A Method of Human Skin Region Detection Based on PCNN

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Abstract. A method of human skin region detection based on PCNN is proposed in this paper. Firstly, the input origin image is translated from RGB color space to YIQ color space, and I channel image is obtained. Secondly, we use the synchronous pulse firing mechanism of pulse coupled neural network (PCNN) to simulate the skin region detection mechanism of human eyes. Skin and non-skin regions are fired in different time. Therefore, skin regions are detected. Our comparison with other methods shows that the proposed method produces more accurate segmentation results.

Keywords: Skin Region Detection, PCNN, YIQ Color Space.

1 Introduction

Human skin detection is very important for many applications, such as face, hands gesture and human body detection or recognition in computer vision. It is widely used in the fields of human and machine interactive interface, access control, video monitoring and Internet pornographic image filtering.. The human skin detection methods based on color are simple, fast and intuitional. On the other hand, they are not sensitive to changes of shape and angle of view. Many researchers have focused on it [1-3]. Angelopoulou[1] indicated that human skin color distribution was consistent in biological and physical aspects. In other words, although different races have different skin colors, the hue of human skin is mostly similar when the influence of luminance and the environment is considered, which means human skin colors can congregate in a small color space.. Zhang et al. [2] pointed out that, I channel in YIQ color space has a good clustering characteristics for the human skin color in spite of the difference of the human race, the age or the gender.. It was obtained that human skin colors located in I charnel was from 20 to 90 by some statistic experiments [2]. These two methods have the low detection performance under various illumination conditions. Tao et al. [3] proved that the characteristics of human skin pixels in RGB color space is that R value is larger than B value, and

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B value is larger than G value, which is stable for various races and illumination conditions. However this method doesn't consider the relationship between neighboring pixels in terms of dealing with every pixel separately.

In order to overcome the problems above mentioned and detect skin regions of different human race efficiently, a novel human skin detection method is proposed based on the clustering characteristics of human skin in YIQ color space and the synchronous pulse firing mechanism of pulse coupled neural network(PCNN).. It can be used to detect human skin area in complex backgrounds. Even though the high light or shadow imposed on the human skin area, this method can also work well.

The paper is organized as follows. Section 2 introduces PCNN model and color space. Section 3 describes the framework of method proposed in this paper. Section 4 shows the experiment results. A discussion is given in Section 5.

2 PCNN Model

In 1990, PCNN is proposed by Eckhorn [4], which explains the experimentally observed synchronous activity among neural assemblies in the cat cortex induced by feature dependent visual activity. PCNN has interesting output, which differs from neural network composed of rate-coding neuron, since PCNN neuron can code information toward time axis. Subsequently PCNN has been used into image processing such as segmentation and fusion [5]. Some researchers modified the linking field network, and then it became the pulse coupled neural network [6] [7].. Fig. 1 shows a basic PCNN neuron model.

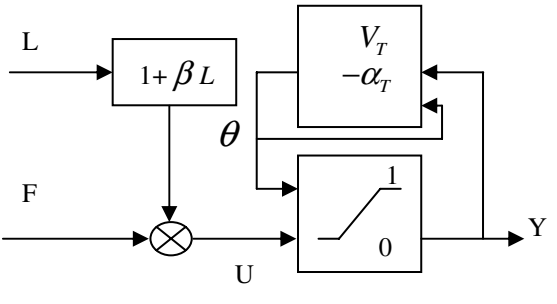


Fig. 1. A PCNN neuron model

The model has three main parts: the receptive fields, the modulation product, and the pulse generator [4]. It can be described by a group of equations [6].

$$F_i = \sum_j M_{ji} Y_j(t) \otimes \phi_{ji}(t) + I_i \ .. \tag{1}$$

$$L_i = \sum_k W_{ki} Y_k(t) \otimes \phi_{ki}(t) + J_i \ .. \tag{2}$$

$$U_i = F_i(1 + \beta_i L_i) \ . \tag{3}$$

$$Y_i(t) = Step(U_i - \Theta_i) \ .. \tag{4}$$

$$\Theta_i = -\alpha_T \Theta_i + V_T Y_i(t) \ . \tag{5}$$

The neuron receives input signals from other neurons and from external sources through the receptive fields. The signals include pulses, analog time-varying signals, constants, or any combination. Then the signals are divided into two channels. One is feeding channel, the other is linking channel.. In the modulation part the linking input is weighted with β_i and added a constant bias, then multiplied with the feeding input. The internal activity U_i is the output of the modulation part. In succession, the pulse generator compares U_i with a threshold θ_i. If U_i is larger than θ_i, the neuron will emit a pulse. It is also called 'fire'. Otherwise, it will not fire. With reference to equation (**6**), Y_i is the output. At last, the pulse generator adjusts the threshold θ_i. If the neuron has fired, θ_i will be increased to a large value; otherwise, θ_i will decay (with reference to equation (**5**)).

Pulse output will be delivered to adjacent neurons. If adjacent neurons have similar intensity with neuron i, they will fire together because of pulse coupled action [5]. In this case, we call that neuron i captures the adjacent neurons. Finally the neuron i and the similar adjacent neurons will emit synchronous pulses. This is the theoretical foundation of PCNN for image segmentation.

Usually, when using PCNN to segment images, a single layer two-dimensional network is designed. In the network, the neurons and the pixels are in one to one correspondence. So, in this paper, one neuron is equal to a pixel.

3 Framework of Human Skin Region Detection Based on PCNN

The framework of human skin region detection based on PCNN is as Fig.2. Firstly, the input origin image is translated from RGB color space to YIQ color space, and I channel image is obtained. Secondly, we use PCNN to segment images. In order to decide the threshold in PCNN, the histogram of I channel is used to identify the range of I value. It is dynamic and adaptive I scope decision method, and it can segment image according to the image's character, so that it is much objective. Finally, we can binary the result of PCNN multi-value segment.

3.1 Converting to YIQ Color Space and Getting I Channel Image

In YIQ color space, I channel can describe the change from orange to cyan, and Q channel can describe the change from purple to yellow-green. When we convert image from RGB color space to YIQ color space, we can divide the luminance information from hue information, then we can deal with images with light information and hue information separately. Zhang et al. [2] pointed out that, I channel in YIQ color

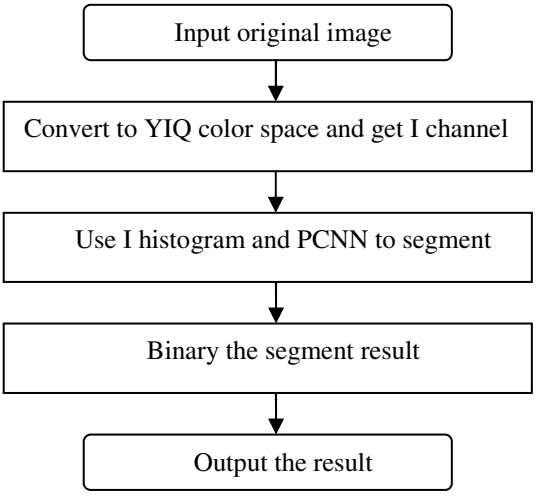


Fig. 2. Framework of human skin region detection based on PCNN

space has a good clustering characteristics for the human skin color in spite of the difference of the human race, the age or the gender.. It was obtained that human skin colors located in I charnel was from 20 to 90 by some statistic experiments [2]. Therefore, we adopt YIQ color space in skin region detection. The conversion formulas are as follows:

$$Y = 0.299R + 0.587G + 0.114B \tag{6}$$

$$I = 0.596R - 0.275G - 0.321B \tag{7}$$

$$Q = 0.212R - 0.523G + 0.311B \tag{8}$$

3.2 Segmenting I Channel Image by Using PCNN

Usually, when using PCNN to segment images, a single layer two-dimensional network is designed. In the network, the neurons and the pixels are in one to one correspondence. So, in this paper, one neuron is equal to a pixel. Pulse output will be delivered to adjacent neurons. If adjacent neurons have similar intensity with fired neuron, they will fire too because of pulse coupled action. In other words, PCNN method thinks about relationship between neighboring pixels. It is coherent with human vision mechanism that the similar color should be segmented into an area block whether the conditions of illuminations are. Usually, the background and the target are much different, so the peaks of backgrounds and targets are different in histogram. Therefore, we can regard the lowest value between neighboring peaks in histogram as threshold in PCNN to filter some areas those are background or non-skin region obviously. It can also accelerate PCNN speed and improve the performance. Based on this method, the pixels in first obvious skin region will be

fired synchronously in advance. Then second obvious skin region fired subsequently. And so on, I channel image will be segmented into several regions.

3.3 Binary the Result of PCNN Segmentation

Because of the illumination condition and other reasons, skin blocks in one image will create several peaks in I histogram. A big skin region in original image will be separated into several small region based on the 3.2 section. However, I values of them are very close. So we can binary the result of PCNN multi-value segment.

The main idea is drawing the histogram of multi-valve segmented result image. Then, the trough between peaks in histogram is obtained. In order to represent non-skin pixels, the pixels whose values are smaller than the trough are regarded as background and labeled into zero, while the pixels whose values are larger than the trough are labeled into 1 and represented skin.

4 Experiments

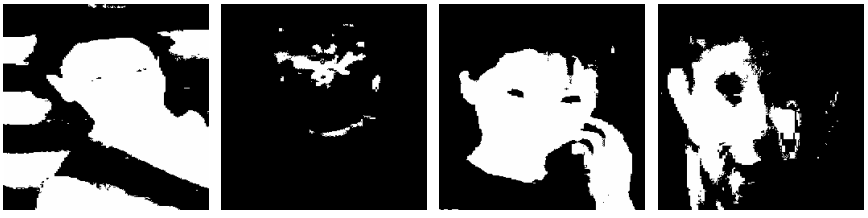
In order to demonstrate the performance of the proposed method, some experiments are performed. We compare our method with that in paper [3], which segmented in YIQ color space and processed images with pixels. The main idea in reference 3 is as following. First, it converted multicolor images from RGB color space to YIQ color space and got I channel images. Then it checked every pixel's value in I channel. If I value of a pixel is between 20 and 90, it is labeled as skin pixel; otherwise it is a non-skin pixel. In order to display experimental results, the white pixels represent human skin; the black pixels represent non-human-skin.

Fig.3 shows the sample images from image library and internet in our experiments. Fig.3a is about yellow race people, and the background is similar to human skin color. Fig.3b is about white people. In Fig.3d, different areas in the picture are different illuminance condition. Fig.3c is got from Internet.

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

Fig. 3. Original images

Fig.4 shows the results by using the method mentioned in paper [3]. It can be found that some backgrounds of the picture are regard as human skin color. And the eyes are also regarded as human skin, as shown in Fig.4a. For the picture in Fig.4b, only a patch of the face area is segmented, while the neck and breast regions are not found. The main reason is that the model mentioned in paper [3] is not suitable for white race face detection. In Fig.4c, the mouth is regard as skin. In the last picture,

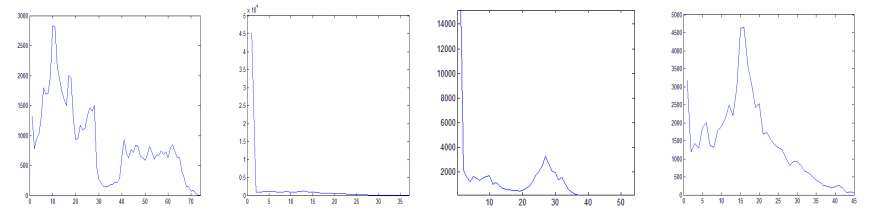


(a) (b) (c) (d)

Fig. 4. The results of Using I Channel to do binary segmentation [3]

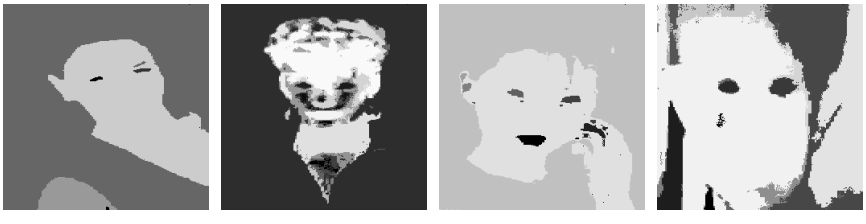
because there is shadow in the right face, it is much darker than the left face. As shown in Fig.4d, the right face cannot be detected by the method in paper [3].

Fig.5 shows the histogram of different images' I channel, we can see usually there are two obvious peaks, and use the trough as a threshold in PCNN segmentation.



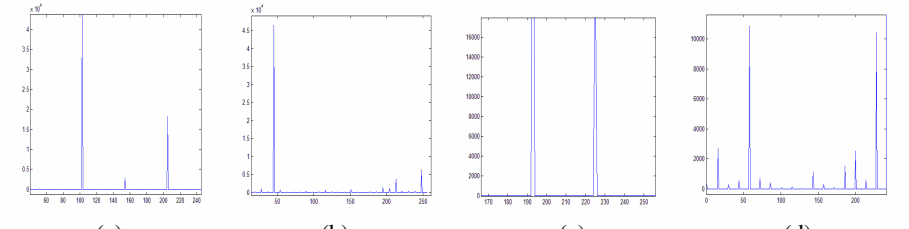
(a) (b) (c) (d)

Fig. 5. I Channel histogram



(a) (I>32) (b) (I>2) (c) (I>20) (d) (I>8)

Fig. 6. The result of PCNN multiple value segmentation



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

Fig. 7. Histogram of PCNN segmentation

Fig.6 shows the results of PCNN segmentation method mentioned in section 3.2. Fig.7 is the histograms of PCNN segmentation result, and Fig.8 is the last result.

As shown in Fig.8a, we distinguish the skin regions with background, the eyes and even eyebrow of the people of the image in Fig.3a. For the image in Fig.3b, by using PCNN we do multiple value segmentation, and get several patches of skin area. After binary the result of PCNN segmentation, it emphasizes the non-skin area as shown Fig.8b, and gets a better result. But the problem is that it cannot distinguish the brown hairs from skin; this is another problem we need to solve. For the picture in Fig.3c, we can distinguish the mouth from face as shown in Fig.8c. As to see the original image in Fig.3d, we can see that it has a complex illumination condition. Our method can detect the skin area easily, as shown in Fig.8d. It is obviously better than the result mentioned in Fig.4d.

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

Fig. 8. Binary result based on PCNN multiple value segmentation

5 Discussion

Inspired by the synchronous pulse firing mechanism, we proposed a new method to detect human skin region in this article. We use the pulse coupled neural network (PCNN) on I channel image to segment skin and non-skin region.. Experiments show that this method can detect most skin areas in the images in spite of high illumination, shadow or people races. The current method is failed to distinguish the brown hair region from skin regions. The further work is to combine texture features to detect human skin region and remove the influence of other elements, such as brown hair.

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References

1. Angelopoulou, E.: Understanding the Color of Human Skin. In: Proceedings of the SPIE Conference on Human vision and Electronic Imaging VI. SPIE, vol. 4229, pp. 243–251 (2001)
2. Zhang, H., Zhao, D., Gao, W., Chen, X.: Combining Skin Color Model and Neural Network for Rotation Invariant Face Detection. In: Tan, T., Shi, Y., Gao, W. (eds.) ICMI 2000. LNCS, vol. 1948, pp. 237–244. Springer, Heidelberg (2000)
3. Tao, M., Pen, Z., Xu, G.: The Feature of Human Skin Color. Journal of Software 12(7) (2001)
4. Eckhorn, R., Reitboeck, H.J., Arndt, M., Dicke, P.: Feature Linking via Synchronization among Distributed Assemblies: Simulations of Result from Cat Visual Cortex. Neural Computation 2, 293–307 (1990)
5. Johnson, J.L.: Pulse-Coupled Neural Nets: Translation, Rotation, Scale, Distortion, and Intensity Signal Invariance for Images. Applied Optics 33(26), 6239–6253 (1994)
6. Johnson, J.L., Padgett, M.L.: PCNN Models and Applications. IEEE Trans. Neural Networks 10(3), 480–498 (1999)
7. Kuntimad, G., Ranganath, H.S.: Perfect Image Segmentation Using Pulse Coupled Neural Networks. IEEE Trans. Neural Networks 10, 591–598 (1999)