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An Efficient Face Detection Method

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***Abstract*—A new human face detection method was proposed in this paper. Firstly, YIQ color model was used as usual to detect possible skin area. And then, edge extracted by using improved Canny algorithm and followed by contour extracting and tracing. Lastly, took advantage of the *Q* component's character to do the final decision. Experimental results had shown that this was an efficient human face detection method.**

Keywords-face detection; YIQ;Canny; skin color; contour extracting

I. INTRODUCTION

Face detection from digital images or video streams had becoming more and more important topic in computer vision. Face detection and location was always the first step in applications such as face recognition, video surveillance and image database indexing.

Face detection was concerned with deciding whether there were any faces or not in a given digital image (usually in colour images). And then returned the location of faces which be found. Several face detection methods had been proposed so far, including neural networks[1], support vector machines[2-3], templates matching[4-5] and skin colour learning[6-15]. Colour was an important feature of human faces, and colour based face detection methods was much faster than others. However, there was a disadvantage of the original colour RGB images. RGB images were sensitive to illumination intensity. We often could not get satisfactory results by coping original colour image directly. One way to improve this fault was to transform the RGB images into colour space, such as YCbCr, HIS and YIQ, whose luminance intensity and chromaticity were separated. Then we could use illumination and chromaticity component to do face detection. But colour based methods were always imperfect in accuracy even if employed colour space. In this paper, a simple and efficient way of face detection by using YIQ colour space was presented. The Main steps of this method were:

1) Illumination compensation.

2) Skin colour region extraction by using the *I* component of YIQ space.

3) Edge detection by using an improved Canny algorithm.

4) Contour extraction and tracing.

5) Final decision by analysing vertical projection curve and *Q* component of YIQ space.

Experiment results had shown that we could find out whether or not there were faces in the test images quickly and returned the corresponding location. The rest of this paper was organized as follows. In section two, skin colour detection methods were discussed. In section three, an improved Canny algorithm was introduced. In section four, the proposed face detection system was analyzed in detail. Finally, in section five, some experimental results were given.

II. SKIN COLOR DETECTION

Skin color detection was always the first and very important step in many vision systems. The main goal of skin color detection was to find out whether a given pixel or pixels region was skin by using some decision rule that discriminate between skin and non-skin pixels. In this section, RGB Skin Detection and YIQ Skin Detection techniques were discussed in detail.

A. The RGB Skin Detection Technique

The RGB colour space was seen as the original colour space and one of the most widely used colour spaces with a lot of research activities being based on it [6].

In the RGB space, each colour appeared in its three primary spectral components, R, G and B. With RGB colour space, skin colour was classified by heuristic rules that under two different conditions: uniform daylight and flash or lateral illumination. The corresponding decision rules were:

1) uniform daylight condition

$$\begin{aligned} &R > 95 \, and \, G > 40 \, and \, B > 20 \, and \\ &\max\{R,G,B\} - \min\{R,G,B\} > 15 \; and \\ &|R-G| > 15 \, and \; R > G \, and \; R > B \end{aligned} \tag{1}$$

2) flash or lateral illumination condition

$$\begin{aligned} &R > 220 \; and \; G > 210 \; and \; B > 170 \; and \\ &|R-G| \le 15 \; and \\ &R > B \, and \; G > B \end{aligned} \tag{2}$$

Obviously, by using these rules we could quickly detect the candidate skin region. However, it was difficult for achieving high recognition rates with this method.

B. The YIQ Skin Detection Technique

The YIQ colour space was the colour primary system adopted by NTSC for colour TV broadcasting. The *Y* component represented the intensity, while *I* and *Q* component represented the hue and saturation respectively. To convert from RGB to YIQ, we could accomplish by using the colour matrix:

$$\begin{pmatrix} Y \\ I \\ Q \end{pmatrix} = \begin{bmatrix} 0.2990 & 0.5870 & 0.1140 \\ 0.5957 & -0.2745 & -0.3213 \\ 0.2115 & -0.5226 & 0.3111 \end{bmatrix} \begin{pmatrix} R \\ G \\ B \end{pmatrix} \quad (3)$$

The corresponding decision rule according to paper [9] was:

$$20 \le I \le 90 \quad (4)$$

In our system, the corresponding range was set to [20, 40] at the step of extracting skin colour regions.

III. IMPROVED CANNY ALGORITHM

The image resulted by skin colour segmentation needed to transform to grey-scaled image. And then it would be processed by Canny edge detection.

A. *Canny Edge Detection*

Canny algorithm was proposed by Canny [16] to discover the optimal edge detection algorithm and was known to many as the optimal edge detector. The Canny Operator was formed by first-order derivative of Gaussian function, because it was susceptible to noise present on raw unprocessed image.

Firstly, the raw image was convolved with a Gaussian filter. The result was a slightly blurred version of the raw one which was not affected by a single noisy pixel to any significant degree. If the corresponding standard deviation of the Gaussian filter was $\sigma = 1.4$, the Gaussian filter was:

$$B = \frac{1}{159}\begin{bmatrix} 2 & 4 & 5 & 4 & 2 \\ 4 & 9 & 12 & 9 & 4 \\ 5 & 12 & 15 & 12 & 5 \\ 4 & 9 & 12 & 9 & 4 \\ 2 & 4 & 5 & 4 & 2 \end{bmatrix} \quad (5)$$

Secondly, after filtering the raw image by Gaussian Filter, it needed to find the intensity gradient of the image.

The Canny algorithm used four filters to detect four directions (0, 90, 45 and 135 degrees). The Sobel operator returned a value for the first derivative in the horizontal and vertical direction (G_x and G_y). From these two values, the edge gradient and direction would be calculated as follows:

$$G = \sqrt{{G_x}^2 + {G_y}^2} \quad (6)$$

$$\theta = \arctan\left(\frac{G_y}{G_x}\right) \quad (7)$$

Thirdly, it needed to do Non-maximum suppression.

In order to make the blurred edges in the image to be shaped, a search was carried out to determine if the gradient magnitude assumed a local maximum in the gradient direction. For example, if $\theta = 0^o$ then the point would be considered to be on the edge if its intensity was greater than the intensities in the north and south directions.

Fourthly, did tracing edges through the image and hysteresis threshholding.

This step required two thresholds—high and low. The high threshold marked out the edges we could be fairly sure were genuine. By using the directional information derived before, edges could be traced through the image. While tracing an edge, it was the time to use lower threshold. It allowed us to trace faint sections of edges as long as finding a starting point. The output image after this step was a binary image containing a set of edge curves.

B. *Improved Canny Algorithm*

At present, there was not a uniform standard for selecting the dual-threshold of Canny Algorithm. They were often set empirically. The edge detection results with Canny algorithm were always different under different conditions, such as shooting conditions and lighting conditions. In addition, different images had different threshold for there different grey-scale distribution. This problem could be solved traditionally by trying repeatedly. Obviously, this way was always time-consuming.

By analysing the gradient amplitude image, we found that it always had double peaks. Therefore, OTSU method could be used to realize the threshold selection. But there was also a problem that the two peaks were sometimes so closely. In order to make the two peaks more separated, a coefficient was multiplied to the grey level to expand the histogram [17].

The corresponding edges detected by this improved Canny algorithm were shown in Figure1.

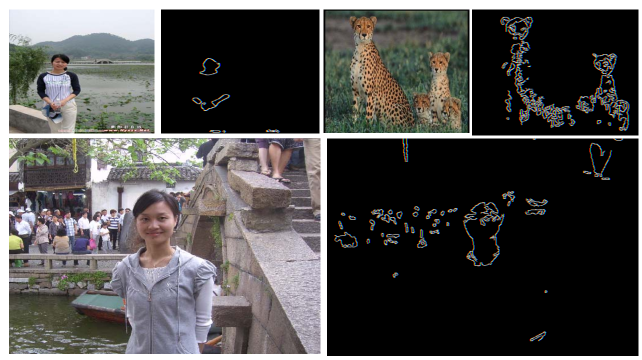

Figure1. Some results of improved Canny operation

IV. FACE DETECTION USING THE PROPOSED METHOD

The face detection method proposed in this paper was developed by VC++6.0. The program flow diagram was shown in figure2.

The final face detection was based on the analysing of the vertical projecting curve of the possible face contours and the Q component of the YIQ colour space.

As mentioned above, we did skin extracting by using YIQ skin model. The corresponding results were shown in Figure3.

And then, contours of possible faces were obtained by using edge detecting, contour extracting and contour tracing. After all these operation, we could get the corresponding vertical projecting curve; some projecting curves of human faces were shown in Figure4.

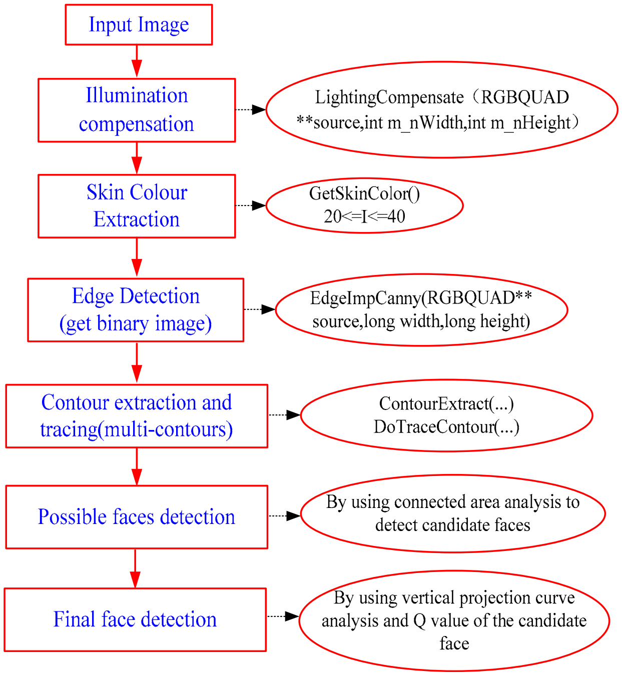

Figure2. Program flow diagram of the proposed system

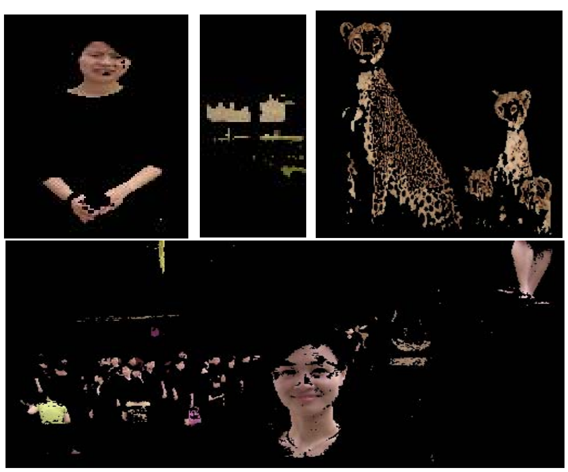

Figure3. Some results after skin extracting

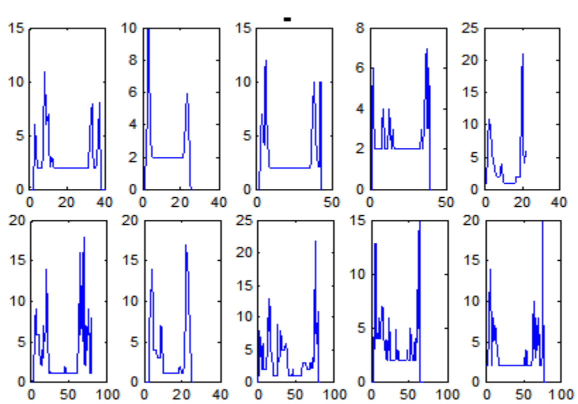

Figure4. Vertical projecting curves of human faces

Obviously, almost all the shown curves could be said to have the same shape, i.e., the left and right sides of curves were normally higher than the mid range a lot. So that in our system, we used this character as one of the most important conditions to detect human face. In order to avoid complicated algorithm for distinguishing curves of possible human faces, we used the criteria experimentally as bellow:

$$V_{low\_max} >= 3 * V_{mean\_mid}$$
$$V_{high\_max} >= 3 * V_{mean\_mid} \qquad (8)$$

Where V_{low_max} and V_{high_max} were the peak values of the lower and upper sides of the projecting curve respectively, V_{mean_mid} was the mean value of the mid range of the projecting curve.

It was not the last step, another key condition was to use YIQ skin model again. However, it was not the I component but the Q component used here. In our system, this condition was:

$$0 \le Q_{mean} \le 10 \qquad (9)$$

Where Q_{mean} was the mean Q value of the possible face area.

Finally, by using these conditions, the conclusion of whether there was human or not was obtained.

V. EXPERIMENTAL RESULTS

The proposed face detection method was developed in VC++6.0. In order to evaluate the performance of this method, about 200 color images were collected from network and some candid photos with 426 human faces and lots of non-faces. Some detecting results were shown in Figure5.

Figure5. Some of the final detecting results

Comparing to the traditional color-based face detection algorithm, it was about 4% improved in the aspect of the accuracy with more than 60% faster detecting speed.

VI. CONCLUSION

An efficiency face detection method was proposed in this paper. The main character used to identify human face was the YIQ color model. However, not only the I component but also the Q component was used to detect human face. And an improved Canny Operator was used as the edge detecting algorithm. Experimental results had revealed that it was a face detection method with high performance on accuracy and speed.

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