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Automatic Face Detection in Frontal Face Color Images

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***Abstract* - Automatic detection of facial features of image is an important stage of various image interpretation works, such as facial expression recognition, face recognition, facial features tracking and 3D face modeling etc. Detection of facial features like eye, mouth, nose, nostrils, lip corners etc., with different facial expression is a challenging task. In this paper, we present a method for automatic detection of facial features. A novel technique using the concepts of facial geometry is used to locate the mouth, eyes and nose positions.**

***Keywords* - Face detection, face recognition.**

I. Introduction

Within the last several years, numerous algorithms have been proposed for face recognition; for detailed surveys see [1][2][3]. While much progress has been made toward recognizing faces under small variations in lighting, facial expression and pose, reliable techniques for recognition under more extreme variations have proven elusive. In order to locate a human face, the system needs to capture an image using a camera and a frame-grabber to process the image, search the image for important features and then use these features to determine the location of the face. In face recognition facial features detection is very important stage in vision related applications, such as face identification, features tracking, facial expression recognition, face synthesis, head pose estimation etc.. Facial features generally include salient points which can be tracked easily, like corners of the eyes, nostrils, lip corners etc.

Currently, most of the applications for facial expressions tracking are manually giving points as initial feature points for tracking [4]. Up to now, much work has been done on detecting and locating faces in color images and the methods like template based[5], neural network-based [6], feature-based [7],machine learning-based [8] have been well studied by many researchers. Among many face detection algorithms, the method based on skin color model has been widely used for its convenient use, simple performance and high detection speed [9][10].

II. Skin color model

Skin color detection is often used as a preliminary step in face recognition, face tracking and CBIR systems. Skin-color information can be considered a very effective tool for identifying/classifying facial areas provided that the underlying skin-color pixels can be represented, modeled and classified accurately.

Most of the research efforts on skin detection have focused on visible spectrum imaging. Skin-color detection in visible spectrum can be a very challenging task as the skin color in an image is sensitive to various factors such as:

- *Illumination:* A change in the light source distribution and in the illumination level (indoor, outdoor, highlights, shadows, non-white lights) produces a change in the color of the skin in the image (color constancy problem). The illumination variation is the most important problem among current skin detection systems that seriously degrades the performance.
- *Camera characteristics*: Even under the same illumination, the skin-color distribution for the same person differs from one camera to another depending on the camera sensor characteristics. The color reproduced by a CCD camera is dependent on the spectral reflectance, the prevailing illumination conditions and the camera sensor sensitivities.
- *Ethnicity*: Skin color also varies from person to person belonging to different ethnic groups and from persons across different regions. For example, the skin color of people belonging to Asian, African, Caucasian and Hispanic groups is different from one another and ranges from white, yellow to dark.
- *Individual characteristics*: Individual characteristics such as age, sex and body parts also affect the skin-color appearance.
- *Other factors*: Different factors such as subject appearances (makeup, hairstyle and glasses), background colors, shadows and motion also influence skin-color appearance.[12]

In order to segment human skin regions from non-skin regions based on color, we need a reliable skin color model that is adaptable to people of different skin colors and to different lighting conditions [2]. The face due to the ambient lighting and is not a reliable measure common RGB representation of color images is not suitable for characterizing skin-color.. In the RGB space, the triple component (r, g, b) represents not only color but also luminance. Luminance may vary across a person's in separating skin from non-skin regions.[3].color in the absence of luminance, are defined by normalization process shown below-

r=R/(R+G+B), b= r=B/(R+G+B), g=G /(R+G+B)

The color distribution of skin colors of different people was found to be clustered in a small area of the chromatic color space. Although skin color of different people appears to vary over a wide range, they much differ in brightness and intensity than color.

Fig.1 shows the color distribution of some skin samples in the chromatic color space. Which are extracted from color images using a low pass filter. It
reveals the distribution of skin-color of different people is clustered in the chromatic color space and a skin color distribution can be represented by a Gaussian model N(m,C).
Mean: $m = E\{x\}$ where $x=(r\ b)^T$
Covariance: $C = E\{(x-m)(x-m)^T\}$
Fig.2 shows the Gaussian Distribution N(m,C) fitted by our data.[4].

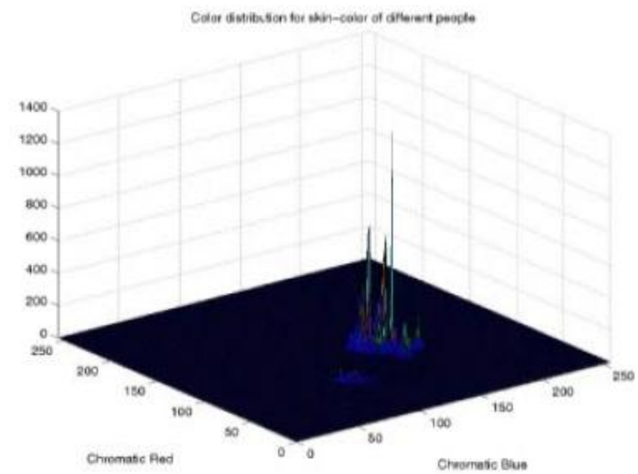

Fig 1. Color distribution for skin color of different people

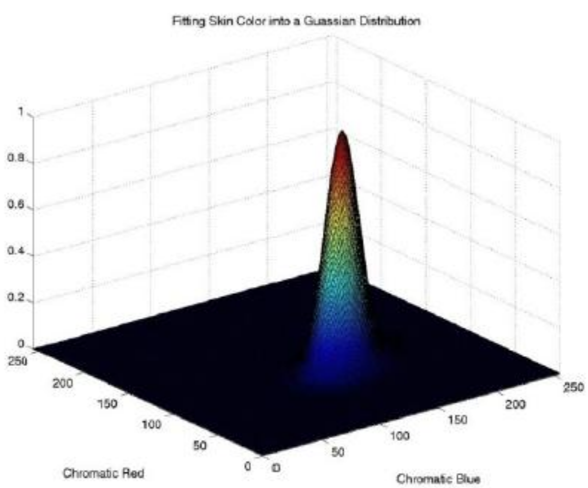

Fig 2. Fitting skin color into a Gaussian distribution

III. Skin Segmentation

A.Color Balance
Among face detection algorithms based-on skin color model, the skin color is often influenced by light, color bias of the image acquisition device and other factors, which leads to deviate from the nature color. Color balance has solved the problem of color offset. In this paper, we use Gray world method in [7] to do color correction in color images.

B.Color Space
Skin color is a powerful fundamental feature of human faces among the face detection algorithms which are based on skin color information and the speed of processing color is faster than other facial features. So skin color detection is firstly performed on the input color image to reduce the computational complexity. There are many color spaces in face detection, such as RGB, HSV, YCbCr, YUV, YIQ, LUV, LAB, XYZ, etc.. Processing color information can be performed in different color spaces, but in order to improve

the performance of skin color clustering, we use the YCbCr [8]to build a skin color model, as the chrominance components are almost independent of luminance component in this space.

C.Elliptical Model

Automatic skin detection has been intensively studied for human-related recognition systems. The first step of the skin color detection algorithm is skin color modeling. There are many ways of skin-color modeling, including Gaussian model [9], mixture of Gaussian model [10], and elliptical boundary model [11], etc. Gaussian skin color model algorithm is relatively complex and long-running, so we use elliptical model. After constructing the elliptical model, we can use it to segment skin color from background image.

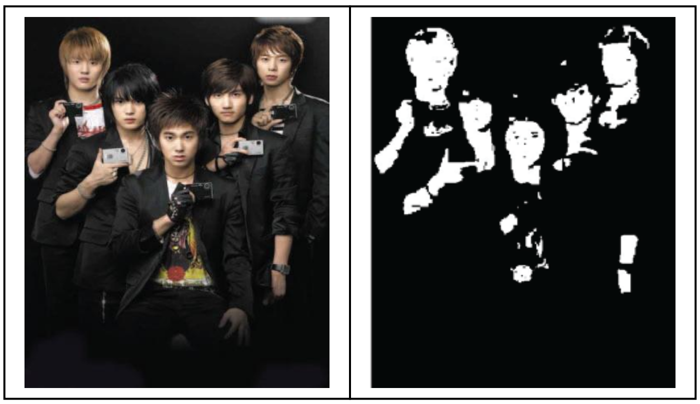

Fig.4. Original image with color segmented result (the binary image)

D. Edge Detection

After skin detection, we get a binary image that contains ones in the skin regions and zeros in non-skin regions. We find that two different skin regions are changed into one region which is difficult to be separated. If we use these region to detect directly, the effects of feature extraction is not perfect, and the results are often not good enough. We propose the method of combining skin segmentation and edge extraction (sobel operator) based on above reason. First, we apply sobel operator detection algorithm on the gray scale version of the original image and get an edge image. Then this edge image is done by negated operation and eroded to connect cross separated pixel in edge image. Finally, we get the edge which is boundaries between face regions and background by logic and operation of the binary image and the edge image. Use median filtering for the final image to remove noise.

Fig.3. Negated edge detection by the sobel operator and logical and Operation

E. Morphological operation

Morphological operation can simplify image data while preserving their essential shape characteristics and can eliminate irrelevancies. We can get a more accurate contour of the skin segment when using it.

IV. Face Verification

After skin color segmentation, we get a series of connected candidate face regions. There are a few non-skin regions which have been erroneously regarded as skin color regions. Furthermore, we have to select suitable regions from all skin regions which could be potential human faces. Thus, to narrow down our search for human faces, we define a number of criteria:

The size of the bounding rectangle surrounding the skin color region is denoted by *Area*1; Area1 must be greater than 400.

A human face always has objects like nose, mouth, eyes, eyebrows etc, so its variance is greater than the candidate region included the hands and arms. If variance is very less then we can discard some regions which don't have any holes or have too much holes

Get the eyes' width according to two eyes' center distance. And identify face's width by adding five parts horizontally. Then, identify face's height by adding three parts vertically on the basis of the distance between the midpoint of the eyes'connection and the center location of the mouth. Finally execute the final verification of the face by the symmetry between the left face and the right face.

V. Experimental results and discussion

In this paper, the Matlab simulated experiments are performed to verify the effectiveness of the proposed scheme. For this we construct the database for face detection from personal photo collections. The images are digital photos from life and collected stochastically from the Internet and these images contain multiple faces with variations in color, position; scale, orientation, and facial expression compose testing set. We choose 100 color images from the database to construct test set. The examples of part experimental result show in Fig.4. Experimental results using the proposed method show that the new approach can detect face with high detection rate and low false acceptance rate. But false alarms and misses are still existing .The statistical data is shown in Table.1

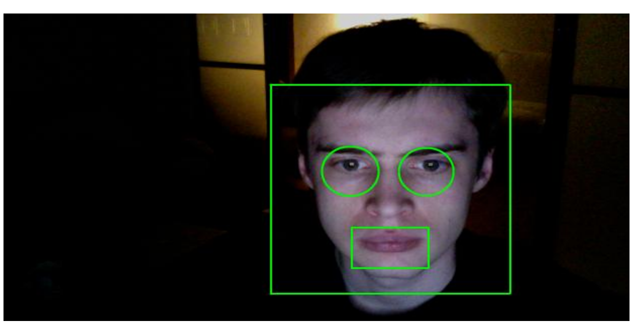

Fig.5.Example of result in image

Face number in one image	Face number	Hits	False alarms	Misses	Precision
1	10	10	0	0	100%
2	22	22	0	0	100%
3	39	37	3	2	94.9%
4	64	60	5	4	93.8%
5	60	56	3	4	93.3%
7	98	95	4	3	96.9%
9	99	93	4	6	93.9%
Above 9	152	143	8	9	94.1%
Total	544	516	29	30	94.9%

V. Conclusion

In this paper a new method is described for face detection, which combines skin color model, edge detection and face verification. It is shown in the experimental results that this paper can achieve high detection accuracy, high detection speed and reduce the false detecting rate , the missing rate.
In the future work, we will improve this algorithm combined with other face detection algorithm to achieve
better performance and further reduce the false detecting rate in dealing with images with more complex background.

VI. Referencess

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