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Frontal human face detection using skin detection,face matching and haarcascade

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Abstract – Human face detection one of the most important fields that attract searches since a long time ago until now because of the huge number of applications that benefit from face detection and recognition like crowd surveillance, Attendance System, ATM and other. In this paper we propose a method of frontal face detection that consists in general from two steps human skin detection and human face matching. For human skin detection we suppose ranges for skin color in two color spaces YCbCr and HSV because RGB model affect to the changes of luminance and in this space we cannot separate it from the color information .For getting almost clear image and getting right information from the image we apply blurring techniques (Median and Bilateral) and morphological transformations to delete the noises (Dilation, Erosion, Opening..). After we get the skin region we find the contours after converting the image to black and white .The contour region that contains at least two contours inside it (two eyes) presents the region that contains absolutely the face. After that we apply face matching using template of frontal human face .At last we compare the model with haarcascade classifier and combine the skin detection and haarcascade and get the results.

Keywords – ***Face detection, skin color detection, color spaces, human face matching, haarcascade, contours.***

I. Introduction

Whereas Facial Rrecognition is a simple process up to human brain, it is complex and very difficult for the computer, but the evolution of computer vision has made this recognition pretty and easy. There are a huge number of commercial applications, security applications, as well as government applications and legal forensic applications that need to use facial recognition techniques.

Facial recognition consists of several important steps the first of all is face detection .Face detection means finding whether or not a face exists in a given image and returns the location and the size of the face. This is the first step of any fully automatic system that analyzes the information contained in faces (e.g., identity, gender, expression, age, race, and pose). Face detection plays an important and critical role for the success of any face processing system [2].

Various algorithms, including skin color based algorithms, exist for face detection. Color is an important feature of human faces. Using skin color as a feature to detect a face has several advantages. Color processing is much faster than processing other facial features and when it is used with another algorithm like human face matching or viola Jones it gives accurate bounding box around the face that means right information will be used for face recognition or whatever we want this information for as we will see in this paper. In This paper new skin color model is presented using two color spaces YCbCr and HSV , which can overcome chromatic color problems .Blurring techniques and morphological transformations are applied to the tested images to get better results .

Skin color detection itself is not enough to detect the face region because hands, chest and other parts of body can appear as skin region so finding contours technique is applied to determine the benefit region that indeed includes the face, because the contour that surrounds the face object absolutely includes at least two contours that present the two eyes. Most the tested face images ,except those belongs to men with bread ,prove that the detected region includes face and neck and any connected skin area .After this step human face matching is applied to detect the face region exactly .Our model has good results for face detection when we apply it to color images that contain frontal faces

II. Related work

Face detection methods are broadly classified into four areas: template matching methods, feature invariant methodes, knowledge-based methods and appearance-based methods [4].

- Template matching methods: In these methods standard template of human faces is presented and by using this template the face in an image is detected by finding the region that has the most correlation with this template. This way suffers from the difficulty of finding the standard

template that fits with the different poses, orientations, facial expressions, illumination conditions, etc...

- Feature invariant methods: These methods use the face features like eyes, nose, lips, ear and skin color to detect faces in image. The benefit of the method of this type that it can handle with the varying lighting condition between images for the same person.
- Knowledge-based methods: The method of this type depends on the rules that describe the relations between the facial features .The limitation of this method comes from the affecting of this method greatly by the rules designed for the face detection .i.e.: when the rules are simple the method may give false detection .In the other hand the method may give low detection when high constraint rules are applied.
- Appearance-based methods : These methods need to be trained on a set of images contain human faces without the need of using predefined face template .After training this model a set of images are used to test the ability of this model to detect .

The face detection system that is presented in [6] consists of two stages The first one consists of skin color detection by a statistical method, based on a Gaussian mixture model in the chromatic CbCr color space. Luminance is not taken into account to reduce the effects of illumination changes .The second stage consists of finding geometrical face characteristics and template matching, in this stage any pixel belongs to skin color region and does not belong to face region is rejected.

In [7] a human face detection algorithm by primitive Haar cascade algorithm combined with three additional weak classifiers is proposed. The three weak classifiers are based on skin hue histogram matching, eyes detection and mouth detection. The result of applying primitive Haar cascade classifier is approximately without wrong human rejection (FN) but with some wrong acceptence of human face (FP) .To enhance this result the three weak classifiers are applied serially .In result the false positive rate is significantly decreased.

In [8] a contour matching based face recognition system is proposed, which uses contour for identification of faces.the algorithmic and computational simplicity of this method makes it suitable for hardware implementation.

In [9] YCbCr and CIELab algorithms are design for skin color segmentation. CIELab includes more color ,even more than the human eye can see, than other color spaces .When proposed compensation scheme is applied, it can detect most of the skin regions by a single skin color map irrespective of the lighting conditions. When the skin color segmentation with CIELab color space is done, in this work if background color match with human skin like hand or chest then segmentation will not be in good manner.

III. SKİN COLOR DETECTİON

Skin color segmentation is used to determine whether the color pixel is a skin color or non skin color.Skin color detection reduces the region of image that we the search of a face in it. Skin color classification means determining if the pixels of the region in image belongs to skin color or not .Luminance is not reliable information to present skin areas .For this reason the preprocessing of the RGB image should be made to convert it to another space that separates luminance from chromatic information YCbCr color space is a good choice to present the image because whereas Y component presents luminance or intensity , Cb and Cr present the color information ,so we can separate luminance from chromatic information easily [1] .

A. RGB Color Space

RGB color space consists of three base colors red, green and blue as appear in Fig. 1 Any color can be obtained by mixing the three base colors depending on how much is taken from each base color Eq (1), Eq (2), Eq(3). This space is used as default color space for presenting and storing digital images in computers, graphics, etc. .Fortunately ,we can get any other color space by linear or nonlinear transformation from RGB space.

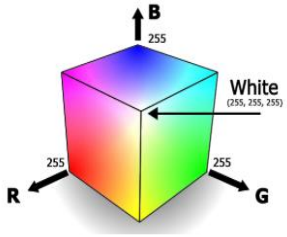


Fig. 1 RGB Color Model

$$r = \frac{R}{R+G+B} \quad (1)$$

$$g = \frac{G}{R+G+B} \quad (2)$$

$$b = \frac{B}{R+G+B} \quad (3)$$

B. YCbCr Color Space

YCbCr is an encoded nonlinear RGB signal [5].In this color space luminance information is presented as (Y) component and chrominance information is presented as color components (Cb and Cr) .YCbCr values can be obtained from RGB values by the equation Eq. (4).

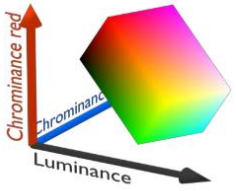


Fig.. 2 YCbCr Color Model

C. HSV Color Space

This space represents color belongs to three components Hue component represents color type such as red, blue or yellow, Saturation component refers to vibrancy or purity of the color and the third component Value is pointing to intensity of the color value .It is also known as HSB and HIS [3]. Reference [5] Explains the values that each of these components takes in RGB and HSV spaces Fig (3).

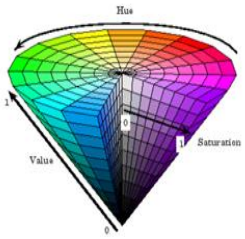


Fig. 3 HSV Color Model

IV. TEMPLATE MATCHING

Template matching presents intensity comparison between predefined template and the sub-region of the image under analysis. The minimum distance between the template and sub-region presents best face matching [1].

V. PROPOSED METHOD FOR FACE DETECTION

A. *Human Skin Detection*

It is done by the following steps:

- Reading RGB image (be sure it is a valid image)
- Resize image
- Smoothing image (using Bilateral filtering)
- Converting from RGB to HSV space
- Applying skin color range for HSV color space by applying hsv_mask like Eq (1)
- Applying Morphological Transformations (opening that presents erosion then dilation) by kernel (3, 3) for deleting noises that are existing inside the object .
- Converting from RGB to YCbCr color space
- Applying skin color range for YCbCr color space that is mentioned in Eq (2).
- Applying Morphological Transformations (opening) with kernel (3, 3) for deleting noises.
- Merge skin detection (YCbCr and HSV) by applying "bitwise and "between HSV mask and YCbCr mask Eq (3).
- Applying smoothing and morphological transformation on global mask.
- Threshold the image for converting it to black and white.
- Perform a series of erosions and dilations to remove any small regions of noise.
- Find contours in the result black and white image
- Take the biggest contour that achieves the condition of having two contours at least inside it. (in this step we have reached to the area of the image that has the face region in large probability).
- Apply human face matching algorithm (B) or haarcascade frontal face detection algorithm (C)
- Crop the face region from the original image and save it

  The result of applying previous steps appears in Fig (1)

$$0 < H < 17 \text{ and } 15 < S < 170 \text{ and } 0 < V < 255 \quad (1)$$

$$0 < Y < 255 \text{ and } 135 < Cb < 180 \text{ and } 85 < Cr < 135 \quad (2)$$

global_mask = cv2.bitwise_and (YCrCb_mask, Hsv_mask) (3)

B. *Human Face Template Matching in Multi Scale*

After we get the human face template we apply Human Face Template Matching,The same way as normal tamplate matching in multi scale .

In the model in this article I get face template from ten frontal human face (jpg images) in the size of 50x50 that just contain the area of face between up of brows and under the mouth without ears and chin Fig (4) .The resulted template in Fig(5) .

I get this template by this way :

- Loop around all images
- Read image
- Convert mage to grayscale
- Convert image to array (the gray image is two dimentional array)
- Build an array that its pixels are the mean of the pixels of all images

  it is done by python with the following code :

```
for im in img_list:
        if validImg (im, ".jpg"):
            img2 = cv2.imread(im)
            cv2.imshow("img2", img2)
            img2gray = cv2.cvtColor (img2,
    cv2.COLOR_BGR2GRAY)

            if img1gray.shape != img2gray.shape :
                continue

            valid_img_num += 1
            new = cv2.add(img1gray, img2gray)
            img1gray = new // 2 #for integer result

    saveImage("template", "mytemp", 1,
    img1gray)
```

Fig..4 50x50 cropped faces used to get the human face template

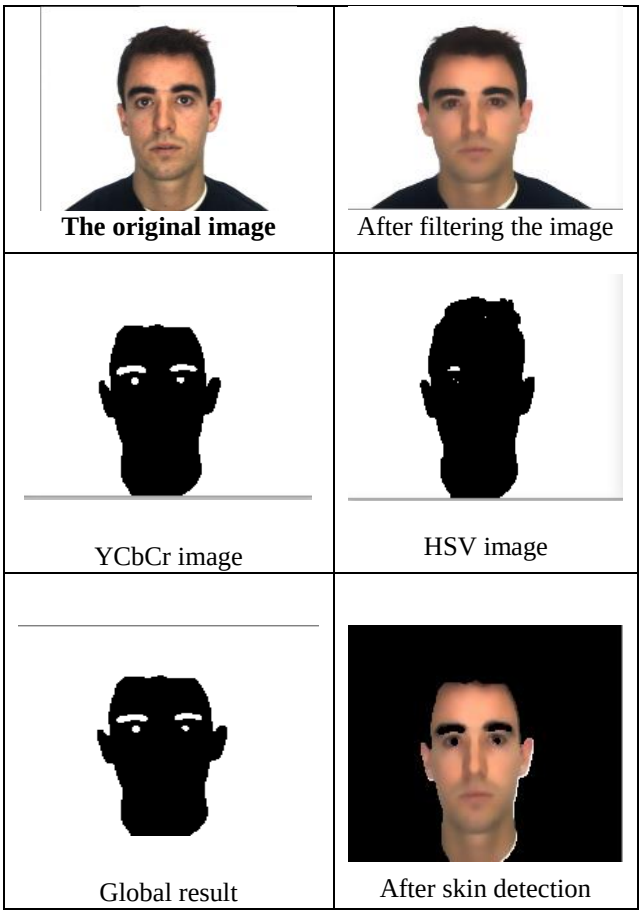
Fig. 5 The resulted human face template

VI. RESULTS AND DISCUSSION

This project is coded and applied in the environment of pycharm community 2018.2.5 ,python 3.6 .
The used libraries : (opencv, numpy, matplotlib, pyimagesearch , os) and in a laptop with this properties (System type: 64 bit Operating System x-64 based processor,Windows edition :Windows10 pro, RAM :16 GB, Processor: Intel core i7 2.6 GHZ).
We apply our model and the comparing on a database that has 564 colored images which present 564 frontal face of different skin color.

A. The result of applying our human skin detection model

By applying our model of human skin detection on the database ,The process needs 38,453.076 second to finish , it detects the human skin in 557 images that contain the face and the neck of a person , the process takes 6696.0 MS for one image Fig(6).



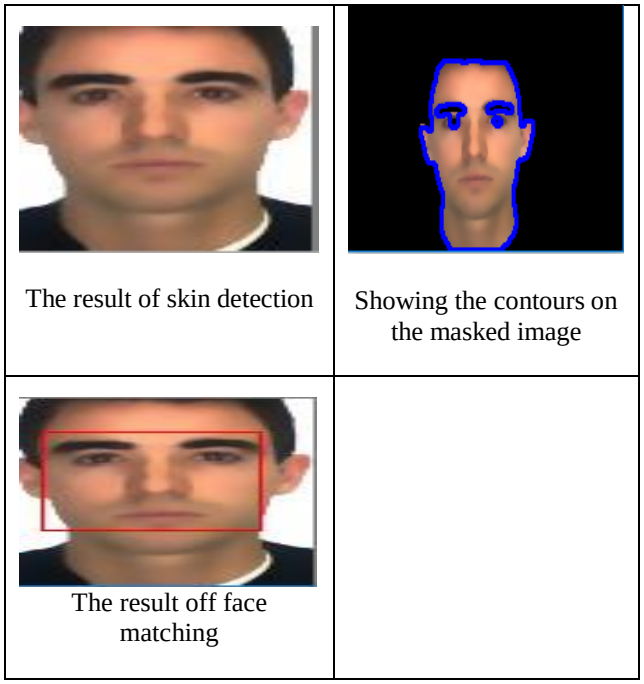


Fig. 6 Steps of human skin detection and face detection

B. The Result of Applying Human Skin Detection and Human Face Matching

It takes 71,074.532 second to finish this process, it can detect 476 human faces from 564 images Fig (8) shows some true results and Fig (7) shows wrong results.

Fig. 7 Wrong results of applying human face matching

C. The Result of Applying Human Skin Detection and Haarcascade Cassifier

when I entered the detected skin area to haarcascade It takes 281,945 second to detect 386 faces from the mentioned database that contains 564 images Fig (8) and table (1). And

it takes 334,810 second to detect 405 face from the mentioned database when I entered the cropped detected skin area from the original image (without filtering) to haarcascade Fig (7) table (1)

The table (2) shows the effect of applying skin detection on haarcascade. The time of executing exceeds but the resulted face is more accurate.

D. The Result of Applying Haarcascade

The process for one image takes 2,862 second and for detect all the faces in the database it takes 160,999 second It detects correctly 560 faces from 564 face image, the results as it is shown in table (1) and Fig (8)

E. Figures and Tables

Table 2. The effect of applying skin detection on haarcascade

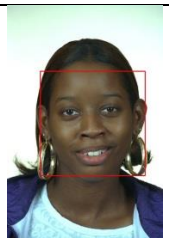
	Orginal	**Haarcascade**	**Haarcascade with skin detectio**
Time/ms		1670.060	1905.438
Resulted image			

Fig. 8 Comparing between the mentioned methods

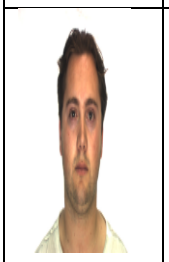
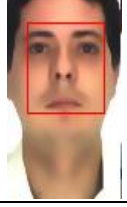
Orginal image	**After applying skin detection and human face matching**	**After applying haarcascade**	**After applying skin detection and haarcascade**
			
			
			

Fig. 7 The result of applying skin detection just for determine the skin area then applying haarcascade

Table 1. Comparing between the methods in time and accuracy for 564 images

	Time/second	**Number of detected faces**	**Number of un detected faces**
Haarcascade	160,999	560	4
Haarcascade and our skin detection model	281,945	386	178
Human face matching and our skin detection model	71,074.	476	88
skin detection model	38,453	557	7
Applying haarcascade and skin detection just for determine skin area	334,810	405	159

VII. CONCLUSION

In this article I supposed a model for face detection composed of human skin detection and human face matching and made comparing between this model and haarcascade in open CV and combined the two ways together and showed the results. The result of this experience shows that the best result according to accuracy comes from applying haarcascade only, but with applying human skin detection first the result was more accurately that the detected face contains just the benefit information of face from little bit over of brow and under a little bit of the mouth ,In applying just haarcascade the detected face can have unhelpful information of the face like hair, hat, ear etc. As future work I will combine between human skin detection ,face matching and haarcascade classifier for more confidence in results .

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