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Investigation of Cellular Neural Networks with Effect from Friends of a Friend

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1. Introduction

In 1988, Cellular Neural Networks (CNN) [1] were introduced. CNN has the local connectivity property and it makes the CNN tailor made for VLSI implementation. Furthermore, the structure of CNN resembles that of animals' retina. Therefore, CNN can be used for various image processing applications. In CNN, each cell is connected to its neighboring cells according to a template. Then, each cell is influenced by neighboring cells and its value is updated.

As the proverb "Birds of a feather flock together" says, we are likely to become friendly with someone who have similar interests, values, purpose and so on. In this study, we propose cellular neural networks with effect from friends of a friend (FF-CNN). The FF-CNN is the new method in consideration of the phenomena in such actual society. Generally, in the conventional CNN, each cell is connected to only its neighboring cells. In this case, the information that a cell can obtain from its neighboring cells is limited. In the proposed method, combinations of among cells are decided by the value of each cell. In each cell, a cell with the nearest value of center cell is defined as "Best friend cell" in eight neighboring cells. Then, the state value of each cell is updated under the influences of the best friend cell and its neighboring cells. We show some simulation results and confirm its effectiveness.

2. FF-CNN

In this section, we explain the algorithm of the FF-CNN. The FF-CNN is the method of constituting a new combination between cells. The algorithm is described as follows.

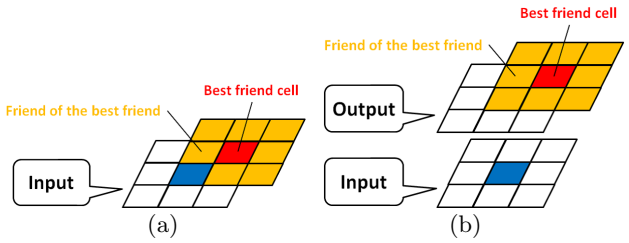

Figure 1: Definition of the best friend cell. (a) The case of input image. (b) The case of output image.

Step 1: In each cell of input image, a cell with the nearest value of center cell $C(i,j)$ is defined as "Best friend cell" in eight neighboring cells.

Step 2: The combination centering on a cell $C(i,j)$ is changed into a combination centering on the best friend cell like Fig. 1(a).

Moreover, the element of template of the best friend and the center cell are replaced. With this, a new combination between cells is constituted.

Step 3: The value of each cell is updated according to the state and the output equations using the new combination between cells.

Step 4: In each cell of output image, a cell with the nearest value of center cell $C(i,j)$ in input image is defined as the "Best friend cell" in eight neighboring cells like Fig. 1(b).

Step 5: Steps 2 to 4 are repeated every 0.0005 [τ].

In the proposed method, each cell in input image is used for basis of definition of the best friend. Therefore, the state value of each cell is updated by receiving influences from the best friend cell and its neighboring cells.

3. Simulation Results

In this section, we show simulation results of image denoising by using the FF-CNN. Generally, in the conventional CNN, "*Small object remover*" template [2] is used for image denoising. However, this template can not remove large-size noises and output value is converged to black or white. Then, the conventional CNN can not perform with maintaining gray scale. As another method for image denoising, noisy image is defused.

In the FF-CNN, we use "*Heat diffusion*" template [2] for image denoising. Boundary condition is fixed to +1.

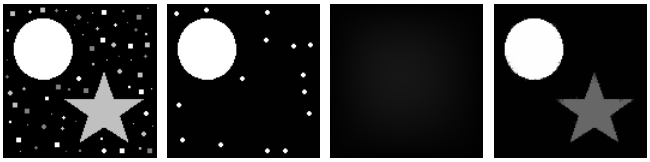

Figure 2: Image denoising results. (a) Gray scale input image. (b) Image denoising result using the conventional CNN with "*Small object remover*" template. (c) Image denoising result using the conventional CNN with "*Heat diffusion*" template. (d) Image denoising result using the FF-CNN with "*Heat diffusion*" template.

Figure 2(b) shows the image denoising result by the conventional CNN using "*Small object remover*" template to the gray scale image in Fig. 2(a). The small-size noises are removed. However, the noises over certain size are not removed. Moreover, an output image is converged to black and white. Then, the right side object of the value near black has disappeared. On the other hand, Fig. 2(c) shows the output image by the conventional CNN using "*Heat diffusion*" template. The input image is diffused to black.

However, Fig. 2(d) shows the image denoising result by the FF-CNN using "*Heat diffusion*" template. All noise in the input image were removed regardless of gray scale. Then, the right side object remained with keeping the value of gray scale.

From these results, we consider that the FF-CNN is more effective than the conventional CNN for image denoising.

4. Conclusions

In this study, we have proposed cellular neural networks with effect from friends of a friend. The FF-CNN is the new method in consideration of the phenomena in actual society. From simulation results of image denoising, we consider that the large-size noises which remained by the conventional CNN were removed. Moreover, the right side object remained with keeping the value of gray scale.

Reference

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

[2] Cellular Sensory Wave Computers Laboratory Computer and Automation Research Institute Hungarian Academy of Sciences, "Cellular wave Computing Library (Template, Algorithms, and Programs) Version 2.1"