A Face Detection Method Based on Skin Color Model

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Abstract

Face detection plays a very important role in pattern recognition and the precision of face detection directly affects the following results. This paper proposes a fast and precise method of face detection in complex background based on skin color model. Firstly, we extract skin color regions of the image. Then we process them with Morphologic processing method and roughly filtering. At last, we show a method to recognize face by geometric feature of eyes, which is similar to the feature of ellipse.

Keywords: Face detection, Skin color model, Geometric feature

1. Introduction

As one of the most important visual parts in images and videos, face plays an important role in the computer vision, pattern recognition and multimedia technology research. With the development of computer science in the field of human-computer interaction, as the key technology of face information process, face detection has been a very active research field. Therefore, studying face detection technology has very important meaning. There have been many face detection methods. For example, Sirohey used the edge extracted image to heuristicly search face and match elliptical edge method[1]; Govindaraju, Srihari and Sher achieved face location by using the deformable template to match contour lines of head and face[2]; Martin, Hunke designed a skin color model to characterize face color, used a photographic model to realize illumination compensation and achieved face detection by a face color classifier and a neural network[3]. In recent years, some typical methods have been developed, such as Adaboost method[4], learning architecture method based on sparse neural network[5], Bayesian discriminating features method[6], fast method based on Boosting[7,8,9], and there are more detailed introductions about face detection in references [10~12].

Each method has its own characteristics, some have high precision, and some are fast algorithms. This paper proposes a face detection method based on skin color model, which can reconcile both the algorithm speed and precision. Procedure: 1) Extract the skin color regions by a skin color model, 2) Roughly filte, 3) Recognize face by geometric feature of eyes.

2. Region segmentation based on skin color model

Skin color feature is mainly described by skin color model. It is an important feature of human face in the dectect method based on knowledge, because it is independent of face details, adapts to the change of facial expressions and rotation,

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has high stability and could be easily distinguished from most backgrounds.

2.1. Illumination compensation[13]

Skin color information often moves to some directions from its original color, which is affected by light source or acquisition equipment etc. We have to process the image as follows to avoid color deviation:

Set the image size is $M \times N$, all the pixels' color are

$$r(i,j), g(i,j), b(i,j),$$
$$i = 1,2,\cdots,M,\ j = 1,2,\cdots,N.$$

Firstly , we obtain the brightness information of each pixel

$$k(i,j) = 0.299 \times r(i,j) + 0.587 \times g(i,j) + 0.114 \times b(i,j),$$

then we sort $k(i,j)$ from big to small: $k_1, k_2, \cdots, k_{M \times N}$. At last, we get the average $\overline{k} = (\sup_{i=1}^{t} k_i)/t$ of the former five percent according value. If t is big enough, we set the brightness of the image as a "reference white", their value are adjusted to the maximum 255, the remained pixels are adjusted by the proportion $255/\overline{k}$.

2.2. Skin color model selecting[14]

By transforming image to YCbCr space and combining Cb and Cr with formula

$$\frac{(x-ec_x)^2}{a^2} + \frac{(y-ec_y)^2}{b^2} = 1,$$

$$\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} Cb - c_x \\ Cr - c_y \end{bmatrix},$$

we can judge it belongs to skin color space when the value is less than or equal to 1,where

$$c_x = 109.8, c_y = 152.02, \theta = 2.53,$$
$$ec_x = 1.60, ec_y = 2.41,$$
$$a = 25.39, b = 14.03$$

We will get segmentation results, which is show in Fig.1.

Fig.1 segmentation results

3. Face detection

The procedure of face detection algorithm is shown in Fig.2.

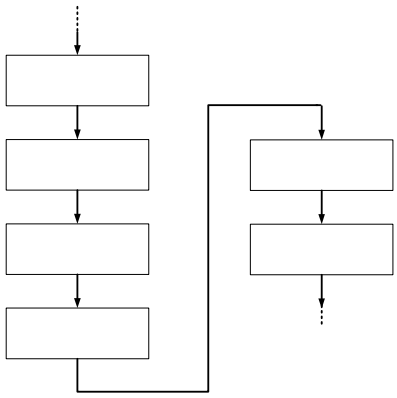

Fig.2 Face detection procedure

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3.1. Morphological image processing

It is very difficult to confirm a face because of a mass of discrete points in image, over-segmentation and some small holes in the region of eyes, nose and mouse etc. after region segmentation. In this paper, we apply dilation, erosion and seed filling methods to overcome above problems.

By making use of the operator $T = D_t \circ E_t \circ E_t \circ D_t$ to process segmented image, we can pad small holes, remove discrete points and horizontal noises as is shown in Fig.3.b), where D_t is the dilation operator, E_t is the erosion operator, t is the scale parameter and structure element $\{(x, y) \mid x^2 + y^2 = 1\}$. Seed filling result is shown in Fig.3.c).

a) Segmented image

b) Processed by T c) Filled with seeds

Fig.3 Morphological processing

3.2. Roughly filtering

Because face has a certain size, if the width or height of one region is less than 19 pixels, we will remove this region. Furthermore, face has a certain geometric feature, that is the ratio of width and height is close to 1. But in practice process, the ratio is often not close to 1, therefore, this proportion may be appropriately expanded to $[0.5, 2]$. We use this threshold to filter remaining regions. The result is shown in Fig.4.

Fig.4 Roughly filtered image

3.3. Human eyes location

3.3.1. Gray image processing

We get original gray image according to Fig.4. Since eyes must be in the first half of face, we preserve the first half of possible region to reduce the amount of computation and binarize them.

Firstly, in order to remove small black points, we deal with binary image by morphological processing. Then we treat possible regions by size and shape filters. At last, according to characteristices of eyes, we do some special processes as follows:

1) There are not black blocks under eyes within a certain distance.

2) The centers of eyes are almost on horizontal line, that is deflection angle is less than a certain angle.

3.3.2 Verify eyes

According to the number m of possible eyes blocks , we take three regulars to verify eyes:

1) If $m = 2$, we establish two pairs of concentric circles with each black block's center as the center of circle and certain lengths as radiuses. For each block, we calculate separately the ratio of pixels of skin color regions landed in the two concentric circles. If the two ratios are larger than threshold 0.8, the two blocks are eyes. Otherwise, we will cal-

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culate the correlation coefficient of them as follows.

2) If $m > 2$, we calculate the correlation coefficient between each block according to gray image as the following formula:

$$\rho_{A,B} = \max_{\Omega \neq \phi} \frac{\int_{\Omega} \left(A(x,y) - \bar{A}\right)\left(B(x,y) - \bar{B}\right) d\Omega}{\sqrt{\int_{\Omega} \left(A(x,y) - \bar{A}\right)^2 d\Omega \cdot \int_{\Omega} \left(B(x,y) - \bar{B}\right)^2 d\Omega}},$$

where A is block-1, $\bar{A}$ is the gray average of A, B is block-2's reversal and translation, $\bar{B}$ is the gray average of B, $\Omega = A \bigcap B$. If the correlation coefficient ρ of certain two blocks is the largest one of all correlation coefficients and no less than 0.5, we verify a pair of eyes. Otherwise, we increase the threshold of binarization.

3) If $m = 0$, we go back to1) and increase the threshold of binarization.

If we find eyes in one region, we can verify this region is face.

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4. Results and analysis

Experimental platform: AMD Sempron Processor 2800+ 1.6 GHz，1.5GB, Matlab7.0. The experimental images are all from Markus Weber's dataset of California Institute of Technology, containing 450 pieces, 27 individual persons in different brightness, posture and background and the image size is 896×592 in this paper. The average detection time is 1.5132s. We successfully detected 424 images, 7 errors and leakily detected 19 images. There are 13 images leakily detected caused by the bad skin color segmentation, the remained 6 images and 7 errors are caused by inaccurate threshold of binarization. Parts of results are shown in Fig.7.

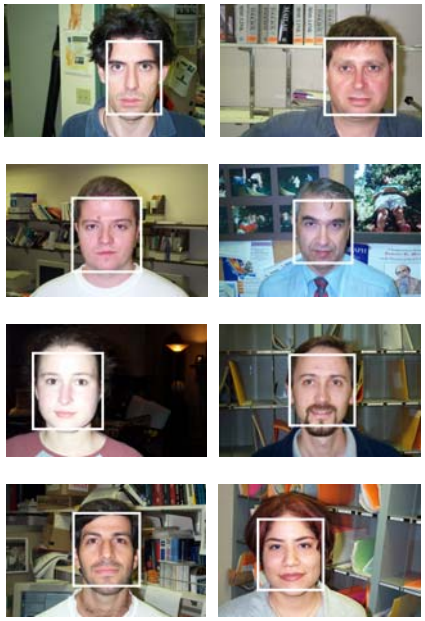

Fig.7 Parts of face detection resutls

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