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Proposing an approach for face detection based on gaussian color filters with template matching

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Abstract:

This article is devoted to introducing a new algorithm for face detection. This method is based on using an algorithm for skin color, and template matching. First, we determined the skin points by considering the standard skin colors. This considering rejects many parts from either the pictures or video images. Then, using the template matching the different parts is combined, and many errors due to the mismatch of the first algorithm, and some noises are reduced vitally. Our simulation results indicate that both positive and negative errors have insignificant.

Keywords:

Face detection, template matching, colored space, Gaussian filter, skin model**.**

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1. Introduction:

Face is a unique feature of human. Even twins have slight differences in face. Because of this, face can be used as one of important criterion of identification, and person's recognition. In all applications that use face feature, in the first stage, the place of face must be determined in the image. Face detection can be utilized in many different areas such as safety and military applications, video lecture, face tracing in video and image, intelligent human and computer intermediates, video compacting according to content, information access [1, 2]. The objective of our face detection is to find all the face situations in an image. In this work, also, pictures that have more than one face are viewed. However, face detection is a complicated work, and should satisfy different expectations [9]. There are diverse recommended methods for face detection. Among them, we may classify up to down methods based on model, down to up based on feature, texture-based method, neural networks, movement, depth, and colors [3, 4]. Among above mentioned methods, skin color as a suitable feature for face detection has attracted many researchers. On the other hand, template matching is considered as a powerful tool for recognizing the subject in an image. Therefore, in our study, this approach was considered.

In this article, human face recognition was examined based on a combined method of template matching, and changes of color space based on Gaussian color filter.

The simulation results on the image information bank show that this method has not only good resolution, but also a high resistance against noise. In continuation and second section, face situation is introduced using designation of skin points and edge information. In third section, recommended method of face detection using combinative template matching method and color space changes and based on Gaussian color filter. Finally in forth section demodulated algorithm and their simulation methods are compared and examined.

2 -Skin points designation in human image:

Skin color of human different races allocates distinct area of color space [5]. But skin color information's are not enough for face detection. For instance, when some faces are close to each other, it is possible that skin areas combine with each other and some mistakes may happen in the face detection or identification. To prevent these mistakes, face situation can be designated through skin points in image and their links as well as edge information [5,6]. To determine skin points, first human skin color is calculated through HSV color space. S and H are divided into 100 levels and then according to a histogram calculated whit two elements S and H the skin color model is calculated.

Skin color histogram is calculated using a set of images included skin areas of human different races and the areas related to skin are extracted from among images. After noise elimination, analogous cell value of each pixel increases one unit in histogram until histogram become normal. Figure 1 shows the face skin color in HS 2–dimensional space.

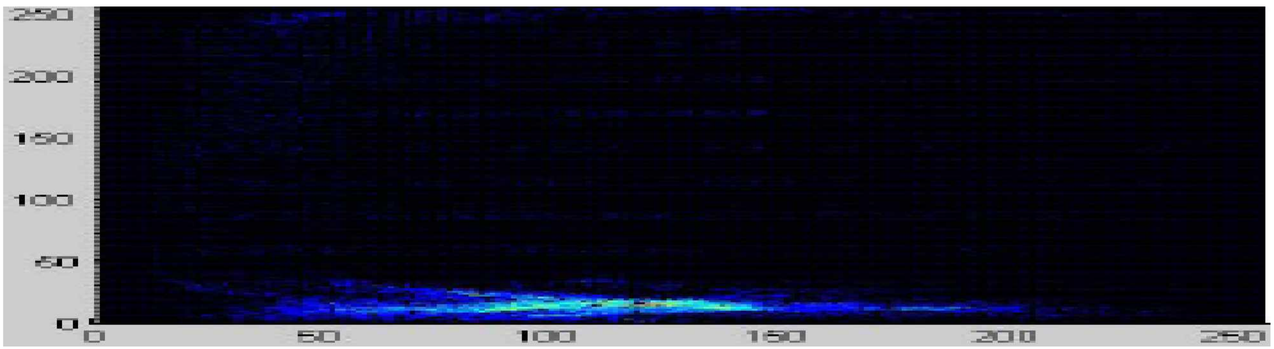

Figure (1): *The histogram of skin color in HS two-dimensional space (adapted from [5]).*

The height of one cell in histogram shows the probability of analogous color belongs to this cell. Thus skin-related pixels in image can be recognized by a threshold value. This threshold value has been selected based upon 0/1 experimental results [5]. In the cases that between two real skin areas in image there are color's similar to skin color, two skin areas are recognized gust as one area. For solving this problem edge information is used. By having this histogram and image of edge, pixel is classified into the skin points class if its analogous cell in histogram be more than 0/1 threshold value and edge gradient value be less than threshold value [10,11,12]. Figure 2 shows a sample of skin point's assignment on face image.
By applying morphological opening and closing operators on binary image, minute objects and traumatic noises are deleted, and cells are filled.

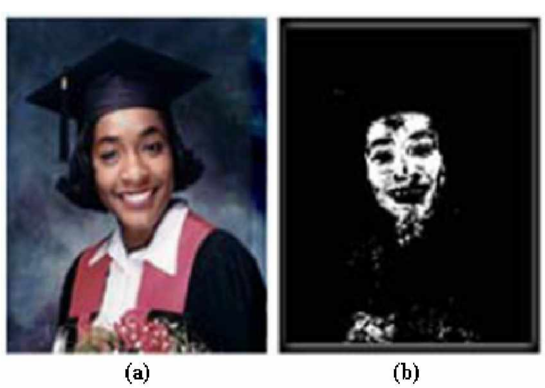

Figure (2): *(a) main image and (b) binary image of points related to skin (adapted from [5])*

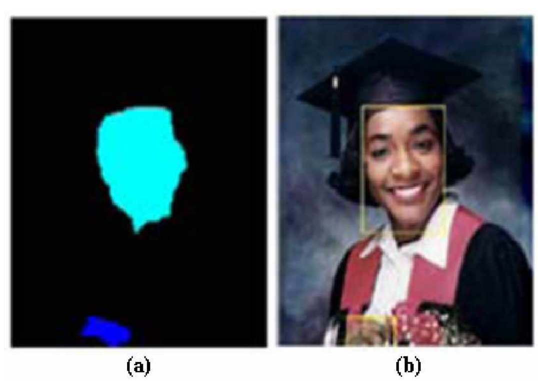

Figure (3): *(a) cutter areas with 8 join operators, (b) detected faces in picture.*

2-1 The extraction of probable areas of face from skin point image:

For extraction of face points from skin point's image, we considered 8 joints. Binary image including skin points divides into skin areas. The divided areas in which skin points percentage be more than one threshold value and simultaneously length-wide ratio of supposed rectangle of area placed in the following bracket will be considered as probable area of face [5].

$$\left[\frac{1+\sqrt{5}}{2}-\text{tolerance},\frac{1+\sqrt{5}}{2}+\text{tolerance}\right] \tag{1}$$

Using the above formula, figure (3-a) shows the identified probable areas applied for figure (2-a). As it has been showed in figure (3-b) skin area of hands has been recognized as one face.

3 - The recommended method of face detection:

In the recommended method skin points are designated using recommended Gaussian color filter firstly, and according to these points skin areas are determined. Then by conducting template matching on skin areas that likely determines one face the limit of faces is determined in the picture.

3 -1 Gaussian color filters for determining skin points:

For determining skin points, a set of images including skin areas (that a sample of it has been showed in figure (4) related to human is used and skin areas are extracted from images. By applying low pass filter on skin samples, the noise reduces and then each skin image changes into YCbCr space. Then, the two color elements, Cb and Cr are obtained.

Figure (4): *the sample of collected skin cluster.*

In this stage, a color filter is introduced for separation skin areas; data station of skin images is considered as a cluster that all of its elements are skin. This cluster has a mean m, and a standard deviation, σ.
Now, the cluster means in skin model are represented according to following equations.

$$\overline{C_b} = E\{pixelC_b(i,j)\} = \frac{1}{n}\sum pixelC_b(i,j) \tag{2}$$

$$\overline{C_r} = E\{pixelC_r(i,j)\} = \frac{1}{n}\sum pixelC_r(i,j) \tag{3}$$

Standard deviation of pixels of element c_b in the skin sample:

$$\sigma_{c_b}(i,j) = \sqrt{\frac{1}{n}\sum(pixel\ \ c_b(i,j) - \overline{c_b})^2} = \sqrt{\frac{1}{n}\sum(c_b - \overline{c_b})^2} \tag{4}$$

Standard deviation of pixels of element c_r in the skin sample:

$$\sigma_{c_r}(i,j) = \sqrt{\frac{1}{n}\sum(pixel c_r(i,j) - \overline{c_r})^2} = \sqrt{\frac{1}{n}\sum(c_r - \overline{c_r})^2} \tag{5}$$

Then, we introduced the cost functions according these formulas:

$$c_{b(cost)} = \frac{(c_{bi} - \overline{c_b})^2}{(\sigma_{c_b})^2} \tag{6}$$

$$c_{r(cos\ t)} = \frac{(c_{ri} - \overline{c_r})^2}{(\sigma_{c_r})^2} \tag{7}$$

In equations (6) and (7), c_{bi} and c_{ri} are pixels. The values of c_r, c_b were obtained from the experiments.
Now we combined these two functions in one cost function as follows:

$$O(i,j) = \left[\frac{(c_{bi} - \overline{c_b})^2}{2(\sigma_{c_b})^2} + \frac{(c_{ri} - \overline{c_r})^2}{2(\sigma_{cr})^2}\right] \times 255 \tag{8}$$

Finally to the control allocated color value to pixel, the α coefficient in equation (8) is introduced as follows.

$$O(i,j) = \left[\frac{(c_{bi} - \overline{c_b})^2}{2(\propto \sigma_{cb})^2} + \frac{(c_{ri} - \overline{c_r})^2}{2(\propto \sigma_{cr})^2}\right] \times 255 \tag{9}$$

Then each noticeable input image after changing into YCbCr space is compared with above equation. Then based on a value for α, we determine if the point is in the face or not.

Figure (5): *binary image of skin points with the sample of skin cluster in figure (4) from the image of figure (2-a) with α =0/3*

In the next part some defects of manifested points are solved using morphological operators and then Gaussian filter. Also in order to unify skin objects these operators are used. Figure (6) shows a better understanding of operations.

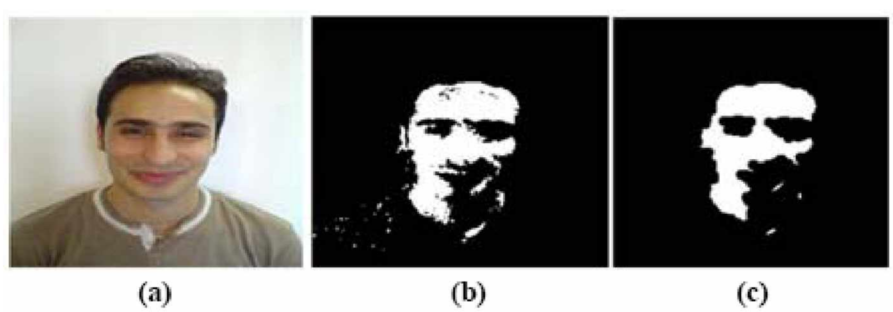

Figure (6): *(a) main image, (b) outage of image after applying Gaussian filter, (c) outage of image after applying closing operator.*

As the main image shows, because of incoherence of color spectrum educated to filter, some areas of skin are not presented in the outage of filter that owing to it recognized areas are incoherent and in cohesive, and also because of using medina filter after first filtering, recognized points away from skin are discarded. Therefore for unifying them and deleting of unnecessary points, the morphological closing operator has been used that is shown in figure (6).

3 -2 Template Matching:

The introduced method clusters all the areas of skin and similar to skin in the image. These areas include 3 general areas of skin, related to face, and related to body organs and finally areas close to skin. Figure (7) shows a sample of extracted areas.

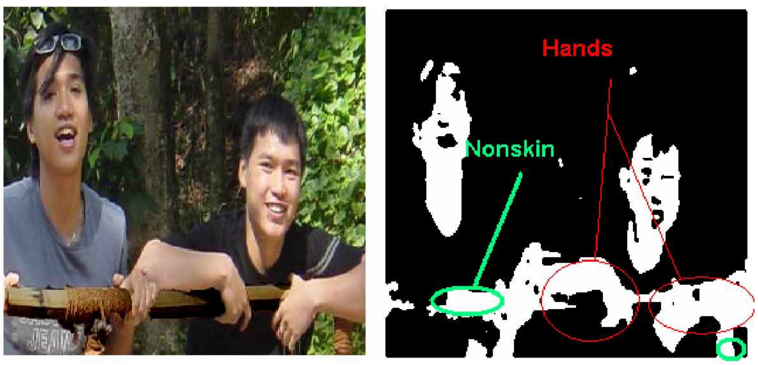

Figure (7): Detection of areas related to skin and body organs.

In a successful detection only the skin area related to face should remain, for this purpose the objective matching test method recognized by a total model from template face is used [7]. In this method a suitable template is considered for face and this template displaces on the image of created areas. In each displacement the adaptability of this template with image is measured according to correlation. If the adaptability be more than a distinct limit, that area will be considered as skin area of face. The adaptability value can be regulated by a suitable coefficient (R). The used template in this method has been used from the existed model in a special database that is as figure (8).

Figure (9) shows the induced results from conducting above method on the image of figure (5) with determined coefficient.

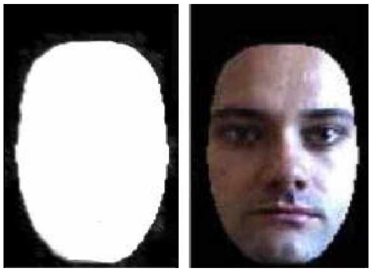

***Figure (8)**: Sample templates*

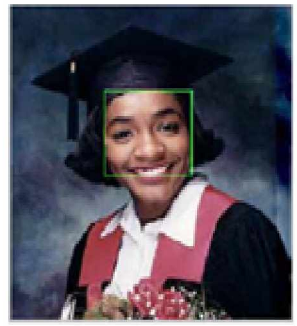

***Figure (9):** Face coordination's from binary image of figure (5) with R > 0/1.*

4 - Simulation Results and Discussions:

In articles and writings related to face detection based on skin color, we did not use any standard information bank. For evaluation our method, we used different images with different diversity. For this reason, and for doing simulation operations and examining the induced results from demodulation of introduced method in this material, a bank from colored images was prepared. The presented images in this bank include images by important materials, choosing some images from internet, and some obtained by us. The built images bank includes 110 one-face images, 45 images including 2-15 faces and also 14 video images with different sizes and qualities. Also for modeling human skin color some images of different human races were collected and their existed skin areas were separated.
For assessing of introduced method positive and negative standard error has been used. The positive error places in situations that non-face areas are reported as face and negative error places when the face is in the image but is not recognized by program. The results of recommended method performance on images bank show that originated negative and positive mean errors [8] were very low. Table (1) shows mean errors on images bank and after the number of distinct stages of implementation. By regulating of R and α value the acceptable results can be achieved after the observation of error. Some samples of algorithm implementation on images bank have been showed in figures (12), (13), and (14).

Table (1): created errors on images bank (R > 0/1, ∝ =0/3)

Negative error	Positive error	# Image	Image species
0	0	110	110 one-face image
0.695%	0	164	54 multi-face image
0.395%	0.117%	18	14 video image

For examining our algorithm in the presence of noise, Gaussian noise with different amplitudes was applied for the images bank. The curve of figures (10) and (11) shows these mean errors. In both cases of changing R, or alpha, the errors are not so vital.

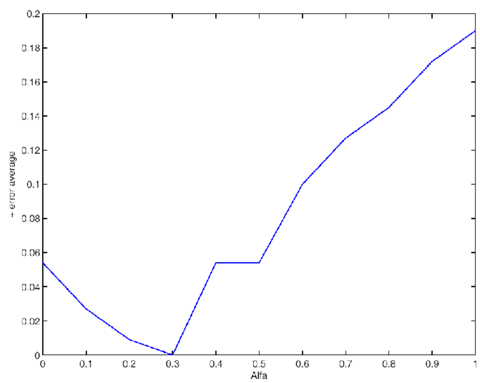

Figure (10): *The curve for average error based on α coefficient for the video images bank.*

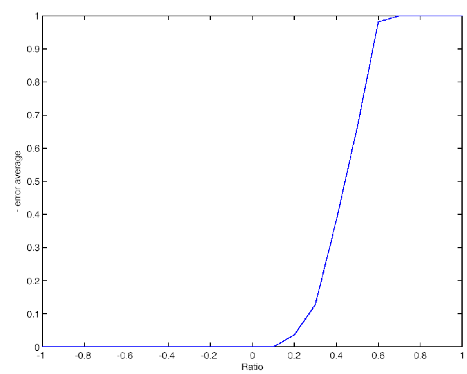

Figure (11): *The curve for average error based on R coefficient for the video images bank.*

Figure (12): *Face detection in one-face images (R > 0/1 and α =0/3)*

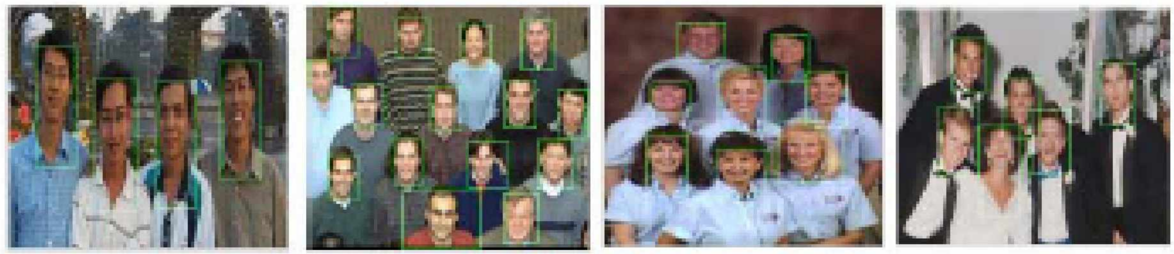

Figure (13): *Face detection in multi-face images.*

Figure (14): *Face detection in video frames (R > 0/1 and α = 0/01)*

4. Conclusion:

In this article, we demonstrated a suitable approach for face detection. As shown in table 1, the percentage error in both positive, and negative case are very small. One good advantage of our method was shown in video images. As shown in figure 14, the faces were detected even though there is more than one face. One important outcome of our algorithm also is the flexibility of having two coefficients, i.e., R and α values. By changing these coefficients we are able to change the error between positive and negative errors. In some cases it might be possible that just one or both errors are vital.

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