1-34

Four-layer Cellular Neural Networks with Layer of Color and Luminosity

Yoshihiro KATO Yasuhiro UEDA Yoko UWATE Yoshifumi NISHIO
(Tokushima University)

1. Introduction

Cellular Neural Networks (CNN) were introduced by L. O. Chua and L. Yang in 1988. The structure of CNN resembles that of human's retina. Human's retina has the capability to identify color and luminosity. The cell identifies color is called a cone cell. On the other hand, the cell reacting to luminosity is called a rod cell. The color image processing using CNN was proposed. Additionally, Inoue et al. have used three-layer CNN based on cone cell which processes the three primary colors of light (R, G, B), and performed edge enhancement in [1] (RGB-CNN). However, the edge of a low luminosity portion is not detected.

In this study, we propose the four-layer CNN considering the three primary colors of light and the luminosity (CR-CNN: Cone and Rod CNN).

2. CR-CNN

In this section, we explain the structure of the CR-CNN as shown in Fig. 1. The CR-CNN is constructed by four single-layer CNNs. Each layer corresponds to the three primary colors of light and luminosity, respectively. Each layer is combined by connection template which are C_R, C_G, C_B, C_L, C_{LR}, C_{LG} and C_{LB}. Before the processing, a color image is converted to four gray-scale images. They correspond to red, green, blue and luminosity value, respectively. These four gray-scale images are inputted to each layer in the proposed four-layer CNN.

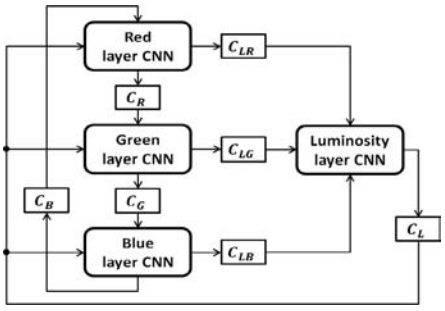

Figure 1: Structure of the CR-CNN.

3. Simulation Results

In this section, we show the simulation result for edge detection by using the CR-CNN. In this simulation, size of all templates are 3×3 matrix. In templates A and C, only center value is the variable b, and other values of the template are zero. Templates for edge detection by using the CR-CNN are shown as follows.

Edge detection template in the CR-CNN :

$$A_{R(2,2)} = A_{G(2,2)} = A_{B(2,2)} = A_{L(2,2)} = 1$$

$$B_R = B_G = B_B = B_L = \begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

$$I_R = I_G = I_B = I_L = -1$$

$$C_{R(2,2)} = b \quad \begin{cases} b = 0.9 & \text{if } v_{yRij} \geq 0 \\ b = 0 & \text{otherwise} \end{cases}$$

$$C_{G(2,2)} = b \quad \begin{cases} b = 0.9 & \text{if } v_{yGij} \geq 0 \\ b = 0 & \text{otherwise} \end{cases}$$

$$C_{B(2,2)} = b \quad \begin{cases} b = 0.9 & \text{if } v_{yBij} \geq 0 \\ b = 0 & \text{otherwise} \end{cases}$$

$$C_{L(2,2)} = b \quad \begin{cases} b = 1 & \text{if } v_{yLij} \geq 0 \\ b = 0 & \text{otherwise} \end{cases}$$

$$C_{LR(2,2)} = b \quad \begin{cases} b = 0.9 & \text{if } v_{yRij} \geq 0, \\ & \quad v_{yRij} > v_{yGij} \text{ and} \\ & \quad v_{yRij} > v_{yBij} \\ b = 0 & \text{otherwise} \end{cases}$$

$$C_{LG(2,2)} = b \quad \begin{cases} b = 0.9 & \text{if } v_{yGij} \geq 0, \\ & \quad v_{yGij} > v_{yRij} \text{ and} \\ & \quad v_{yGij} > v_{yBij} \\ b = 0 & \text{otherwise} \end{cases}$$

$$C_{LB(2,2)} = b \quad \begin{cases} b = 0.9 & \text{if } v_{yBij} \geq 0, \\ & \quad v_{yBij} > v_{yRij} \text{ and} \\ & \quad v_{yBij} > v_{yGij} \\ b = 0 & \text{otherwise} \end{cases} \quad (1)$$

where A, B and I of each layer are the same as existing edge detection template. Red, green and blue layers are influenced through connection template (C_B, C_R, C_G and C_L) from blue, red and green layers, respectively and luminosity layer. Luminosity layer is influenced though connection templates (C_{LR}, C_{LG} and C_{LB}) only from the cell whose value is the large among red, green and blue layer when the value is lager than zero. In the case of each cell are the same output value, luminosity layer is influenced through connection template only from one of them.

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

Figure 2: Simulation results. (a) Input image. (b) Simulation result using the basic CNN. (c) Simulation result using the RGB-CNN. (d) Simulation result using the CR-CNN.

Figure 2 shows the simulation results of edge detection. In Fig. 2 (a), this input image is a low luminosity image. In Fig. 2 (b), using the basic CNN, most edge is not detected. In Fig. 2 (c), using the RGB-CNN, this output image is not edge detection image which would appear that the input image is a low luminosity. In Fig. 2 (d), we can see that the CR-CNN can detect the edges more effectively than the basic CNN and the RGB-CNN.

The simulation result using the CR-CNN arise from the structure which consideration of three primary colors of light and luminosity.

4. Conclusions

In this study, we have focused on retina cells which are cone and rod cell. Then, we have proposed four-layer cellular neural networks with layer of color and luminosity. From simulation result, we have confirmed that the CR-CNN could detect the edge of color images more effectively than the basic CNN and RGB-CNN.

Reference

[1] T. Inoue and Y. Nishio, "Edge Enhancement of Color Image by Three-Layer Cellular Neural Network Considering Three Primary Colors," Proc. of NOLTA'08, pp. 540-543, Sep. 2008.