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# Extraction of Intermediate Brightness by CNN Using Two Kinds of Cloning Templates

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**Abstract**

In this study, a cloning template for CNN using Two kinds of cloning templates is introduced. The template can extract intermediate brightness parts of an images. A similar processing by a conventional CNN is also introduced. By comparing the two results, the advantage of CNN using Two kinds of cloning templates are shown.

## 1. Introduction

Many modified Cellular Neural Networks [1]-[10](CNNs) have been proposed. Most of modified CNN obtained higher ability in exchange for losing the simplicity of the system. However, the simplicity is important characteristics of CNNs.

CNN using two kinds of cloning templates was proposed by Fujii et al [6]. The feature of this modified CNN is not lost the simplicity. Some interesting phenomena which are active pattern formations, clustering and so on are observed. The system was investigated as coupled oscillatory system mainly. Therefore, the applications is not investigated. In order to expand the potentialities, investigating its applications is an important task.

In our previous study, new cloning template of CNN using two kinds of cloning templates is proposed in [10]. The template can extract the intermediate brightness parts of an image with one process.

In this study, CNN using two kinds of cloning templates are compared with a conventional CNN by processing the extraction of the intermediate brightness parts.

## 2. CNN using two kinds of cloning templates

Figure 1 shows the CNN using two kinds of cloning templates. The system has a two-dimensional $M$ by $N$ array structure. Each cell in the array is denoted as $c(i,j)$, where $(i,j)$ is the position of the cell, where $1 \leq i \leq M$ and $1 \leq j \leq N$. The coupling radius is assumed to be one in this study. This system has two kinds of cloning templates. Cells having one template set are called as Cell $\alpha$ and the other are called as Cell $\beta$. These two cells are placed as checkered patterns.

The state equations of the cells are given as follows:

**1:** The case that $i+j$ is an even number.

$$\begin{aligned}\frac{dx_{ij}}{dt} =& -x_{ij} + I_\alpha \\ &+ \sum_{c(k,l)} A_\alpha(i,j;k,l)y_{kl} \\ &+ \sum_{c(k,l)} B_\alpha(i,j;k,l)u_{kl}\end{aligned} \tag{1}$$

**2:** The case that $i+j$ is an odd number.

$$\begin{aligned}\frac{x_{ij}}{dt} =& -x_{ij} + I_\beta \\ &+ \sum_{c(k,l)} A_\beta(i,j;k,l)y_{kl} \\ &+ \sum_{c(k,l)} B_\beta(i,j;k,l)u_{kl}\end{aligned} \tag{2}$$

$A_{\{\alpha\beta\}}(i,j;k,l)y_{kl}$, $B_{\{\alpha\beta\}}(i,j;k,l)u_{kl}$ and $I_{\{\alpha\beta\}}$ are called as the feedback coefficient, the control coefficient and the bias current, respectively.

The output equation of the cell is given as follows:

$$y_{ij} = f(x_{ij}). \tag{3}$$

where,

$$f(x) = 0.5(|x+1| - |x-1|). \tag{4}$$

The variables $u$ and $y$ are the input and output variables of the cell, respectively. $\boldsymbol{A}_\alpha$, $\boldsymbol{B}_\alpha$, $\boldsymbol{A}_\beta$ and $\boldsymbol{B}_\beta$ are 3 times 3 matrices, which can be described to have a similar form to Eq. (5).

$$\begin{pmatrix} A_\alpha(i,j;i-1,j-1) & A_\alpha(i,j;i-1,j) & A_\alpha(i,j;i-1,j+1) \\ A_\alpha(i,j;i,j-1) & A_\alpha(i,j;i,j) & A_\alpha(i,j;i,j+1) \\ A_\alpha(i,j;i+1,j-1) & A_\alpha(i,j;i+1,j1) & A_\alpha(i,j;i+1,j+1) \end{pmatrix} \tag{5}$$

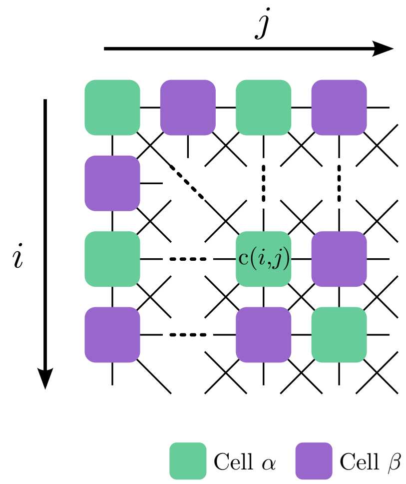



Figure 1: Structure of CNN using two kinds of template sets.

## 3. Cloning templates for an extraction of intermediate brightness

In this section, cloning templates for an extraction of intermediate brightness are introduced.

### 3.1 CNN using two kinds of cloning templates

By using following cloning template, intermediate brightness parts are extracted as checkered.

$$\boldsymbol{A}_\alpha = \begin{pmatrix} 2 & 0 & 2 \\ 0 & 2 & 0 \\ 2 & 0 & 2 \end{pmatrix}, \quad \boldsymbol{A}_\beta = \begin{pmatrix} 2 & 1 & 2 \\ 1 & 2 & 1 \\ 2 & 1 & 2 \end{pmatrix}$$

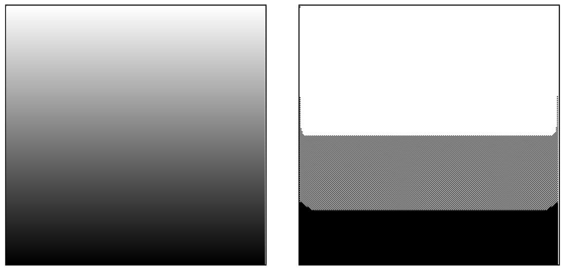
$$\boldsymbol{B}_\alpha = \begin{pmatrix} 0 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}, \quad \boldsymbol{B}_\beta = \begin{pmatrix} -1 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & -1 \end{pmatrix}, \tag{6}$$

$$I_\alpha = 2 \quad \text{and} \quad I_\beta = -2.$$

The computer simulation results are shown in Fig. 2. Figure 2 (a), (b) shows the original image and the simulated result, respectively. Dark area and bright area become black and white, respectively. The intermediate area becomes checkered pattern. Changing the parameters $I_\alpha$ and $I_\beta$ is corresponding to the brightness and sensitivity of the extracted area like as shown in Fig. 3. Peaks of border areas are observed because boundary cells are set as black in this simulation.

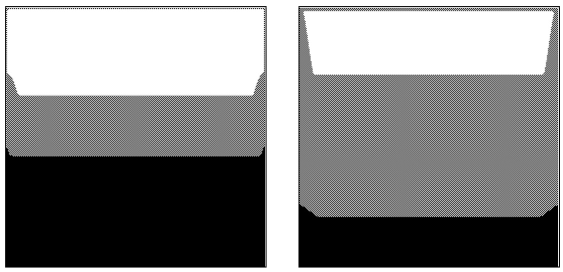
### 3.2 Conventional CNN

In order to extract of intermediate brightness, combining two following cloning templates are needed.



(a) Original image. (b) Result.

Figure 2: Computer simulation result of CNN using two kinds of cloning templates. $I_\alpha = 0.0$ and $I_\beta = -5.0$.



(a) (b)

Figure 3: Computer simulation results of CNN using two kinds of cloning templates. (a) $I_\alpha = 3.0$ and $I_\beta = -3.0$, (b) $I_\alpha = 5.0$ and $I_\beta = -5.0$.

A cloning template of a binarization is shown as follows.

$$\boldsymbol{A} = \begin{pmatrix} 0 & 1 & 0 \\ 1 & 2 & 1 \\ 0 & 1 & 0 \end{pmatrix}, \quad \boldsymbol{B} = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix} \quad \text{and} \quad I = 0.2. \tag{7}$$

Figure 4 shows the computer simulation result. By changing parameter $I$, the threshold value can be changed.

A cloning template of a subtract two images is shown as follows.

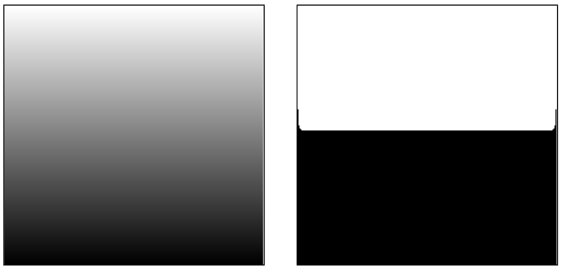
$$\boldsymbol{A} = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 1.5 & 0 \\ 0 & 0 & 0 \end{pmatrix}, \quad \boldsymbol{B} = \begin{pmatrix} 0 & 0 & 0 \\ 0 & -1.5 & 0 \\ 0 & 0 & 0 \end{pmatrix} \tag{8}$$

$$\text{and} \quad I = -1.5.$$

Figure 5 shows the computer simulation result. By subtracting Fig. 5 (b) from Fig. 5 (a) Fig. 5 (c) is obtained.

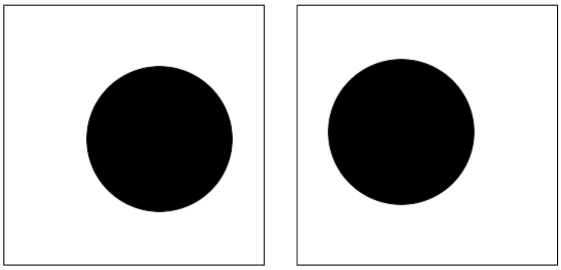
## 4. Comparison

In order to compare a CNN using two kinds of cloning templates and a conventional CNN, Computer simulations using same original image are carried out. Figure 6 shows the original image. Figure 7 shows a computer simulation result in

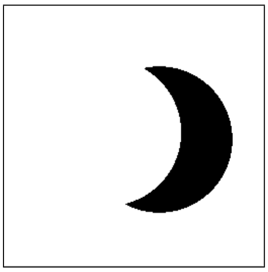


(a) Original image. (b) Result.

Figure 4: Computer simulation result of a binarization.



(a) (b)



(c)

Figure 5: Computer simulation Result of subtraction. (a) Original image set as an input image. (b) Original image set as an initial state. (c) Result.

the case of a CNN using two kinds of cloning templates. The cloning template is set as Eq. (6) except parameters $I_\alpha$ and $I_\beta$. Intermediate brightness parts are extracted as checkered patterns. Figure 8 shows a computer simulation result in the case of a conventional CNN. Intermediate brightness parts are extracted as black. Similar results are obtained. However, in the case of the conventional CNN, some processing are needed as shown in Fig. 9. Therefore, we can mention that a CNN using two kinds of cloning templates has a advantage in this point.

## 5. Conclusions

In this study, we have introduced cloning templates for an extraction of intermediate brightness. By comparing a CNN using two kinds of cloning templates and a conventional CNN, an advantage of a CNN using two kinds of cloning templates is shown.

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Figure 6: Original image ( Woman ).

Figure 7: Computer simulation result in the case of a CNN using two kinds of cloning templates. $I_\alpha = 1.5$ and $I_\beta = -1.9$

Figure 8: Computer simulation result in the case of a conventional CNN.

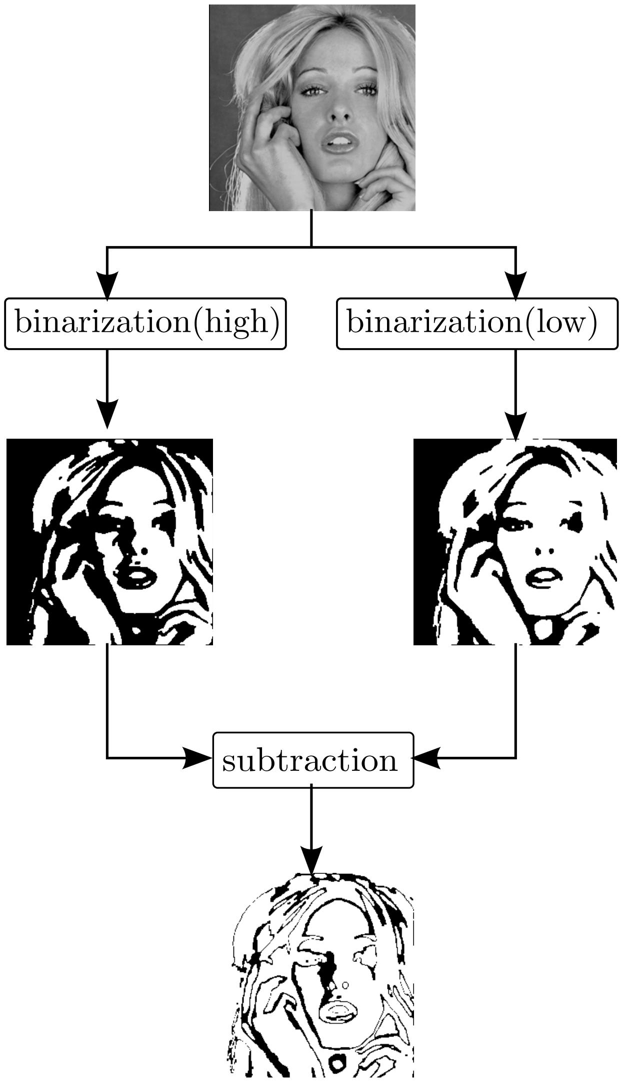


Figure 9: Processing for the extraction of intermediate brightness by a conventional CNN.