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Processing Color Images by Three-Layer Cellular Neural Networks

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1. Introduction

Cellular Neural Networks (CNN) [1] were introduced by Chua and Yang in 1988. The idea of the CNN was inspired from the architecture of the cellular automata and the neural networks. Unlike the conventional neural networks, the CNN has local connectivity property. Since the structure of the CNN resembles the structure of animals' retina. The humans retina have an ability distinguishing colors and consist of three types of cells responding to the three primary colors. Roska et al. have proposed a concept using a three-layer CNN processing the three primary colors in [2]. They have confirmed that the three-layer CNN could produce half-toned images of color images. However, after their pioneering work, there have not been many researches on the CNN dealing with three primary colors of the image effectively. In this study, we propose a three-layer CNN considering three primary colors (RGB-CNN). In our RGB-CNN, the connections between the three layers play an important role. Namely, the three layers do not operate independently but all the outputs influence to the other layers. In this research, we confirm that the RGB-CNN can enhance the edges of color images.

2. RGB-CNN

The proposed RGB-CNN is the three-layer CNN considering the three primary colors. Figure 1 shows the structure of the RGB-CNN. In Fig 1, CR, CG and CB are the connection templates introduced to couple the three layers. Before the processing, a color image is divided into three primary colors and they are converted to three gray-scale images corresponding to red value, green value and blue value. These three images are inputted to the Red-Layer, Green-Layer and Blue-Layer in RGB-CNN.

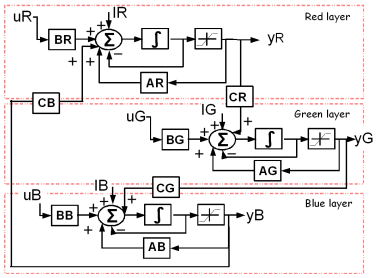


Figure 1: Structure of the RGB-CNN.

3. Simulation results

In this section, we show some effective edge detection results using RGB-CNN. The templates are as follows.
Edge Detection Template in CNN:

$$A = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix}, \; B = \begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}, \; I = -1. \tag{1}$$

Edge Detection Template in RGB − CNN:

$$AR = AG = AB = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

$$BR = BG = BB = \begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

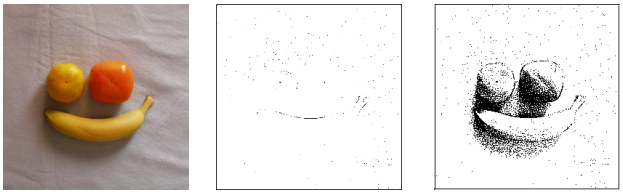
$$IR = IG = IB = -1.$$

$$CR = \begin{bmatrix} 0 & 0 & 0 \\ 0 & b & 0 \\ 0 & 0 & 0 \end{bmatrix} \quad \begin{cases} b = 2 & if \;\; v_{yRij} \geq 0 \\ b = 0 & otherwise \end{cases}$$

$$CG = \begin{bmatrix} 0 & 0 & 0 \\ 0 & b & 0 \\ 0 & 0 & 0 \end{bmatrix} \quad \begin{cases} b = 2 & if \;\; v_{yGij} \geq 0 \\ b = 0 & otherwise \end{cases}$$

$$CB = \begin{bmatrix} 0 & 0 & 0 \\ 0 & b & 0 \\ 0 & 0 & 0 \end{bmatrix} \quad \begin{cases} b = 2 & if \;\; v_{yBij} \geq 0 \\ b = 0 & otherwise \end{cases} \tag{2}$$

In Eq. (2), A, B and I are the same as those in Eq. (1). For the connection template CR, CG and CB, we consider the nonlinear (threshold-type) function to make the effect of each layer more significant.



(a) (b) (c)

Figure 2: Edge detection of fruit image. (a) Color input image. (b) Output image using CNN. (c) Output image using RGB-CNN.

Figure 2 shows the simulation results for Edge detection. From these results, we can see that the proposed edge-detection RGB-CNN produces the output image in which all the edges are enhanced and also the shaded area remains as like a half-toned image.

4. Conclusions

In this study, we have proposed the three-layer CNN considering the three primary colors. By computer simulations of edge detection tasks for a color image, we have confirmed that the RGB-CNN could enhance the edges of color images more effectively than the regular processing by using the original CNN. We feel that the RGB-CNN is available to various image processings.

References

[1] L.O. Chua and L. Yang, "Cellular Neural Networks: Theory," IEEE Trans. Circuits Syst., vol. 32, pp. 1257-1272, Oct. 1988.
[2] T. Roska, A. Zarandy and L.O. Chua, "Color Image Processing by CNN," Proc. of ECCTD'93, pp. 57-62, Aug. 1993.