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Alternative Arrangement Cellular Neural Networks for Image Processing Applications

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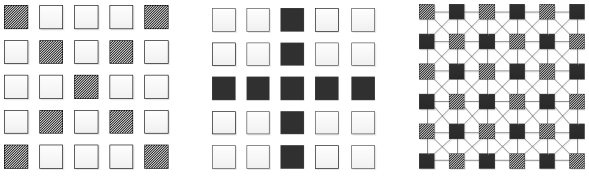
1. Introduction

In this study, we propose a new model of CNN. This model has set up by turns two templates which connection of cells is different. Cellular neural network spatially uniform can not perform complex processing. However, implementation cost of proposed model is same as conventional CNN. We proposed the model which mounting cost is comparatively cheap and conformation is easy to basic image processing applications. And we observed good results even if it is not a complicated structure.

2. Proposed Model

In this section, we explain the structure of the proposed model. The proposed model has two templates that is different characteristic in Figs.1(a) and (b). In particular, two templates are alternately set up as shown in Fig 1(c). A α template is placed in a black cell, and a β template is placed in a diagonal cells.



(a) (b) (c)

Figure 1: (a) Connection structure of the α template. (b) Connection structure of the β template. (c) Template placement assignment.

In addition, cells are coupled to the specified eight surrounding cells. The values of each cell are determined by the state and the output equations as follows.

State equation of the α template :

$$\frac{dv_{xij}}{dt} = -v_{xij} + \sum_{k=i-r_\alpha}^{i+r_\alpha}\sum_{l=j-r_\alpha}^{j+r_\alpha} A_\alpha(i,j;k,l)v_{ykl}(t) + \sum_{k=i-r_\alpha}^{i+r_\alpha}\sum_{l=j-r_\alpha}^{j+r_\alpha} B_\alpha(i,j;k,l)v_{ukl}(t) + I_\alpha. \quad (1)$$

State equation of the β template :

$$\frac{dv_{xij}}{dt} = -v_{xij} + \sum_{k=i-r_\beta}^{i+r_\beta}\sum_{l=j-r_\beta}^{j+r_\beta} A_\beta(i,j;k,l)v_{ykl}(t) + \sum_{k=i-r_\beta}^{i+r_\beta}\sum_{l=j-r_\beta}^{j+r_\beta} B_\beta(i,j;k,l)v_{ukl}(t) + I_\beta. \quad (2)$$

Output equation :

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

3. Simulation Results

In this section, we show simulation results of edge detection. The pillar on the left side in the background is an indistinct portion in Fig. 2(a). This indistinct portion is not detected by using the conventional CNN in Fig. 2(b). Although, the edge of the indistinct portion is detected in Fig. 2(c), the detected edge becomes bold line. In Fig 2(d), the edge of the indistinct portion can be detected more clearly than the Fig 2(c). However, detection of indistinct portion is not enough. Therefore, the double value of the β template as shown in Eq. (4), it is resulted in Fig. 2(e). By using proposed model, noise is less than using the template of 5×5 matrix. From these results, we can say that our proposed model is more effective than the conventional CNN.

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

Figure 2: (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 proposed model. (e) Double value of the β template.

$$\alpha = \begin{bmatrix} -1 & 0 & 0 & 0 & -1 \\ 0 & -1 & 0 & -1 & 0 \\ 0 & 0 & 8 & 0 & 0 \\ 0 & -1 & 0 & -1 & 0 \\ -1 & 0 & 0 & 0 & -1 \end{bmatrix}, \quad \beta = \begin{bmatrix} 0 & 0 & -2 & 0 & 0 \\ 0 & 0 & -2 & 0 & 0 \\ -2 & -2 & 16 & -2 & -2 \\ 0 & 0 & -2 & 0 & 0 \\ 0 & 0 & -2 & 0 & 0 \end{bmatrix} \quad (4)$$

4. Conclusions

In this study, we have proposed a new model of CNN. This model has set up by turns two templates which connection of cells is different. When we set up alternately template and change the value of the parameter, the performance of the proposed CNN has improved.