

Interpolation of Gap between Two Lines by Cellular Neural Networks

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1. Introduction

Cellular Neural Networks (CNN) were introduced by Chua and Yang in 1988 [1]. The structure of CNN imitated the retina of the animal. The idea of CNN was inspired from the architecture of the cellular automata and the neural networks. A different point from a common neural network has the feature that CNN has local connectivity property. The performance of the CNN is decided by template, and the contents of processing are determined by changing the parameter.

In this study, we propose a method to interpolate a gap between two separate lines by using CNN. We consider that such a task is a kind of the subjective contour, which is one of optic illusions. Computer simulations show that the proposed method successfully performs the interpolation.

2. Proposed Method

In this section, we describe the proposed method. Stability of the templates in this study has been confirmed in [2].

First, make two lines thick by “Black Propagation” template.

Black Propagation Template (BP)

$$A = \begin{bmatrix} 0.25 & 0.25 & 0.25 \\ 0.25 & 3 & 0.25 \\ 0.25 & 0.25 & 0.25 \end{bmatrix}, B = 0, I = -1. \quad (1)$$

This template extends black to every directions.

Secondly, the gap between the two thick lines is filled by “Concave Location Filler” template.

Concave Location Filler Template (CLF)

$$A = \begin{bmatrix} 0.5 & 0.5 & 0.5 \\ 0.5 & 3 & 0.5 \\ 0.5 & 0.5 & 0.5 \end{bmatrix}, B = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 0 \end{bmatrix}, I = 3.25. \quad (2)$$

The template transforms all the objects to solid black concave polygons with vertical, horizontal and diagonal edges only.

Thirdly, contour of a black object is gradually cut down with “Center Point Detector” template.

Center Point Detector (CPD)

CENTER1

$$A = \begin{bmatrix} 1 & 0 & 0 \\ 1 & 4 & -1 \\ 1 & 0 & 0 \end{bmatrix}, B = 0, I = -1.$$

CENTER2

$$A = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 6 & 0 \\ 1 & 0 & -1 \end{bmatrix}, B = 0, I = -2.$$

...

CENTER8

$$A = \begin{bmatrix} 1 & 0 & -1 \\ 1 & 6 & 0 \\ 1 & 1 & 1 \end{bmatrix}, B = 0, I = -2. \quad (3)$$

By using the eight templates in order, the contour of a black object is peeled gradually. Only one point of the

target center remains by this template. Then, the one point and the input image are added. After this, we using BP, CLF, and CPD to the new image again. Finally, the interpolated image is obtained by adding the input image again.

3. Simulation Results

In this section, an example of the interpolations using the proposed algorithm is shown.

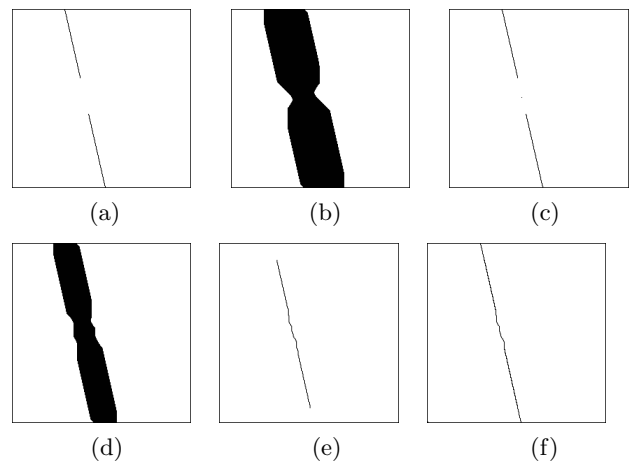


Figure 1: Simulation results. (a) Input image. (b) Output image of BP and CLF. (c) New input image. (d) Output image of second BP and CLF. (e) Output image of second CPD. (f) Final output image.

Figure 1(a) is the input image with two lines with a gap between them. Figure 1(c) is the new input image obtained by adding the one point after BP, CLF, and CPD and the original input image. Figures 1(b) and (d) are output of BP and CLF. Figure 1(e) is the interpolated two lines. Finally, we add Figs. 1(a) and (e) and obtain the final output image in Fig. 1(f). Although slight distortion is in the interpolated portion, the task is able to be performed.

4. Conclusions

In this study, we proposed an algorithm using CNN to interpolate a gap between two lines without the measurement of the angle by digital calculations. For the future, we study more complicated processing imitating the subjective contour.

References

- [1] L.O. Chua and L. Yang, “Cellular Neural Networks: Theory,” IEEE Trans. Circuits Syst., vol. 32, no. 10, pp. 1257-1272, Oct. 1988.
- [2] Cellular Sensory Wave Computers Laboratory, Computer and Automation Research Institute, Hungarian Academy of Science, “Cellular Wave Computing Library (Templates, Algorithms, and Programs), version 2.1.”