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Identification of Hand Region Based on YCgCr Color Representation

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Abstract:

For hand gesture recognition, the quality of gesture region segmentation has a direct impact on the recognition and classification results. This paper introduces a color balance method to correct the image color bias of the input images in the RGB color space, and to remove the influence of the correlation of the luminance information contained in the RGB space. We process the input images in the YCgCr color space so that brightness and chrominance are separated. Efficient processing techniques are then proposed in order to remove noisy and skin-like regions in the hand skin segmentation results. Experimental results show that after color balancing and converting to YCgCr color space, it is more effective to detect skin regions from the color images with complex backgrounds, also has more robust illumination adaption.

Keywords: hand detection, skin color detection, color balancing, YCgCr color space

INTRODUCTION

Hand gesture detection is the process of identifying the location and size of the hand gesture of a given image with hand gesture contained. It is the basic step of the automatic hand gesture recognition system, and the location result will directly affect the follow-up works of hand gesture recognition. Hand gesture detection can be divided into gray image and color image based gesture detection. Hand gesture detection based on gray image [1] only takes use of the changing of gray degree of the image as detecting factor, it has to map the whole image from multi-scale, which will consume a large amount of calculation and time. Hand gesture detection based on color image [2] mainly taking advantage of the characteristics of no sensitive to direction and can be different from most of the background color of skin, can greatly reduce the search range of hand gesture area and improve executive efficiency. But, because the skin color info is easily affected by factors such as light source color, the color of the image may deviate from its essential color and has color bias occur. In addition, the skin color info is susceptible to complex backgrounds, especially the impact of skin-like backgrounds. Therefore, it is often not reliable to only use skin color info for hand gesture detection, is needs the verification of other assistant methods.

Considering the effect of illumination, color balancing is carried out by this paper to correct the image color bias of the input image, by locating and preprocessing the target areas in YCgCr color space, of which brightness and chrominance are independent of each other, to remove the obvious non-skin regions and improve the accuracy of hand gesture recognition.

COLOR BALANCE

In the skin color based hand gesture detection methods, skin color model is usually established under standard light source, however, this kind of skin color model cannot correctly detect the skin area when the light source of image deviates from the standard light source, which then will affect the follow-up works of hand gesture recognition. With the method of color balance the problem of color deviation can be better solved.

The basic aim of color balance is mainly to eliminate the color deviation problem when doing skin region detection under colored light source. The process of color balance is to determine the illumination intensity of scene, adjust the value of R, G, B, and restore the original color property of the image scene. Since it is difficult to determine the illumination condition for most images, so here we use "Gray World" hypothesis method [3] to correct color.

The calculation steps of color balance are as follows:

1) Calculate the respective mean $\mathrm{avgR}, \mathrm{avgG}, \mathrm{avgB}$ and total mean avgGray of R, G, B of hand gesture image, where

$$\mathrm{avgGray} = (\mathrm{avgR} + \mathrm{avgG} + \mathrm{avgB})/3;$$

2) Calculate the adjustment coefficient of each component, let

$$\mathrm{aR} = \mathrm{avgGray}/\mathrm{avgR},$$

$$\mathrm{aG} = \mathrm{avgGray}/\mathrm{avgG},$$

$$\mathrm{aB} = \mathrm{avgGray}/\mathrm{avgB};$$

3) Adjust the values of R, G, B with adjustment coefficients:

$$\mathrm{R} = \mathrm{aR} * \mathrm{R},$$

$$\mathrm{G} = \mathrm{aR} * \mathrm{G},$$

$$\mathrm{B} = \mathrm{aR} * \mathrm{B}.$$

4) Change values that greater than 255 to 255.

Figure 1 (a) shows an original hand gesture image with color deviation, the color of the whole image seems reddish, and (b)

is the image after color balance, we can see that after color balance the hand skin color has almost been recovered and can be used for skin detection.

(a) Original image (b) Image after color balance

Figure 1. Processing effect of color balance

YCgCr COLOR SPACE CONVERSION

At present, there are a lot of color spaces which can be applied to skin detection, such as normalized RGB, YCbCr, YUV, YIQ, HIS/GIHS, CIE-Lab, CIE-Luv space color, etc. [4]. In RGB color space, the color is composed of three components which are R, G and B, these three components all contain the luminance information and have great correlation between each other, and this correlation is not conductive to the detection and segmentation of skin color. Some hand gesture detection algorithms based on skin color adopt normalized RGB color space, but the normalized RGB color space only can remove the relative part of brightness in R, G, B but still has brightness information left, so the brightness adaptability of this kind of color space is not ideal for skin color detection. Therefore, it has important significance to choose a suitable color space for skin color detection, and one way is to convert the RGB color space represented image to color spaces that have brightness and chrominance independent of each other.

YCbCr color space has the similar advantage of separating the luminance component from image color with HIS and some other color spaces, but better than HIS and other color formats, the calculation process and space coordinate form of YCbCr color space is relatively simple. YCbCr color space is consistent with human visual perception, and has the characteristic of good color clustering and color mutual independence. Because the Cb component of YCbCr is the diffidence between blue component B of RGB and luminance Y, and the proportion of B component in skin color is relatively small, so the YCbCr color space is often used for the building of skin color model.

Since the aggregation of skin color in YCgCr space is better than YCbCr space, this paper will use the new color space YCgCr, which is based on and similar to YCbCr color space. Firstly, YCgCr color space is not sensitive to the changing of illumination, secondly, the Y channel on behalf of the brightness information, if there is somewhere needs to extract the features of gray image, it can be directly carried out on the Y channel, which can reduce the amount of computation. Finally, [5] pointed out that the YCgCr color space has strong skin color aggregation, the Cg and Cr components can effectively distinguish skin and non-skin color. YCgCr color space and RGB color space conversion formula can be derived from the YCbCr color space and RGB color space conversion formula [6], the conversion formula is as follows:

$$\begin{bmatrix} Y \\ Cg \\ Cr \end{bmatrix} = \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} + \begin{bmatrix} 65.481 & 128.553 & 24.966 \\ -81.085 & 112 & -30.915 \\ 112 & -93.786 & -18.214 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

This paper uses fixed threshold method to determine skin areas, this method is simple, mature and easy to use. Zhang [7] presents experiments of 10^{10} skin color pixels which are in different ages and body areas. Finally, he builds a parallelogram model in Cg-Cr color space for skin color detection, the model for the skin color in the transformed Cg-Cr is described as following:

$$\begin{cases} Cg \in [85, 135] \\ Cr \in [-Cg + 260, -Cg + 280] \end{cases}$$

When the image pixel in YCgCr color space satisfies the above model, it can be regarded as color pixel and reset to 255, otherwise, as non-skin pixel and reset to 0, thus, we can get the corresponding binary image.

HAND GESTURE REGION LOCATION

For images with complex background, it is inevitable to produce noisy and skin-like regions in the process of skin color segmentation. For the obtained binary image F(x,y) contained noise, we can remove the non-gesture regions and thus only keep the gesture region according to the following conditions.

1) Remove regions whose skin area is less than 400 pixels. Because the gesture features will be lose and difficult to ensure the detection of fingertips if the area is too small, so these parts should be removed as noised. The area is the number of target pixels, its calculation formula is:

$$m_{00} = \sum_{x=1}^{w} \sum_{y=1}^{h} f(x, y),$$

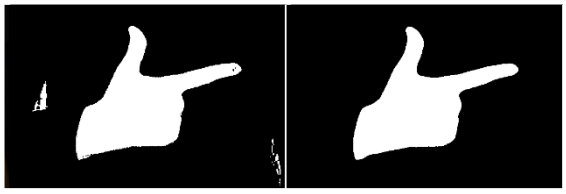
Where,

$$f(x, y) = \begin{cases} 1, & \text{if}(x, y) \in R \\ 0, & \text{otherwise} \end{cases}$$

m_{00} represents the area, w is the width of region, h is the height of region, and R is the target binary region.

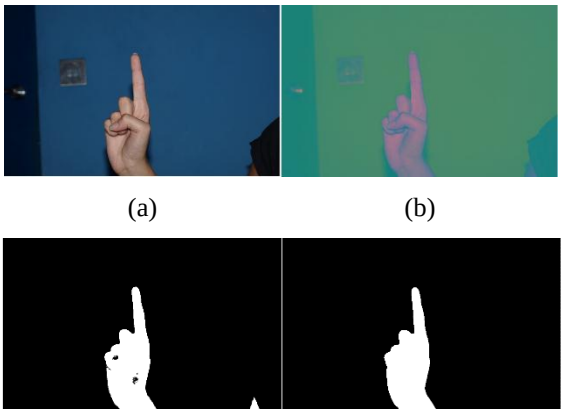
2) The width and height of skin region should be bigger than 20 pixels in order to avoid the mistaken extraction of some small regions that meet condition 1) but not human hands.

(a) (b)



(c) (d)

Figure 2. Hand gesture segmentation result of image with simple background



(a) (b)

(c) (d)

Figure 3. Hand gesture segmentation result of image with complex background

3) The palm and fingers should appear in the visual window.

4) It is known from 3) that the center of the gesture area should be inner skin region, that is, the center of gravity should locate inside of the palm. The calculation formula of center of gravity (x_c, y_c) is [8]:

$$x_c = \frac{m_{10}}{m_{00}}, y_c = \frac{m_{01}}{m_{00}}$$

where,

$$m_{10} = \sum_{x=1}^{w}\sum_{y=1}^{h} xf(x,y),$$

$$m_{01} = \sum_{x=1}^{w}\sum_{y=1}^{h} yf(x,y),$$

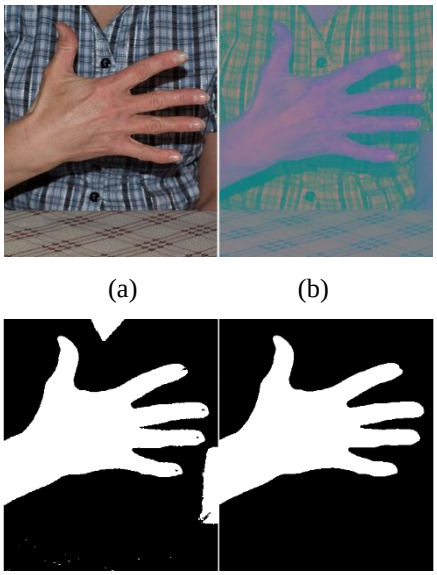
5) Calculate the aspect ratio of skin color region, because the aspect ratio of a normal person's gesture is in a certain proportion range. Let's define the aspect ratio of skin region as σ [9]:

$$0.7 \leq \sigma = \frac{\text{Height}}{\text{Width}} \leq 3.0$$

CONCLUSION

Figure 2, 3, 4 are the segmentation results of hand gesture of images captured under different backgrounds, (a) are original images, (b) are results after converting the image from RGB to YCgCr color space, and the conversation will separate the illumination info of images to the component of Y and choma info to Cg and Cr, (c) are binary images with white areas detected as skin and black areas non-skin after binarization by thresholding, and (d) are final segmentation results with only hand gesture regions contained after denoising.

In figure 2, we can clearly get from (c) that this image (a) still contains two pieces of skin-like regions in its background even it seems to be captured under a pure black one. Figure 3 is



(a) (b)

(c) (d)

Figure 4. Hand gesture segmentation result of image with noisy skin area contained

the segmentation result of an image with a more complex background, and it shows that even under a complex background, the hand gesture region can still be well located.

Figure 4 can prove that by adopting fixed thresholding method, the algorithm proposed by this paper can successfully remove those skin-like areas or noisy skin areas.

Hand gesture location is an interesting and challenge job. Due to the existence of colored lighting sources and a variety of skin-like colors [10], we introduces the concept of color balance and YCgCr color space. Compared with other methods, it has the advantages of high locating accuracy and low computational complexity, which is more suitable for the application of hand gesture recognition. Therefore, the research work in this paper has certain practical significance and good practicability.

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