A New Approach for Color Image Edge Detection Using Improved PCNN

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Abstract: -Recent researches indicate that pulse coupled neural network can be implemented on image processing , such as image segmentation and edge detection effectively. However, up to now it has mainly been used in the processing of gray images or binary images , and the parameters of the network are always adjusted and confirmed manually for different images, which impede PCNN's application in image processing. To solve the problem, this paper use PCNN in the color image segmentation with the parameters determined by images' spatial and gray characteristics automatically at the first ,then use the above method to obtaine the edge information . The experiment results shows its validity and robustness.

Key Words: pulse coupled neural network (PCNN) ;color image segmentation ,parameter determination ;image edge detection

1. Introducion

Pulse Coupled Neural Network , PCNN[1] was brought forward by Eckhorn firstly， it can be used to explain the phenomena of synchronous burst of cat's brain neural element. Johnson and his colleagues had modified the model of the initial PCNN, which was applicable for the computer more easily. The improved model of PCNN have the well feature of transmitting burst, which is used widely in the fields of image processing, mode recognition and so on. Edge detection is one of the most important application to the image processing by PCNN.

The existed algorithm of PCNN is often applied to the fields of segmentation of grey image[2], edge detection of grey image[3] or binary image[4] lonely, Bao qingfeng put forward a new algorithm based on PCNN firstly, which is applied to the segmentation of colorized image[5]， in her paper, Bao used PCNN in the colorized image, and tried for both segmentation and edge detection of colorized image. However, Bao's algorithm is based on Xiao Dong Gu's[6], which is a predigestion algorithm of segmentation of image based on PCNN. In this algorithm, the parameter of network should be adjusted manually, then it could be used to segment the image, and it didn't use the model of PCNN when it was used to edge detection of he image. If she wanted to get the result, she should adjust the parameters based on the features of the image time after time, and switch the model of PCNN when edge detection began. This algorithm restricted the application of the PCNN in the fields of colorized image. In order to improve the model of PCNN, we put forward a new PCNN system, which can adjust the parameters of the network voluntarily based on the reference [5], and we can use it to process the segmentation and edge detection of colorized image. The experimental results show that we can get the approving results.

2. PCNN

PCNN is a neural network which is composed of lots of neural elements. Every neural element is made up of dendritic tree, linking modulation, and pulse generator. Dendritic tree is divided into two small portions, which are applied to let the different input link with the linking part of the neural element. One of them is applied to accept the outside input signal which we called it feed-in input, and another is applied to receive the other neural element's linking input. We can describe them as follows:

$$F_{ij}[n]=\exp(-\alpha_F)F_{ij}[n-1]+V_F\sum M_{ijkl}Y_{kl}(n-1)+I_{ij} \quad (1)$$

$$L_{ij}[n]=\exp(-\alpha_L)L_{ij}[n-1]+V_L\sum W_{ijkl}Y_{kl}[n-1] \quad (2)$$

$$U_{ij}[n]=F_{ij}[n](1+\beta L_{ij}[n]) \quad (3)$$

$$Y_{ij}[n]=\begin{cases}1\ , & U_{ij}[n]>T_{ij}[n]\\ 0\ , & otherwise\end{cases} \quad (4)$$

$$T_{ij}[n]=\exp(-\alpha_T)T_{ij}[n-1]+V_T Y_{ij}[n] \quad (5)$$

As the top formulas, I_{ij} , F_{ij} , L_{ij} , U_{ij} , Y_{ij} , T_{ij} mean separately neural element's outside stimulating input, feed-in input, linking input, inside activity, firing output, dynamic threshold. M and W are linking weight matrix (usually, $M=W$), V_F , V_L , V_T mean separately inherent electricity in F_{ij} , L_{ij} , and T_{ij} , α_F , α_L , α_T mean separately attenuation constant of time in F_{ij} , L_{ij} , T_{ij} , n is a loop constant, and Y_{ij} is a binary output, which means a planar PCNN network is corresponding with a planar image.

When PCNN is applied to the image processing, it is a monolayer and planar linking network. every input image's point is corresponding a PCNN neural element.

3. The description of the new approach

there are two colorized model in common use now: the first is RGB model which has relations with hardware. Secondly, there is HIS model which has relations with colorized processing. In this paper, we use HIS model, which means hue, saturation, intensity, there are two advantages, firstly, hue has not relations with the colorized information of the image, secondly, hue and saturation have a close relation with the feeling of human . All of these features let HIS model fit for the segmentation of image based on the human's vision system.

We consider that the traditional PCNN model use the neural element's feature of firing and the threshold and exponential attenuation. In fact, the mechanism of exponential attenuation and threshold is not fit for the image processing [7] , so we propose a new improved PCNN model which can ensure the parameters adaptively based on the traditional PCNN, and at the same time, we apply the same improved model to the colorized image segmentation and edge detection.

3.1 Confirming the parameters adaptively

Firstyly, we should transform a colorized image into a space of HIS, secondly, set up a Corresponding model of PCNN for the hue, saturation, intensity separately, thirdly we should set image point: (i,j) , which is unitary, at last, we get the final image: $f(i,j)$.

When we segment the image, if we want to get a binary image which has a well effect, we should set the right parameters based on the image's features of grey and space, and when we process edge detection, we use the same new PCNN model, and we just need to ensure the right area(grey value=1) of the binary image which has the corresponding neural element, and the corresponding neural element can fire the impulse alone the shape of the target and transform freely, then we control the dynamic threshold, at last, we can get the whole edge of the target. So when we do the edge detection, we can predigest the parameters. The material methods as follows:

(1) Linking weights W_{ijkl} :

According to the PCNN approach, this parameter means how much the output impulse of the surrounding neural element has effect upon the current neural element. As the current neural element, if the distance between it and its corresponding image point is more small, and the value is more close, then we can conclude that the degree of effect is more strong, whereas is more little.

$$W_{ijkl}=\left(\frac{1/(|d_g(i+k,j+l)\times d_s(i+k,j+l)+1|)}{\sum_{k,l}(1/(|d_g(i+k,j+l)\times d_s(i+k,j+l)+1|))}\right)^e$$

Let $d_g(i+k, j+l)$ means the distance of grey value between the corresponding two image points , and $d_s(i+k, j+l)$ means the distance of space between the corresponding two image points.

$d_g(i+k, j+l)$ is defined ： $f(i,j)-f(i+k,j+l)$

$d_s(i+k, j+l)$ is defined ： $\sqrt{k^2+l^2}$;

when we do the image segmentation: let $e=1$;

when we do the edge detection: we want to make the output impulse of neural element transform freely and quickly, let $e=0$ 。

(2) Adjusting the step of threshold r :

Let $n_{\max}$ means the times of iterative in the image processing, we want to ensure the threshold value can be through all of the image points. The adjusting step of threshold is: $r=1/n_{\max}$.

when we do the edge detection: let $r=0$.

(3) inherent electricity V_T :

the inherent electricity V_T in the PCNN is used to judge whether the neral element is firing at a moment, if it is firing, then we should set V_T and let the corresponding threshold increase quickly, and stop V_T when $V_T > U_{ij}$, then the impulse creator can stop firing. In this paper, we have the same V_T no matter what kinds of images, and let $V_T=100$.

(4) initial dynamic threshold T_{ij} :

$T_{ij}=\alpha$ 。

when we do the image segmentation: let $\alpha=1$;

when we do the edge detection: let $\alpha=0.15$.

(5) modulating parameters β :

$$\beta=(\sqrt{V_{ij}}/M_{ij})^e$$ 。

when we do the image segmentation: let $e=1$, then we can control the degree of increasing of F_{ij} , V_{ij} means that image point (i,j) which corresponding image points' grey value variance in the surrounding area, and M_{ij} means that image point (i,j) which corresponding image points' grey value mean in the surrounding area, when $M_{ij}=0$, let $\beta=0.2$. More little the β is, more small the distributing scope of grey value of image points are , and more average the distributing is in the surrounding area, then we can find a little improving of grey value can make it firing as the neural element firing in the surrounding area at the same time, whereas, the distributing is not average, and we need a big improving of grey value can make it firing as the neural element firing in the surrounding area at the same time, then, in a certain extent, we can confirm the integrality of the area of segmentation.

When we do the edge detection, we will predigest β , and let $e=0$.

3.2 the threshold segmentation of the image based on the Shannon entropy maximum rule

In the reference [8], the author want to make sure the best segmentation results and choose the best times of iteration. So the author defines the segmentation methods based on the Shannon entropy maximum rule as follows:

$$H(S)=-S_1\ln S_1-S_0\ln S_0 \qquad (6)$$

S_1 and S_0 mean the probability of the "1" and "0" in the output binary image separately. The formula (6) means that how much the information of statistical mean value of the image points(“1” or “0”) include in a binary image after segmentation. Usually, the more Shannon entropy is, it means the image after segmentation get more information from the initial image, and lastly, the image after segmentation has ample details, and well segmentation effect as a whole. In this paper, we will calculate the S_1 and S_0 from the output binary image Y. When S_1 and S_0 make the H maximum, which means we get a best segmentation binary image: Y.

3.3 new approach of colorized image segmentation

At the first, we should transform the initial colorized image into HIS space, then we can get the hue image, saturation image, and intensity image, we should calculate them by improved PCNN approach, the improved PCNN model as follows:

$$F_{ij}(n) = I_{ij}$$

$$L_{ij}(n) = \sum_{p \in K} W_p{}^e Y_p(n-1)$$

K is a 3*3 matrix and surrounding the image point (i, j)

$$U_{ij}(n) = F_{ij}(n)(1 + \beta_{ij}{}^e L_{ij}(n))$$

$$T_{ij}(n) = T_{ij}(n) - r + V_T Y(n)$$

$$Y_{ij}(n) = step(U_{ij}(n) - T_{ij}(n)) = \begin{cases} 1, & if\, U_{ij} > T_{ij} \\ 0, & else \end{cases}$$

Secondly, we use the PCNN to calculate the he hue image, saturation image, and intensity image separately as follows:

(1) We should transform the grey value of image point I_{ij} into be unitary, and the initial status of the neural elements should be set as follows:

$L = U = \mathrm{Re}s = Y = 0$， $n_{\max} \in [10,50]$

K is a 3*3 matrix, and all of its value are 1, $\mathrm{Re}s$ is a matrix which means the result, Y is a matrix which means the firing status, and n is the times of iteration, the rest are calculated by the top formulas automatically.

(2) $L_{ij} = \sum_{p \in K} W_p{}^e Y_p$;

$U_{ij} = F_{ij}(1 + \beta_{ij}{}^e L_{ij})$； $Y_{ij} = step(U_{ij} - T_{ij})$；

(3) $T = \alpha$;

(4) $L_{ij} = \sum_{p \in K} W_p{}^e Y_p$;

(5) $Tem = Y(i, j)$; $U_{ij} = F_{ij}(1 + \beta_{ij}{}^e L_{ij})$;

$Y_{ij} = step(U_{ij} - T_{ij})$;

Thereinto， Tem is a temporary matrix；

(6) If $Y(i, j) = Tem$ go to (7);

Else $L_{ij} = \sum_{p \in K} W_p{}^e Y_p$ go to (5);

(7)If $Y(i, j) = 1$ $\mathrm{Re}s(i, j) = 1$，

$Y(i, j)$ 、 $\mathrm{Re}s(i, j)$ is the elements of Y 、 $\mathrm{Re}s$;

(8) $T(i, j) = \alpha - r + V_T * Y$

(9)To calculate Shannon entropy of the corresponding image, if we find the maximum when the time of iterative is n, and the corresponding $Y(n)$ is the last binary image.

(10) $n = n - 1$; If $n \neq 0$, go to (4); Else END；

(11)To integrate the three binary image, then we can get the result, which is the segmentation image: Bin.

3.4 new approach of colorized image edge detection

When we get the segmentation image: Bin, we use the same PCNN model to detect the edge, firstly, we should let the corresponding image points of the bright area fire impulse, and the corresponding image points of the dark area not fire impulse in this image, secondly, the bright area will transmit as the same width as a image point, then the edge between the dark area and bright area would be fire. If we control the above transmitting distance, we can control the width of result of edge detection image expediently. For example, if the impulse of bright area transmits distance as the same width as 5 image points, at last, we get a result of image, and the width of this image is 5 image points. The approach is as follows:

(1) To set a matrix: E, which can save the result of edge detection.

We should transform the Bin into be unitary as 0.1(corresponding the dark area of Bin), and 1(corresponding the bright area of Bin), $F = Bin$, $L=U=Y=E=0$, $n_{\max} = N+1$, N is the width of the edge image, and the rest are calculated by the top formulas automatically;

(2) $L = \sum_{p \in K} W_p{}^e Y_p$;

$U = F(1+\beta^e L)$; $Y = step(U - T)$;

(1) if $Y_{ij} = 1, T_{ij} = T_{ij} + V_T Y_{ij}$, it means a neural element is inspired to fire, we should increase this neural element's threshold to stop it fire.

(4)if $n = N+1, n = n-1$,go back to (2); else $n = n-1$

(5)if $Y_{ij} = 1, E_{ij} = 1$ 。

(6)if $n = 0$,output E , and we will get the edge image. else go back to (2).

4 Experimental Results

In my paper, we use the new approach to process two kinds of images. We can find if we adopt the Bao's PCNN model, the results which are figure 2(a), and figure 4(a) create noises, some bright areas are short of segmentation, and the details are not good. When Bao adopts preweitt operator to detect edge of image, the edge result is not clear, and has lots of disconnected points, however, we apply the new PCNN model into the same images, and we get the results which are figure 2(b), and figure 4(b), we can find the details of the image keep the integrality, the shape of the image is intact. The results which are figure 3(b), and figure 5(b) after edge detection, we apply the same PCNN model into the image, and our results have the whole targets' edge, and we can change the width of the last results of images according to the necessary to make these images more clearly.

Fig. 1(a)The initial car's image **(b)The initial human's image**


Fig. 2(a)The result after segmentation according to Bao **(b)The result after edge detection according to Bao**

Fig. 3(a)The result after segmentation according to the new approach **(b)The result after edge detection according to the new approach**


Fig. 4(a)The result after segmentation according **(b)The result after edge detection according**

to Bao **to Bao**

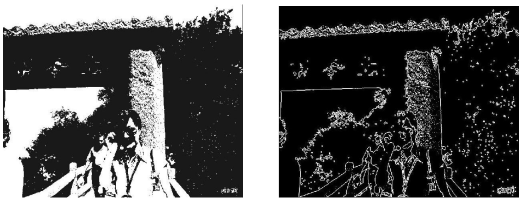

Fig. 5(a)The result after segmentation according to the new approach **(b)The result after edge detection according to the new approach**

5 Conclusions

In this paper, we create an improved PCNN model, which can choose the right network parameters adaptively, and we apply it into colorized image segmentation and edge detection. At the different processing stage, the new PCNN model can adjust the network parameters automatically, and this can solve the problem of the traditional PCNN, which needs to adjust parameters manually. Because of this new PCNN model, we can apply it into different kinds of images in the image segmentation and edge detection. After the experiment, we can get a robust and intact result according to this new approach no matter how complexity our processing image. At the same time, we also find that this new approach has a lot of disadvantages, too. For example, we should waste more time to process these images, which will restrict the application of this approach to the environment of real time processing. As an open issue, how to improve the PCNN model, predigest the approach, and increase the efficiency, we need to research more.

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