Motion Picture Processing by Two-Layer Cellular Neural Networks with Switching Templates

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***Abstract*—In this paper, we investigate characteristics of output values by a proposed new system of two layer cellular neural networks (two-layer CNN). In a general way, image processing of using conventional cellular neural networks is still image processing. On the other hand, it is few for motion picture processing. Therefore, we propose the new system which is effective structure for motion picture processing. From simulation results, we confirm that the proposed system makes it possible to characterize the time course characteristic of moving object.**

I. Introduction

We human beings get many information on a daily basis. It mostly depend on information obtained from eyes. One of the component of eyes, retina convert optical image into neural signal. Structure of cellular neural networks is similar to retina. Cellular Neural Networks (CNN) were introduced by Chua and Yang in 1988[1]. The idea of the CNN was inspired from the architecture of the cellular automaton and the neural networks. Unlike the conventional neural networks, the CNN has local connectivity property. And, the structure of CNN resembles that of animals' retina which is grating coupling of basic analog circuit units. Therefore, CNN can be used for various image processing applications [2]-[6]. The basic analog circuit is called a cell that has an effect on each other. The cell circuit is constructed from linear capacitor, linear resistors, independent voltage source, linear and nonlinear controlled sources. Mostly, image processing of using CNN is still image processing. Though, it is few for motion picture processing. Whereat, we consider the effective system that can be process the motion picture by using the input image and the previous output image of other layer.

In this study, we propose the new system which is effective structure for motion picture processing. The proposed system is based on the two layer CNN. In the two-layer CNN, output values of both layer are transfered for other layer by two coupling templates. In some image processing, the two-layer CNN is better than the single-layer CNN [7]. Also, in the proposed system, new input image and previous output image are input in each layer CNN. The switching template can execute different task by provided condition. Therefore, CNN with switching template is better than the single-layer CNN [8]. The switching template is mounted in proposed system in order to characterize new input values and previous output values. From simulation results, we confirm that the proposed system can effectively process for motion picture.

II. Cellular Neural Network

In this section, we explain the single-layer CNN and the two-layer CNN.

A. Single-Layer CNN

In this subsection, we explain the basic structure of the CNN. A block diagram of the conventional single-layer CNN is shown in Fig. 1. The conventional single-layer CNN uses two templates A and B in processing. Templates A and B are used in weighting of feedback of output value and input value.

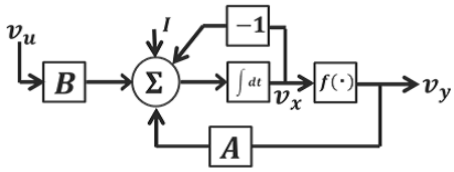

Fig. 1. Block diagram of the single-layer CNN.

The state equation and the output equation are described as follows.

State equation of the conventional single-layer CNN :

$$\frac{dv_{xij}}{dt} = -v_{xij} + \sum_{k=i-r}^{i+r}\sum_{l=j-r}^{j+r} A_{(i,j;k,l)}v_{xkl}(t) + \sum_{k=i-r}^{i+r}\sum_{l=j-r}^{j+r} B_{(i,j;k,l)}v_{ukl}(t) + I \quad (|i-k| \le 1 \ , \ |j-l| \le 1). \tag{1}$$

Output equation of the conventional single-layer CNN :

$$v_{yij}(t) = \frac{1}{2}(|v_{xij}(t)+1| - |v_{xij}(t)-1|). \tag{2}$$

B. Two-Layer CNN

Figure 2 shows the block diagram of the conventional two-layer CNN. The conventional two-layer CNN is constructed two conventional single-layers CNN. Two conventional single-layer CNN is coupled by two coupling templates C_1 and C_2. And the two coupling templates are used to transfer output values between both layers. Also, the conventional two-layer CNN has been confirmed to have more efficient structure for high performance image processing.

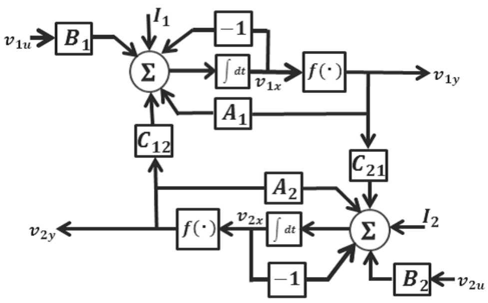

Fig. 2. Block diagram of the two-layer CNN.

III. Proposed Two-Layer CNN

In this section, we explain the system of the proposed two-layer CNN. Figure 3 shows the block diagram of the proposed system. The structure of the proposed system is based on the conventional two-layer CNN. Though, the proposed system differs the conventional system to the extent of one coupling template and the switching templates. In particular, the feature of the proposed system, the outputs of second-layer have an effect on processing of first-layer CNN. Also, the templates (A_S, B_S) of second-layer and the coupling templates (C_S) are switched by the input values of first-layer and output values of second-layer. Input values of each layer are switched every 10 [τ]. After 10 [τ], the previous output values of the first-layer CNN are inputed in the second-layer CNN.

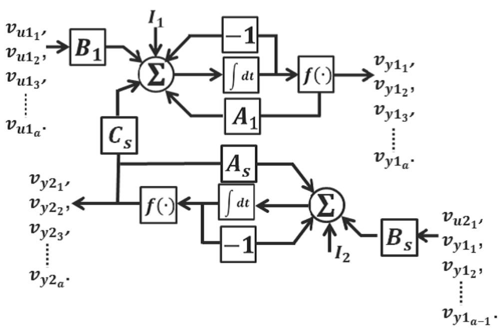

Fig. 3. Block diagram of the proposed two-layer CNN.

The algorithm of the proposed system is shown as follows.

STEP 1 : We determine the switching templates A_S, B_S and C_S by output and input valuers. If v_{2yij} is smaller than v_{1uij}, templates A_{21}, B_{21} and C_{21} are used. On the other hand, If v_{2yij} is bigger than v_{1uij}, the templates A_{22}, B_{22} and C_{22} are used. The switching rule of templates are shown as follows.

Switching rule of templates :

$$
\begin{aligned}
&v_{2yij} < v_{1uij} : A_{21}, B_{21} \ and \ C_1 templates. \\
&v_{2yij} \geq v_{1yij} : A_{22}, B_{22} \ and \ C_2 templates. \qquad (3)
\end{aligned}
$$

STEP 2 : The value of each cell in the first-layer CNN is updated. The state equation and the output equation of first-layer are described as follows.

State equation of the first-layer CNN :

$$
\begin{aligned}
\frac{dv_{1_a xij}}{dt} &= -v_{1_a xij} + \sum_{k=i-r}^{i+r}\sum_{l=j-r}^{j+r} A_{1(i,j;k,l)} v_{1_a ykl}(t) \\
&+ \sum_{k=i-r}^{i+r}\sum_{l=j-r}^{j+r} B_{1(i,j;k,l)} v_{1_a ukl}(t) \\
&+ \sum_{k=i-r}^{i+r}\sum_{l=j-r}^{j+r} C_S(i,j;k,l) v_{2_a ykl}(t) + I_1 \\
&(|i-k| \leq 1 \ , \ |j-l| \leq 1), \quad (a = 1,2,3,4,...). \qquad (4)
\end{aligned}
$$

Output equation of the first-layer CNN :

$$
\begin{aligned}
v_{1_a yij}(t) &= \frac{1}{2}(|v_{1_a xij}(t)+1| - |v_{1_a xij}(t)-1|) \\
&(a = 1,2,3,4,), \qquad (5)
\end{aligned}
$$

where, a means number of input and output images.

The value of each cell in the second-layer CNN is updated. Until 10 [τ] the state and the output equations are described Eqs. (6) and (7), respectively. After 10 [τ] the state and the output equations are described Eqs. (8) and (9), respectively.

State equation of the second-layer CNN (until 10 [τ]):

$$
\begin{aligned}
\frac{dv_{2_1 xij}}{dt} &= -v_{2_1 xij} + \sum_{k=i-r}^{i+r}\sum_{l=j-r}^{j+r} A_{S(i,j;k,l)} v_{2_1 ykl}(t) \\
&+ \sum_{k=i-r}^{i+r}\sum_{l=j-r}^{j+r} B_{S(i,j;k,l)} v_{2_1 ukl}(t) + I_2 \\
&(|i-k| \leq 1 \ , \ |j-l| \leq 1). \qquad (6)
\end{aligned}
$$

Output equation of the second-layer CNN (until 10 [τ]):

$$
v_{2_1 yij}(t) = \frac{1}{2}(|v_{2_1 xij}(t)+1| - |v_{2_1 xij}(t)-1|). \qquad (7)
$$

State equation of the second-layer CNN (after 10 [τ]):

$$
\begin{aligned}
\frac{dv_{2xij}}{dt} &= -v_{2_b xij} + \sum_{k=i-r}^{i+r}\sum_{l=j-r}^{j+r} A_{S(i,j;k,l)} v_{2_b ykl}(t) \\
&+ \sum_{k=i-r}^{i+r}\sum_{l=j-r}^{j+r} B_{S(i,j;k,l)} v_{1_{b-1} ykl}(t) + I_2 \\
&(|i-k| \leq 1 \ , \ |j-l| \leq 1), \quad (b = 2,3,4,...). \qquad (8)
\end{aligned}
$$

Output equation of the second-layer CNN (after 10 [τ]):

$$
\begin{aligned}
v_{2_b yij}(t) &= \frac{1}{2}(|v_{2_b xij}(t)+1| - |v_{2_b xij}(t)-1|), \\
&(b = 2,3,4,...), \qquad (9)
\end{aligned}
$$

STEP 3 : The steps 1 and 2 are repeated every 0.005 [τ].

IV. SIMULATION RESULTS

In this section, we show simulation result of the motion picture processing with four input images by using the proposed system. For simulation, we use four types of templates which are found in [9]. Templates of each layer and coupling are assigned as follows.

Template of first-layer:

$$A_1 = \begin{bmatrix} 0 & -0.1 & 0 \\ -0.1 & 0.5 & -0.1 \\ 0 & -0.1 & 0 \end{bmatrix},$$
$$B_1 = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix}, \; I = 0. \tag{10}$$

Two types of templates of the second-layer:

$$A_{21} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0.2 & 0 \\ 0 & 0 & 0 \end{bmatrix},$$
$$B_{21} = \begin{bmatrix} -0.2 & -0.2 & -0.2 \\ -0.2 & 1.6 & -0.2 \\ -0.2 & -0.2 & -0.2 \end{bmatrix}, \; I_1 = 0. \tag{11}$$
$$A_{22} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & -0.2 & 0 \\ 0 & 0 & 0 \end{bmatrix},$$
$$B_{22} = \begin{bmatrix} 0 & 0.1 & 0 \\ 0.1 & 0.2 & 0.1 \\ 0 & 0.1 & 0.1 \end{bmatrix}, \; I_2 = 0. \tag{12}$$

Two types of coupling template:

$$C_1 = \begin{bmatrix} 0 & 0.1 & 0 \\ 0.1 & 0.35 & 0.1 \\ 0 & 0.1 & 0 \end{bmatrix},$$
$$C_2 = \begin{bmatrix} 0 & 0.1 & 0 \\ 0.1 & -1 & 0.1 \\ 0 & 0.1 & 0 \end{bmatrix}. \tag{13}$$

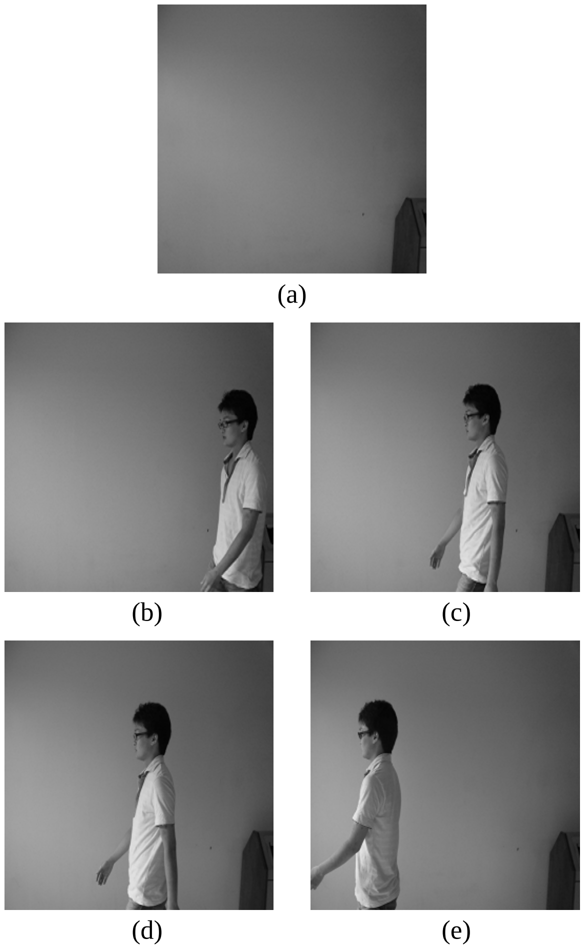

Fig. 4. Input and initial state images. (a) Initial state of each layer and input image of second layer From 0 to 10 [τ], (b) Input image of first-layer from 0 to 10 [τ], (c) Input image of first-layer from 10 to 20 [τ], (d) Input image of first-layer from 20 to 30 [τ], (e) Input image of first-layer from 30 to 40 [τ].

Figures 4(b) to (e) show the four types of input images of first-layer. Figure 4(a) shows the first input image of second-layer and initial state images of each layer. In Fig. 4, a parson is moving on to right side from left side.

Figures 5 and 6 show the simulation results using the proposed system. Figure 5 shows the output images of the first-layer. In Figs. 5(b) to (d), moving objects of previous outputs are appeared. In Fig. 5(b), moving object of Fig. 5(a) is appeared. Gray scale values of moving object are diluter than original object in Fig. 5(a). Next, in Fig. 5(c), the two moving objects of the previous outputs are appeared. In addition, edge lines of the most right side moving object are accented. In a similar way, in Fig. 5(d), the all moving objects of previous output are appeared about same characteristic.

Figure 6 shows the output images of the second-layer. In Fig. 6, the output value translate into similar gray scale value. In Figs. 6(b) to (d), moving object of previous outputs are appeared. Also, in Figs. 6(b) and (c), we can discern edges of moving object and right side object in back ground. And, in Fig. 6(d), edges of right side moving object are more accent than other moving object.

Figure 7 shows the variation of cell values of first-layer. Point of Vy(30,30) corresponds to the pixel of back ground. Point of Vy(220,70) corresponds to the pixel of head in first appeared moving object. Point of Vy(204,170) and Vy(211,127) correspond to the pixel of edge line in first appeared moving object. Slope of Vy(30,30) is little change at every switching input images. On the other hand, other slopes are large change at every switching input images. Slope of Vy(204,170) and Vy(220, 70) are changed high scale values at every switching input images. That is to say, the edge of moving objects is accented at every switching input images. Therefore, the edge of old moving object is more accent than new moving object.

From simulations result, the proposed system could be appeared about characteristic of moving object. Also, the time course of moving object could be discerned by the accent of the edge lines.

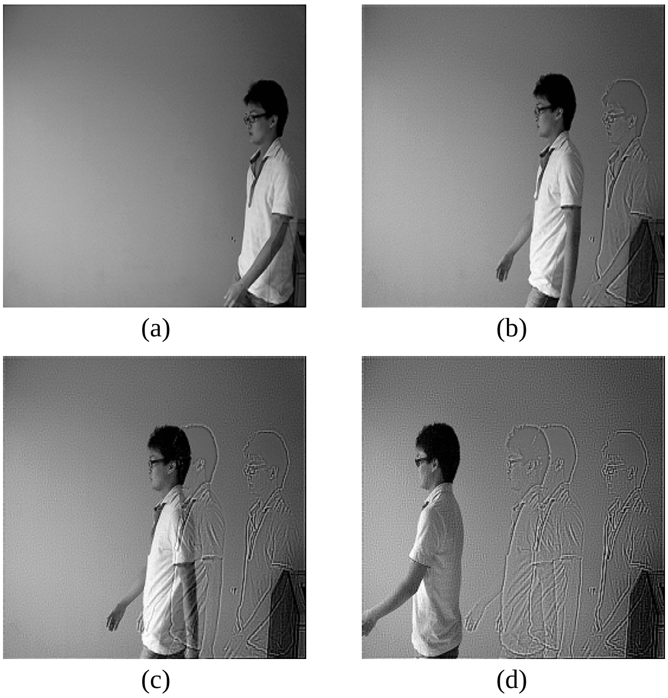

Fig. 5. Simulation results of the first-layer. (a) 0 [τ], (b) 10 [τ], (c) 20 [τ], (d) 30 [τ].

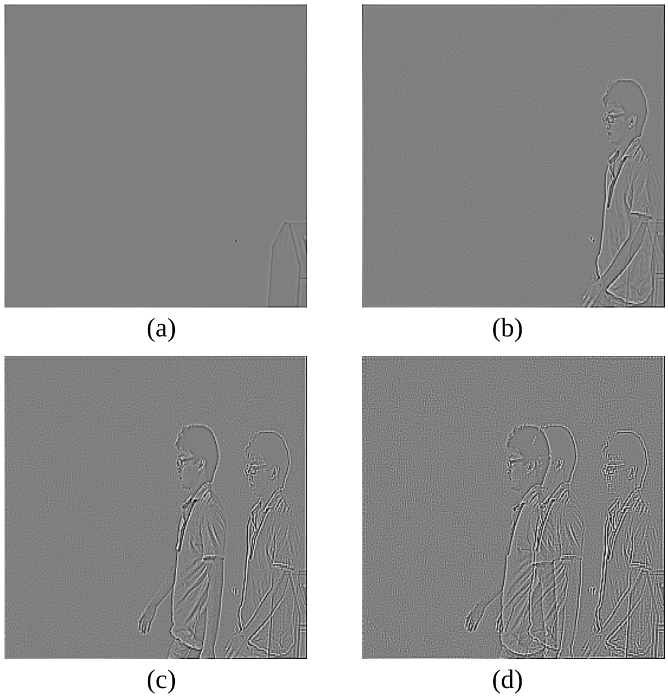

Fig. 6. Simulation results of the second-layer. (a) 0 [τ], (b) 10 [τ], (c) 20 [τ], (d) 30 [τ].

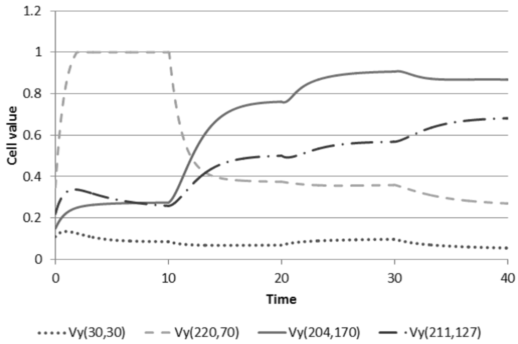

Fig. 7. Change of cell values of first-layer.

V. Conclusion

In this study, we have proposed two-layer CNN with switching templates of second-layer. The feature of the proposed system are only coupling template and the switching templates. The first-layer and the second-layer were connected only coupling template. Outputs of second-layer CNN have an effect on processing of first-layer CNN.

From simulation results, the proposed system could be detected about characteristic of moving object. Therefore, we could say that the proposed system makes it possible to characterize the detection of moving objects. In the future works, we would like to process detection of moving object in image that is changed background.

Acknowledgment

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