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Face Detection Technology Based on Skin Color Segmentation and Template Matching

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Abstract—**Face Detection is image processing of determining the face location, size and number. Meantime, Face Detection is the premise of face recognition, human-computer interaction and so on. This paper presents a new Face Detection method ,which firstly clusters skin-color model in YCbCr chrominance space with the templates collected, then locates candidate face areas through the given skin-color model .After the normalization of the candidate face areas, a calculation of Hausdorff distance is performed between the given template and the candidates. Finally according to the length of the distance, whether the given area is face or not is determined .Plentiful experiments indicate that this method possesses high accuracy.**

Keywords- skin-color clustering ; template matching ; face detection

I. INTRODUCTION

Face Detection[1-2] is an important role in the field of Authentication and Identification. The purpose of face detection is whether there is a face and determining the face location, size and number. During recent several decades, this technology became a hot topic in the field of World image processing. Early face detection method has a method based on knowledge and a method based on characterization and template matching. Their main drawback is that they have more sensitive, lower accurate and higher rate of false alarms of the noise, transformation of light, face size transformation. At present, Face Detection has two different styles. They are heuristic model method and statistical model method. Statistical model method has feature space method, Artificial Neural Networks method, and probability model approach and support vector machine[3]. In this thesis, Characteristics of detection algorithm is finished by YCbCr[4] color space segmentation. The flow chart of Face Detection algorithmic is fig.1.

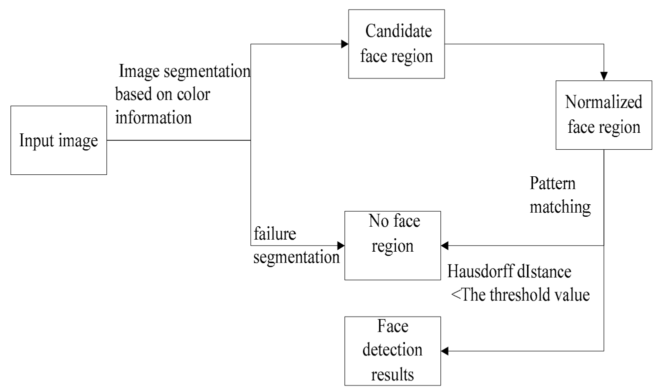

Fig.1 The flow chart of Face Detection algorithmic

II. SKIN COLOR SEGMENTATION

A. *The feasibility of skin color segmentation[5]*

Skin color is the most remarkable features of human face. Skin color is the field of relatively concentrated and stable image region. Skin color information can distinguish the human face form the background region. The studies show that in spite of different skin color of the different race, age, sex, this difference is mainly concentrated in brightness. And different peoples' skin color distributions have clustering in the color space removed brightness. So this method is feasible.

B. *YCbCr color room*

Skin color segmentation can use color room, such as RGB color room, HIS color room, YCbCr color room, rgb color room. Meantime, YCbCr color room has a composition which likes the process of human visual perception mechanism. It is easier than others. So this thesis uses YCbCr color room to input skin color of image environment. In the standard of JPEG, RGB image is converted to a luminance color space; it is often called YCbCr color space. It is derived from the YUV color space.Y stands for brightness.Cb and Cr are obtained by chancing U and V. Cb stands for red component, and Cr stands for blue component. Cb and Cr are often called color. In the coding program, the sampling rate of Y ,Cb and Cr is 4:2:2,because people eyes has more sensitive for signal variation than for brightness signal. We found that Y has little effect on the distribution of the sample in the YCbCr color space. But sample datas are concentrated in one area of Cb-Cr.

YCbCr color space has the following advantages:

a. Its principle is similar to the process of human visual perception.
b. Space format of YCbCr color room is widely used in the television display area. It is also used in video compression coding, such as MPEG,JPEG.
c. Its space format separates brightness component

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from the color components.

d. Its space format's calculation process and representation of spatial coordinates are easier than others.

e. Clustering characteristics of skin color is better in YCbCr color room. YCbCr color space and RGB color space can transform from each other

f. Formula is as follows :

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ 0.596 & -0.275 & -0.321 \\ 0.212 & -0.523 & -0.311 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

C. Skin color clustering features in the YCbCr color room

As the statistics show that different races' color is mainly affected by the brightness information. So we directly need consider CbCr in the YCbCr space. Through practice, we select a large number of color samples to be statistical; we found skin color showed good clustering properties[6]. Diagram is as follows Fig 2.

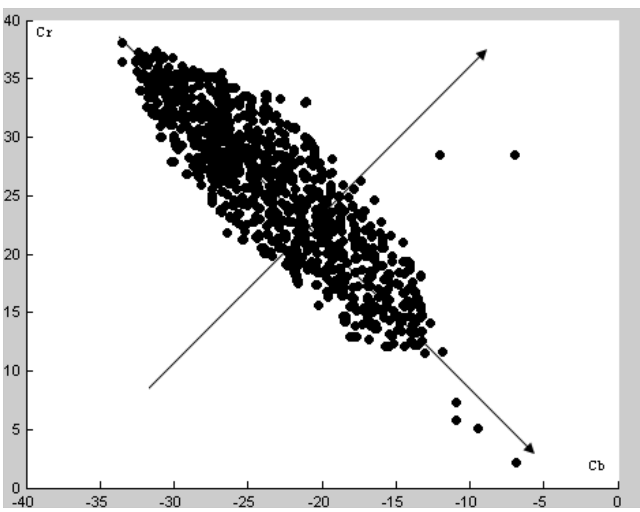


fig 2. The color clustering results in the YCbCr

We can see that the result of clustering expressed as flat oval-shaped in the YCbCr color space.Firstly, we estimate an oval in the cluster diagram and request that it can cover most of the data points. And then, we can use (Cb, Cr) to determine its color point.

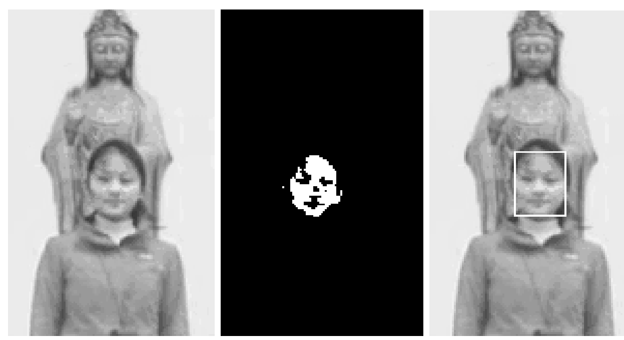
In this thesis we supposed d is the straight-line distance from point (Cb, Cr) to an elliptical cluster center (eCx, eCy).So there are the geometric model of color distribution.

$$d = \sqrt{\left(Cb - eC_x\right)^2 + \left(Cr - eC_y\right)^2} \qquad (1)$$

$$\frac{\left(d\cos\left|\arctan\left|\frac{Cr - eC_y}{Cb - eC_x}\right| - \theta\right|\right)^2}{a^2} + \frac{\left(d\sin\left|\arctan\left|\frac{Cr - eC_y}{Cb - eC_x}\right| - \theta\right|\right)^2}{b^2} \le 1.0 \qquad (2)$$

a stands for a long axis length of the ellipse; b stands for a Short axis length of the ellipse. θ is an angle between a and cb axis. Though Linear fitting and the least square method, we can get eCx=－21.61， eCy=22.30， a=19.28， b=5.64， θ =0.7243.If Pixel (Cb, Cr) meets the requirements, we should think this point is the point of skin color.

We can get color segmented binary image, before each pixel of the image to be judged. And then, we can get candidate face region for binary image to an external point of the matrix operation algorithms. The diagrams are as follow Fig.3 ((a) The original input image, (b) Color segmented image, (c) Candidate face region).



(a) (b) (c)

Fig.3 Color segmentation results and the candidate face region

III. NORMALIZED HUMAN FACE CANDIDATE AREA

Before face image feature extraction, we should need to standardization of the image processing, and candidate face region has the same size and height as matching template. Normalization will increase the anti-jamming capability. Normalization of face candidate region can be divided into two parts: geometric normalization and grayscale normalization.

A. geometric normalization

Geometric normalization is further divided into two steps: normalized profile and normalized size. Normalized profile, also known as position correction, is carried out by various regional candidates face posture normalized to achieve image registration. It has resolved differences about human face on the size and tilt angle .The differences come from imaging distance and face gestures. Normalized size is a size by using bilinear interpolation to change the image size into the template size.

B. Gray-scale normalization

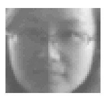
The role of gray-scale normalization is compensating for image of different lights, light sources. Using histogram specification approach can achieve better gray-scale normalization. We choose the log transformation normalized to transfer function form:

$$g\left(x,y\right)=r+\frac{\ln\left(f\left(x,y\right)+1\right)}{p\ln q} \qquad (3)$$

$g\left(x,y\right)$ is the output image, $f\left(x,y\right)$ is the input image; r, p and q are introduced to change the position of histogram add-in curve. This method is used to the provisions of gray image, and it makes uniform of gray images[7].

We get human face candidate windows used to feature authentication.

a) Normalized ago



b) Normalized image

Fig.5 Human face normalized candidate area results

IV. TEMPLATE MATCHING BASED ON HAUSDORFF DISTANCE[8]

Hausdorff distance is an effective similarity measure used comparison of images. So hausdorff distance is used to measure the window of the candidates' face and the matching degree of the standard template. If there are two collections, such as $A=\left\{a_1,...,a_p\right\}$, $B=\left\{b_1,...,b_q\right\}$, hausdoff distance is defined as follow:

$$H\left(A,B\right)=\max\left(h\left(A,B\right),h\left(B,A\right)\right) \qquad (4)$$

$$h(A,B)=\max_{a\in A}\min_{b\in B}\left\|a-b\right\| \qquad (5)$$

$$h(B,A)=\max_{b\in B}\min_{a\in A}\left\|b-a\right\| \qquad (6)$$

$\left\|*\right\|$ is distance paradigm between A and points set.

Equation (4) is called bi-directional Hausdorff distance. It is the most basic form of Hausdorff distance; $h(A,B)$ is called one-way collection of Hausdorff distance from A to B ,and $h(B,A)$ is called one-way collection of Hausdorff distance from B to A.Bi-directional Hausdorff distance is a larger value between $h(A,B)$ and $h(B,A)$. The minimum matching extent between the two points is measured by hausdorff distance.

X stands for the general form of pattern vector; y is the image gray-scale matrix; $\overline{Y}$ is the image mean gray level; σ_Y is the mean square excursion of the image gray value.

$$X=\begin{bmatrix}x_1\\x_2\\x_3\end{bmatrix}=\begin{bmatrix}Y\\\overline{Y}\\\sigma_Y\end{bmatrix} \qquad (7)$$

$$Y=\begin{bmatrix}y_{11} & y_{12} & \cdots & y_{1n}\\ y_{21} & y_{11} & \cdots & y_{11}\\ \cdots & \cdots & \cdots & \cdots\\ y_{m1} & y_{m2} & \cdots & y_{mn}\end{bmatrix}_{m*n} \qquad (8)$$

Template matching algorithm step based on Hausdorff distance is as follows:

a. To calculate the candidate areas and the face template window Y, $\overline{Y}$ and σ_Y from the first candidate area window and to get A and B.
b. To use equation (6) to determine the window and Hausdorff distance (A, B) of the human face template .
c. If H (A, B) is less than a certain threshold value, this window can be thought as face area.
d. To Calculate hausdorff distance of others windows, turn to b, and to determine whether there are other people face windows.

V. EXPERIMENTAL RESULTS AND ANALYSIS

We selected 300 images for testing; the image comes mainly from digital cameras and Interact download. This algorithm is achieved in the VC++ 6.0.

During the testing process, by the color modeling, we can separate most of the background and objectives of the region. After the selection rules, we can be further remove smaller size and the proportion of inappropriate non-face area. So this method reduces the detection space and improves the detection efficiency.

Before the Hausdorff distance used, face detection accuracy rate in a simple background is 92.3%, detection accuracy rate in complex background is 63.4%. After using Hausdorff distance, face detection accuracy rate in the complex background reached 94.5%.Experiments show that these two methods to improve detection efficiency and accuracy.

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