Skin Color Based Facial Features Extraction

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ABSTRACT

This paper discusses on facial features extraction based on proposed skin color model. Different parts of face from input image are segmented based on skin color model. Moreover, this paper also discusses on concept to detect the eye and mouth position on face. A height and width ratio (δ= 1.1618) based technique is also proposed to accurate detection of face region from the segmented image. Finally, we have cropped the desired part of the face. This exactly exacted face part is useful for face recognition and detection, facial feature analysis and expression analysis. Experimental results of propose method shows that the proposed method is robust and accurate.

1. Introduction

"Eyes are the window of the soul." Some parts of human face are more important than other parts to successful face recognition and expression analysis. The literature shows various methods. In [1] a combination of skin color and luminance is used to find the face in a head-shoulder image. A combination of facial components like eyes and nostrils found by SVMs and their geometric relation is used in [2]. They used this method to detect faces in frontal and near-frontal views of still grey level images. A probabilistic face detection method for faces of different pose, with different expression and under different lighting conditions is the mixture of factor analyzers used by [3]. Only color information is used by [4] to form a statistical model for person detection in web images. A common method is to identify facial action units (AU). These AU were defined by Paul Ekman in [5]. In [6] a neural-network is used to recognize AU from the coordinates of facial features like lip corners or the curve of eye brows. As a classical self-organized learning method, principle component analysis (PCA) is widely used in the field of data compression and feature extraction [6]. Therefore, we are going to present skin color based facial feature detection system.

The rest of this paper is organized as follows. Section 2 represents the skin color detection system and feature extraction like mouth and eye with experimental results. Conclusion of this work is given in Section 3.

2. Implementation of Proposed Method

This section presents discussion on skin color detection and feature extraction with experimental results. The proposed method only significant pixels are selected automatically for facial features extraction.

Color and feature-based detections can fast and accurately find human. However, the traditional color-based method is hard to detect the skin-color for the case of different lighting condition, and the typical feature-based method has high computation complexity. In this section, we propose a new lighting compensation scheme to overcome the problem of color-based method and simplify the feature-based detection. A system overview of our face detection algorithm is illustrated in Figure 2.

1. Color: In order to apply to the real-time system, we adopt skin-color detection as the first step of face detection. Due to YCbCr color space transform is faster than other approaches [5][6], we select this transform to detect human skin. However, the luminance of every image is different. It results that every image has different color distribution. Therefore, our lighting compensation is based on luminance to modulate the range of skin-color distribution.

First, we compute the average luminance Y_{aveg} of input image.

$$Y_{aveg} = \sum Y_{i,j} \quad (1)$$

Where $Y_{i,j} = 0.3R + 0.6G + 0.1B$ is normalized to the range (0,255) and i, j are the index of pixel. According to Y_{aveg}, we can determine the compensated image $C_{i,j}$ by following equations:

$$R'_{ij} = (R_{ij})^{T} \quad (2)$$

$$G'_{ij} = (G_{ij})^{T} \quad (3)$$

$$C_{ij} = \{R'_{ij}, G'_{ij}, B_{ij}\} \quad (4)$$

$$\tau = \begin{cases} 1.4, & Y_{aveg} < 64 \\ 0.6, & Y_{aveg} > 192 \\ 1, & otherwise \end{cases} \quad (5)$$

Note that we only compensate the color of R and G to reduce computation. Due to chrominance C_r can represent human skin well, we only consider C_r factor for color space transform to reduce the computation. C_r is defined as follow:

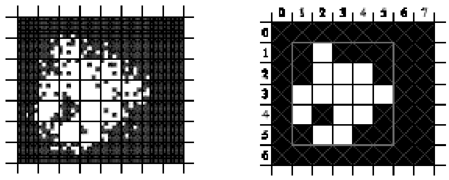
$$C_r = 0.5R' - 0.419G' - 0.081B \quad (6)$$

In Eq. (5) we can see that R and G are important factors due to their high weight. Thus, we only compensate R and G to reduce computation. According to C_r, we define the human skin by a binary matrix:

$$S_{ij} = \begin{cases} 0, & 10 < C_r < 45 \\ 1, & otherwise \end{cases} \quad (7)$$

where "0" is the white point, and "1" is black point. Figure 2 shows the compensation effect on bright and dark image respectively.

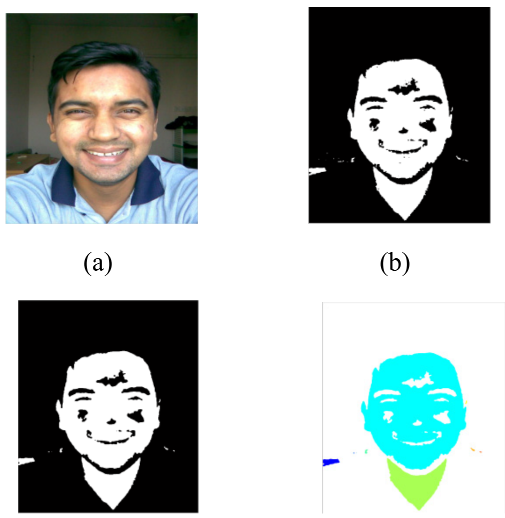
2. High frequency noisy removing: In order to remove high frequency noise fast, we implement a low pass filter by a 5 × 5 mask. First, we segment S_{ij} into 5×5 blocks, and calculate how many white points in a block. Then, every point of a 5 × 5 block is set to white point when the number of white points is greater than half number of total points. On the other hand, if the number of black points is more than a half, this 5 × 5 block is modified to a complete black.



(a) (b)

Figure 1. Mask for removing noise

3. Find out the skin-color blocks: After performing the low pass filter, there are several skin color regions may be human face will be in S_{ij}. In order to mark these regions, we store fore vertices of rectangle for every region.

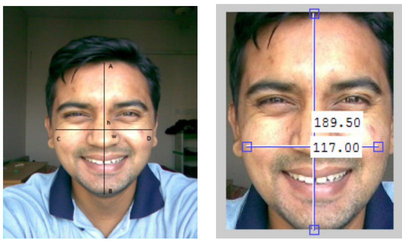


(a) (b) (c) (d)

Figure 2. a) Lighting compensation b) face skin detection c) skin with noise removal d) face candidate

First, we find the leftmost, rightmost, upmost, and down most points. By these four points, we create a rectangle around this region. Figure 2(b) shows an example that store (1, 1), (1, 5), (5, 1), and (5, 5) to describe the candidate region. Thus, we can get several skin-color blocks called candidate blocks to detect facial feature.

4. Height and Width ration checking : the height to width ratio, mouth, and eyes are detected sequentially for every candidate block. Because any of these three detections can reject the candidate blocks, low computation module has high priority to process. Height to width ratio is a very fast and simple detection. Let the size of candidate block is hxw. We define that if the height to width ratio $(h:w)$ is exactly 1.618 or nearest to the mentioned value then it is face else it should be not a face. If the ratio is between 1.55 and 1.7 may be a face, the block should be processed by the following two detections.



(a) (b)

Figure 3. Ratio of face features (δ = h/w =1.618)

5. Mouth Detection: We use θ proposed by [7] to find the mouth pixels. The θ value is calculated for all of the pixels in every candidate block. The θ is defined as:

$$\theta = \cos^{-1}\left(\frac{0.5(2R' - G' - B)}{\sqrt{(R' - G')+(R' - B)(G' - B)}}\right) \qquad (8)$$

The pixel will be determined to be part of mouth by a binary matrix M:

$$M_{pq} = \begin{cases} 0, & \theta < 90 \\ 1, & otherwise, \end{cases} \qquad (9)$$

where 0 means that pixel is mouth. Figure 4(a) and (b) is an example for mouth pixel detection. In Figure 4(b), the mouth pixel is presented by white point. Then, we use vertical based histogram to determine whether or not it is a mouth in this block. We calculate how many mouth pixels are in the same y-coordinates, and use to store the value of different y-coordinates. Figure 4(c) illustrates an example of the histogram of Figure 4(b). Note that the maximum value of that is denoted by wmax and the y-coordinate of wmax is represented by hm. Thus, we define if wmax is less than 1/6 block width w, this block will be rejected. For example, in Figure 4(c) wmax is more than (1/3) w, we can know that the mouth feature is embedded in this block.

(a) (b) (c)

Figure 4. Mouth Segmentation

6. Eyes Detection : After mouth detection stage, we know that the y-coordinate of mouth is h_m and the y-coordinate of eyes must smaller than h_m according to our definitions. This information let us to detect human eyes in the smaller region. The region is defined by the y-coordinate 0 to $h_m - w_{\max}$. Because the y-coordinate of mouth is must larger than eyes, the considered height of region must be less than hm. An example of detecting region is shown in Figure 5(a). Due to the deeper lineaments around human eyes, we can detect the existence of human eyes by the luminance which is slightly darker than average skin-color. The pixels which around human eyes is defined by $E_{\hat{h}w}$:

$$E_{\hat{h}w} = \begin{cases} 0, & 65 < Y < 80 \\ 1, & otherwise, \end{cases} \qquad (10)$$

where $E_{\hat{h}w} = h_m - w_{\max}$. Figure 5(b) shows an example that we find out the pixels around eyes. Then, the vertical based histogram, illustrated in Figure 5(c), shows the distribution of $E_{\hat{h}w}$. In this histogram, we assume the candidate block has human eyes if there exist a α value greater than a threshold β. Here we let $\alpha = 0.5w_{\max}$ and $\beta = w_{\max}$. When we finish the eyes detection, we regard the blocks which pass three feature detections are human face

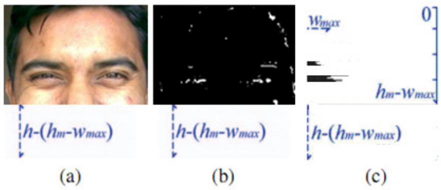


Figure 5. Eye Segmentation

7. Cropping the desired part of face: After selecting the specific face part of human from the image. The desired part has cropped from the selected face shows in Figure 6.

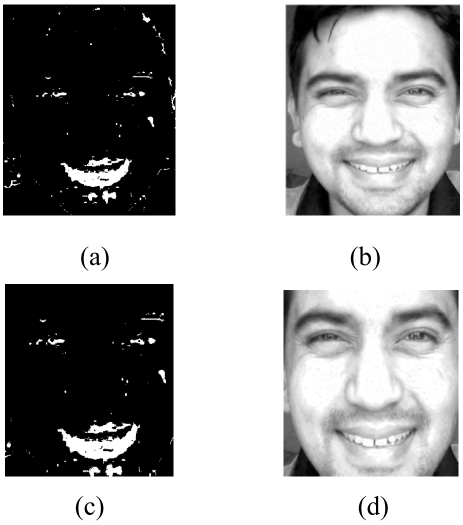


Figure 6. (a) possible face region segmentation (b) Crop the segmentated region (c) Desired part segmentation and (d) Crop the desigred part of face.

4. Conclusion

In this paper, we have proposed an accurate face features detection system from input images which contains environmental background. The color and feature-based detection was adopted to find skin-color fast and selected candidate blocks correctly. Also we have used lighting compensation to improve the performance of color-based scheme, and reduce the computation of feature-based scheme. The major contribution of this paper is that the proposed method can detect face part based on a ratio (δ= 1.618) successfully. This method also detect successfully under dark or bright vision, close eyes, open mouth, wearing glasses, and half-profile face.

5. References:

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