Maintaining Images by Cellular Neural Networks with Switching Two Templates

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Abstract— **The Cellular Neural Networks (CNN) was developed by Chua and Yang in 1998. The performance of the CNN depends on the parameters which are called the template. The CNN is applied to various image processing by changing the template. The output image processed by CNN is a binary image. Therefore, the unnecessary objects are removed in the process. In this research, we propose a method of switching two templates to stop the image processing in a certain state and output in the grayscale state.**

Keywords; Cellular Neural Networks; Image Processing

I. INTRODUCTION

In recent years, it has advanced information society. In general, the von Neumann computer is used for many information processing. However, the von Neumann computer cannot process many information in real time. Therefore, Neural Networks were proposed. The idea was based on the human's nervous system. The Cellular Neural Networks (CNN) was introduced by L. O. Chua and L. Yang in 1988 [1]. Hence, the CNN has been successfully used for various highspeed parallel signals processing applications such as image processing, pattern recognition and so on [1]. The CNN was paired Neural Networks with the Cellular Automata by L. O. Chua in 1998 [2]. The CNN consists of cells connected each other and the structure of CNN resembles the structure of the animal's retina [3]. Therefore, the CNN has been applied to various image processing applications. The performance of CNN depends on the parameters which are called the template. The template represents strength of connection between each cell. The template consists of the feedback template, the feedforward template and the threshold.

In the image processing of the CNN, there are methods to process a grayscale image into a binary image. Some researches are reported that it is possible to process complex parts by switching two templates which have the different feature[4]. These methods turn into a binary image with decreasing amounts of information depending on the number of calculations. However, there is little method how to maintain the process in the grayscale image. Therefore, we propose a new method of maintaining the status of the image with switching two templates. We apply the proposed method to the image and investigate its performance.

II. CELLULAR NEURAL NETWORKS

In this section, we describe the basic structure and processing flow of the simple CNN. The basic circuit unit of the CNN is called a cell. The cell consists of linear element and nonlinear element. The CNN is formed from an array of many cells. We show a two dimensional array composed of $M \times N$ cells arranged in M rows and N columns. A cell is coupled with only adjacent cells. Adjacent cells interact with one another. Cells which do not couple with only adjacent cells have an indirect influence. The range which some cells influence one cell is defined by neighborhood. We describe a state equation of the cell and an output equation of the cell below.

State Equation:

$$\frac{dv_{x(ij)}}{dt} = -v_{x(ij)} + \sum_{k=i-r}^{i+r}\sum_{l=j-r}^{i+r} A_{(i,j;k,l)} v_{y(kl)}(t) + \sum_{k=i-r}^{i+r}\sum_{l=j-r}^{i+r} B_{(i,j;k,l)} v_{u(kl)}(t) + T. \quad (1)$$

Output Equation:

$$v_{y(ij)}(t) = \frac{1}{2}\left(\left|v_{x(ij)}(t)+1\right| - \left|v_{x(ij)}(t)-1\right|\right). \quad (2)$$

III. PROPOSED METHOD

In this section, we explain the proposed method by using CNN. In our proposed method, two templates are switched according to the input and output values (y_{ij} : cell's output value, u_{ij} : cell's input value) of surrounding the center cell. The processing steps of the proposed method are described as follows.

Step 1: Fix certain value a. Decide the center cell and the size of 3×3 and 5×5 neighborhoods. Then, find the y_{ij} and u_{ij} from 5×5 range of the input and output values.

Step 2: Calculate the standard deviation within 3×3 and 5×5 ranges of the output value of the center cell, and within 3×3 range of the input value of the center cell. Each value is defined as S_1, S_2 and S_3.

Step 3: The template is applied to the center cell. Switching condition is given as follows:

$$\begin{cases} S_2 \le S_1 \\ aS_1 \ge S_3 \end{cases} \tag{3}$$

When either inequality of Eq. (3) is satisfied, it is applied 1st template. In the other case, it is applied 2nd template.

Step 4: Step 1 to step 3 are applied to all cells and repeated every 0.005 [τ]. This process is conducted every certain number of calculation n.

IV. SIMULATION RESULTS

In this section, we show the simulation results of the proposed method and the conventional CNN. Figure 1shows the input image and the simulation results by the "Edge detection" template and the proposed method. In this simulation, 1st template is "State value" template and 2nd template is "Edge detection" template. Using templates of the proposed method are described as follows [5].

State Value template:

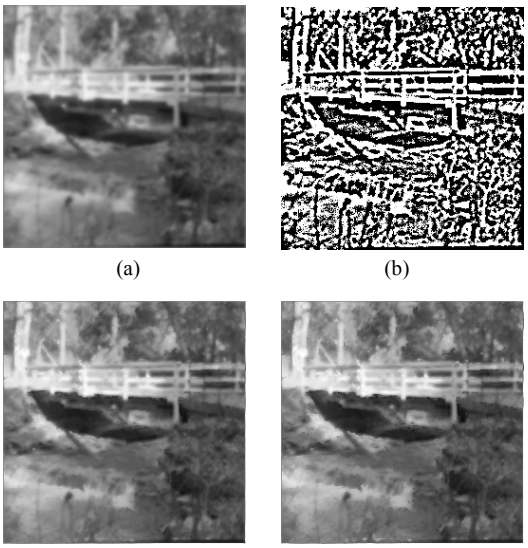
$$A = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix},$$

$$B = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}, \; T = 0. \tag{4}$$

Edge Detection template:

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

$$B = \begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}, \; T = 0. \tag{5}$$



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

Figure 1. Simulation results. (a) Input image. (b) Simulation result of the "Edge detection" template. (c) Simulation result of the proposed method(a = 0.85; n = 400). (d) Simulation result of the proposed method(a = 0.85; n = 800).

Figure 1(a) shows input image including a bridge, a lake and a forest. Figure 1(b) shows binary edge detected image of Fig. 1(a). Figure 1(c) shows the grayscale image with the information in Fig. 1(a). Figure 1(d) shows the output image increasing the number of calculations compared to Fig. 1(c). There is little difference between Fig. 1(c) and Fig. 1(d). From the simulation results, the proposed method is effective in increasing the number of calculations.

V. CONCLUSION

In this study, we have proposed a method of maintaining the image with switching two templates. In the proposed method, we focus on the standard deviation of the input image and the output image. From the simulation results, the output image is maintained as a grayscale image with the number of calculations. Therefore, the proposed method is effective in maintaining the image. In the future work, we will confirm that the proposed method is effective for other image processings.

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