method, 2 types of template were switched by the value of cell. We confirmed from simulation results that our proposed method is effective for edge detection.

References

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