

A Method of Face Detection Based On Improved YCBCR Skin Color Model

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Abstract Face detection is a key technology in the information processing field of face recognition. The paper proposes a new face detection method to detect the human face. According to the clustering characteristics of Cb and Cr to detect the skin-color, then the image is labeled. The paper summarizes and presents a localization ears algorithm of human face. It also presents a method to locate the human chin based on the center line of pixel gray [CLPG]. The two methods can remove the interference of the ear and neck region. Experimental results show that the method can detect face quickly and accurately in an image and provide a certain value for the study of face recognition.

1. Introduction

Vision is the main means for human to get information from the nature world. According to the statistics, visual information is about 60%, auditory information is about 20%, other way adds up to about 20%^[1]. This shows the importance of visual information to mankind. In color images, skin color information is used to detect human face, which can provide more accurate search range and face positioning. Therefore, the skin color has important research and great application value.

Compared with processing gray level information, face skin color has some advantages, like that it is not sensitive to light, attitude change, and contains a wealth of facial information. It is widely used in skin color feature extraction, face detection, face recognition, and some other research directions. Among them, skin detection based on YCbCr color space is the most widely used method^[2]. In YCbCr space, the distribution of Cb and Cr components of facial color tends to be consistent. It can effectively remove the illumination brightness effect of Y, and it also has a good clustering feature^[3]. Based on the above characteristics, many researchers have carried out the study of human face detection. For example, Wu Yaoling, from the University of Electronic Science and technology, uses template matching and clustering characteristics to detect skin color in the YCbCr space. That way can effectively detect the position of the human face and calibrate its position in a complex background^[4]. However, his algorithm is complex, and it needs to be improved in positioning accuracy; Wang Lijuan, from Sichuan University, uses a fast face detection algorithm based on skin color^[5]. Although the detection time is shortened, the detection rate and the accuracy are insufficient.

This paper uses MATLAB 7 as the experimental platform. Firstly, do some in-depth study about YCbCr space and the clustering characteristic of Cb and Cr components; Secondly, build the skin color model for color separation and remove interference of the small area; Thirdly, select the candidate faces; Finally, the paper presents a localization ears algorithm to remove ear region, and another method based on CLPG is proposed to remove the human chin's interference.

2. Face detection method

Compared with other features, skin-color has the following characteristics^[6]: it is not affected by posture and size; regardless of whether the face is spinning and the expression changes, skin color are available; it is not sensitive to direction. Although the light source will affect the skin-color, some auxiliary method can be used to correct. The method in the paper is a face detection based on static image, belonging to the feature-based method.

The algorithm flow of this paper is simplified as shown in Fig.1:

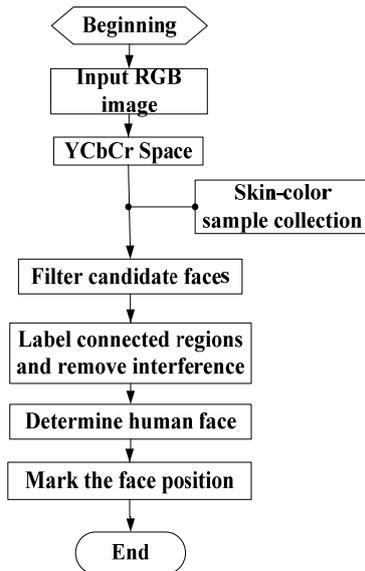


Fig.1 Flow chart

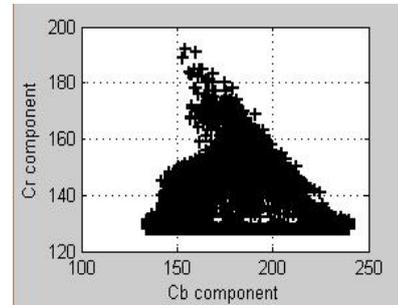


Fig.2 The clustering characteristic of Cb, Cr

3. Skin color modeling

3.1 YCbCr color space

In the JPEG standard, the image is converted from the RGB color space to the Luminance-chrominance spaces. The converted space is called YCbCr color space. Among it, Y is the luminance, Cb is blue component, Cr is red component.

Conversion formula of RGB color space to YCbCr color space is shown as formula (1):

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 0.257 & 0.504 & 0.098 \\ -0.148 & -0.219 & 0.439 \\ 0.439 & -0.368 & -0.071 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} + \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} \quad (1)$$

The clustering properties of Cr, Cb in YCbCr space are shown as Fig.2.

3.2 skin-color model

In order to establish the skin-color model, 100 144*192 pixels color images are cut into 63*85 pixels which contain mainly the face. After going on a low-pass filter, they will be converted from the RGB space to YCbCr space. According to the statistics, obtain $Cb \in (128, 240)$, $Cr \in (128, 166)$.

The values of Cb and Cr are brought into the formula (2):

$$U(i, j) = \begin{cases} 1, & (Cb_min \leq Cb(i, j) \leq Cb_max, Cr_min \leq Cr(i, j) \leq Cr_max); \\ 0, & \text{other;} \end{cases} \quad (2)$$

In the formula, U is a logical matrix. The white means skin-color regions, as shown in Fig.3 (b).

4. Precise positioning face region

4.1 Select candidate face

After going on mathematical morphology processing, the paper adopts the method of area ratio to eliminate these interference of small connected regions. Human face aspect ratio is between 1.1 and 1.6. Due to the interference of neck, the range is expanded to between 1.0 and 2.6. Filtered face region in experiment is shown in Fig.3 (c).

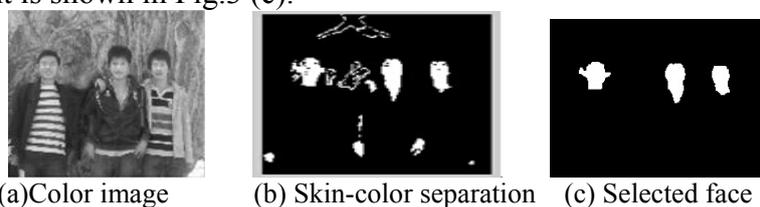


Fig.3 Skin color separation

4.2 Ear root positioning

In order to eliminate the ear region of the candidate's face, this paper proposes an ear root positioning method. It is shown in Fig.4. Among the connected region, the 'width' is width; col_min and col_max are respectively the min and max column; L_ear and R_ear are respectively the column of left and right ear roots; col_centre is the central line.

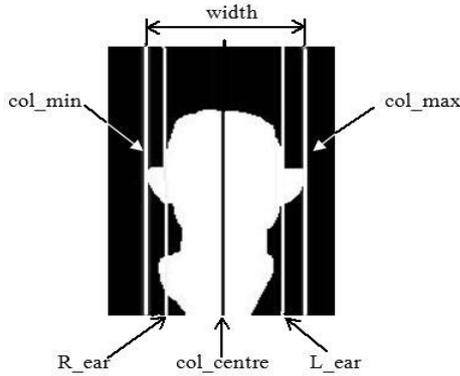


Fig.4 The position of the ears



Fig.5 Eliminate ear interference

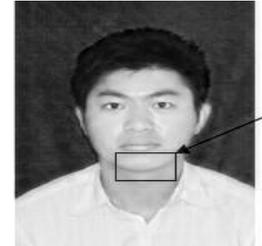


Fig.6 The gray change of the chin

Methods are as follows: ① Mark the connected regions that contains the face;

② If Fig.4 is the N-th ($N=1, 2, \dots$) connected region, the gray value of the connected region is N;

③ Searching image by column, find out the max column col_max and the min column col_min of the n-th connected region. And then, according to the formula (4), the col_centre of the connected region is calculated out:

$$col_centre = col_min + (col_max - col_min + 1) / 2 \quad (4)$$

④ Let L_n is the pixels' number of n-th column in the n-th connected region. Statistics the every column pixel number of the connected regions. Among it, the column value of n is from col_min to col_centre. Respectively, they are recorded as L_1, L_2, \dots, L_k , $k=col_centre-col_min+1$;

⑤ Judgment the formula (5), and find out the all L_i ($i \in (1, k-1)$) that the proportion is less than the threshold. And then record all L_i corresponding to the column $C_i, C_1, C_2, \dots, C_i$ form a matrix. The matrix is recorded as $A = [C_1, C_2, \dots]$. In matrix A, the max C_max is calculated. The C_max is the right ear root location R_ear . Here, according to the ratio of ear length account for face and a large number of experimental statistics, the range of thresh is between 0.20 and 0.30.

$$0.20 \leq \frac{L_1}{L_k}, \frac{L_2}{L_k}, \dots, \frac{L_{k-1}}{L_k} \leq 0.30 \quad (5)$$

⑥ Using the principle of ④ and ⑤ to calculate the ear root location L_ear of the other side face;

⑦ For the connected region, if its column coordinates are not in the range $[L_ear, R_ear]$, then its gray value is set to 0. Thereby, the interference of the ears regions is eliminated, as shown in Fig.5.

4.3 Cycle detection method based on CLPG

The gray has an obvious change between the chin and neck in the image, as shown in Fig.6. Therefore, this paper proposes a cycle detection method based on CLPG to remove interference of the neck. The specific methods are as following:

① Remove the ears' interference.

② Calculate the image-processed vertical center line col_centre and the left-most pixel column coordinate L, the right-most pixel column coordinate R, the row coordinate H of the top pixel and the column coordinate M of the bottom pixel. According to the formula (6), the face's width is obtained.

$$width = R - L + 1 \quad (6)$$

③ According to the ratio $\in [1.1, 1.6]$ of face length and width, using the formula (7), the lower boundary min row Q_min (when Q it takes the min 1.0) and the maximum row Q_max (when Q takes the max 1.6) of the face region are anticipated.

$$Q = width \times ratio + H \quad (7)$$

④ Find out all the pixels' coordinates that their gray value are 1 (if it is the N-th block connected region, the gray value is N) on the center line of the connected regions. And they will be recorded as (H, col_centre), ..., (M, col_centre); According to the coordinates above to take out the pixels' gray values of the corresponding gray image. The gray values are placed in a matrix B.

⑤ Calculate the min V_{min} of the matrix B and its abscissa V_h in the image. Then to get the row coordinate V_r of the min V_{min} by formula (8); If $V_r \in (Q_{min} Q_{max})$, then V_r is the location of chin, otherwise V_r will be not. In this case, the min V_{min} in the matrix B will be set to 255, and the V_{min} and its coordinate V_h, V_r will be recalculated.

$$V_r = V_h + H - 1 \quad (8)$$

⑥ Remove those pixels of the connected region that the row coordinates are more than V_r and the gray value is 1; if there are multiple connected regions, the interference in the n-th connected area should be removed according to its corresponding V_r .

Use the method above, the experimental results is got, as shown in Fig.7 (a), (b).

In this paper, the accuracy of face location is shown in Fig.8 (c), (d), (e):

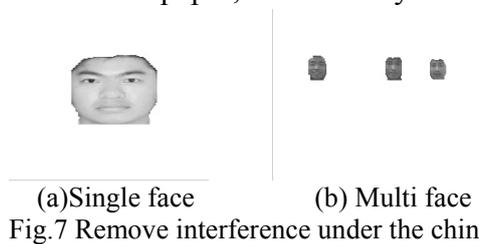


Fig.7 Remove interference under the chin

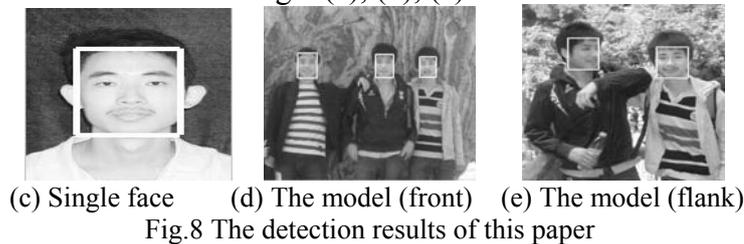


Fig.8 The detection results of this paper

5. Conclusion

A lot of experiments prove that compared to the traditional Gauss skin color model, this method can accurately locate the face. Even if the face has a certain degree of tilt when it is taken, it can work. The method can provide a certain basis, reference and research value for the face recognition in the latter. Use above method to detect the face on 270 photos, the detection rate is shown in table 1.

Table 1 Face detection rate comparison

Model	Single face	Multi face
Gauss skin color model	84.6%	71.0%
The model of this paper	97.4%	94.7%

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