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Associative Memory by Partitioned Hopfield Neural Network

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1. Introduction

Memory ability of human is an interesting ability. For example, human memorizes an image. After that, when human sees the partial image, human could recall the whole image. If this memory ability is applied in engineering, much information can be obtained from little information. Hopfield Neural Network (HNN) is one of the computation models which simulate memory ability of human [1], and is used for associative memory.

In this study, we propose Partitioned HNN (PHNN) and apply PHNN to image processing (64×64 size image). The conventional HNN recalls a similar pattern to the input image from some memorized patterns. In our method, PHNN is disposed on every cell (each cell has 4×4 neurons) on the image space and recalls a similar pattern to the local input image only on the cell. Thereby, we can recall the whole image which has partially same patterns.

2. Method of Associative Memory

We consider the PHNN composed of 4×4 neurons in one cell. PHNN is shown in Fig. 1. The memorizing method of patterns in a cell is given by

$$w_{ij} = \begin{cases} \frac{1}{P}\sum_{p=1}^{P} x_i^{(p)} x_j^{(p)} & (i \neq j) \\ 0 & (i = j), \end{cases} \tag{1}$$

where P is the number of patterns, x is the input, and w is the weight parameter. The updating rule and the internal state of the neuron are given by

$$x_i(t+1) = \begin{cases} 1, & (u_i(t) \geq 0) \\ -1, & (u_i(t) < 0), \end{cases} \tag{2}$$

$$u_i(t) = \sum_{j=1}^{n} w_{ij}(t) x_j(t), \tag{3}$$

where u is the internal state of the neuron. We apply this update to all neurons in a cell. PHNN recalls one of the memorized patterns in a cell by repeating this update. We compare the recalled images with the memorized images for every cell and count the number of the cells which have the exactly same patterns. PHNN outputs the whole image which has more cells of the same patterns from the two memorized images.

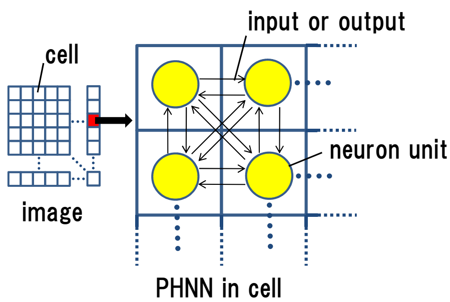
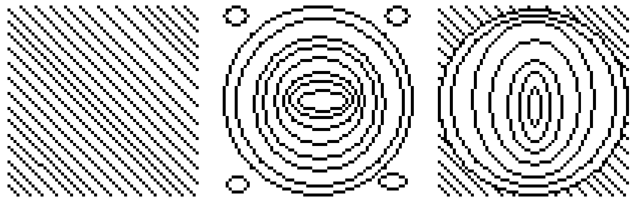


Figure 1: Composition of PHNN.

3. Simulation Results

We compare PHNN with the conventional HNN. For HNN, we do not consider the cells, namely every pixel are connected each other. Two binary images shown in Figs. 2(a) and (b) are memorized into the networks. Figure 2(c) is an input image. The part of slash in Fig. 2(c) has the same pattern as Fig. 2(a). The part of circle in Fig. 2(c) has similar pattern to Fig. 2(b).



(a) (b) (c)

Figure 2: (a) Stored image (slash). (b) Stored image (circle). (c) Input image.

Figure 3(a) is recalled by HNN. Figure 3(b) is recalled by PHNN, which has more cells of the same patterns as Fig. 2(a) than Fig. 2(b). Hence, PHNN outputs the slash image as shown in Fig. 3(c).

From these results, PHNN recalls the whole image from partially same image.

(a) (b) (c)

Figure 3: (a) Recalled image of HNN. (b) Recalled partial image of PHNN. (c) Recalled whole image of PHNN.

4. Conclusions

In this study, we have proposed PHNN and applied PHNN to image processing. In our method, PHNN was disposed on every cell and recalled a similar pattern to the local input image only on the cell. Computer simulation results showed that PHNN output the image which had more same patterns.

References

[1] J. J. Hopfield, "Neural Networks and Physical Systems with Emergent Collective Computational Abilities," *Proc. Natl. Acad. Sci. USA*, vol.79, pp. 2554-2558, 1982.