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Cellular Neural Networks with Switching Two-Type Templates for Edge Detection and Noise Removal

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1. Introduction

In this study, we propose switching two-type templates CNN. In our proposed method, Edge Dector template (hereinafter, this is called "ED") and our proposed template similar to SmallObjectRemover template (hereinafter, this is called "SOR") are switched. We investigate this method in edge detection and noise removal.

2. Proposed Method

Our proposed method switches two templates according to the output values around cells in processing. Switching condition depends on magnitude of the difference between the output value of the center cell and the output value of the cells around it y_{ij}, y_{kl} of each 5×5 neighborhood and is given as follows:

$$\left\{ \ |y_{ij} - y_{kl}| > a. \right. \tag{1}$$

$$\left\{ \ b \leq count < c. \right. \tag{2}$$

We fix certain value a, b and c. When the inequality of Eq. (1) is satisfied, we count one. When the inequality of Eq. (2) is satisfied, ED template is used. Otherwise, the proposed template is used. When the number of calculation becames m or more, the proposed template is used. This switching process is conducted every certain number of calculation n_{max}.

3. Simulation Results

In this section, we show simulation results of the edge detection and noise removal for using our proposed method and the conventional CNN. Using ED, SOR and proposed templates of the edge detection and noise removal is described as follows.

EdgeDetector template :

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

$$B = \begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}, \ I = -1. \tag{3}$$

Small Object Remover template :

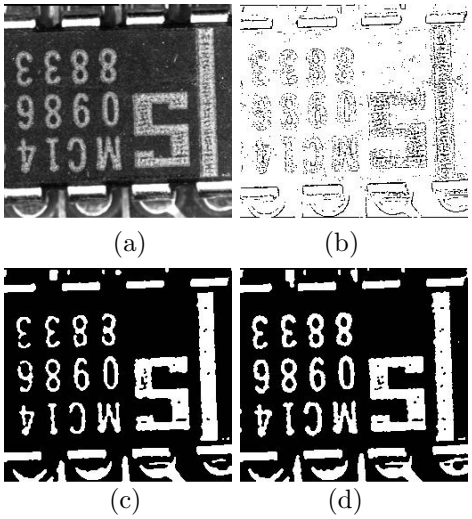
$$A = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 2 & 1 \\ 1 & 1 & 1 \end{bmatrix},$$

$$B = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}, \qquad I = 0. \tag{4}$$

Proposed template :

$$A = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 2 & 1 \\ 1 & 1 & 1 \end{bmatrix},$$

$$B = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 6 & 0 \\ 0 & 0 & 0 \end{bmatrix}, \qquad I = 0. \tag{5}$$



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

Figure 1: Simulation results. (a) Input image. (b) Simulation result of using the ED template (c) Simulation result of using the SOR template. (d) Simulation result of using the proposed method ($a = 0.32$, $b = 6$, $c = 17$, $n_{max} = 50000$, $m = 25000$).

Figure 1(a) shows input image including Noise inside numbers and letters. Figure 1(b) shows noise remains. Figure 1(c) shows edge unclear. Figure 1(d) shows to detect edge lines of indistinct portions and to remove noise compared to Fig. 1(b) and Fig. 1(c). However, a little noise remains. From the simulation results, our proposed method is more effective than the conventional CNN.

4. Conclusions

In this study, we proposed the new method of switching two-type templates by the magnitude of difference and the certain number of calculation n_{max} for CNN. In order to confirm the effectiveness of our proposed method, we applied our proposed method to edge detection and noise removal. As a result, our proposed method is more effective than the conventional CNN in edge detection and noise removal. In future work, we will confirm that the proposed method is effective for noise removal. .