

Automatic Face Detection Using Color Based Segmentation

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Abstract- Because of the increasing instances of identity theft and terrorism incidences in past few years, biometrics based security system has been an area of quality research. Modern day biometrics is a cutting edge technology which enables the automated system to distinguish between a genuine person and an imposter. Automated face recognition is one of the areas of biometrics which is widely used because of the uniqueness of one human face to other human face. Automated face recognition has basically two parts one is face detection and other one is recognition of detected faces. To detect a face from an online surveillance system or an offline image, the main component that should be detected is the skin areas. This paper proposes a skin based segmentation algorithm for face detection in color images with detection of multiple faces and skin regions. Skin color has proven to be a useful and robust cue for face detection, localization and tracking.

Index Terms- Color space model, Face Detection, HSV Component, Morphology operation, Skin detection

I. INTRODUCTION

Different aspects of human physiology are used to authenticate a person's identity. The science of ascertaining the identity with respect to different characteristics trait of human being is called biometrics. The characteristics trait can be broadly classified in to two categories i.e. physiological and behavioral. Measurement of physical features for personal identification is an age old practice which dates back to the Egyptians era. But it was not until 19th century that the study of biometrics was extensively used for personal identification and security related issues. With the advancement in technology, biometric authentication has been widely used for access management, law enforcement, security system. A person can be identified on the basis of different physiological and behavioral traits like fingerprints, faces, iris, hand geometry, gait, ear pattern, voice recognition, keystroke pattern and thermal signature.

This paper presents an improved color based segmentation technique to segment the skin regions in a group picture and use of skin based segmentation in face detection. Skin based segmentation has several advantages over other face detection techniques like this method is almost invariant against the changes of size of face, orientation of face. The primary aim of skin based segmentation is to detect the pixels representing the skin regions and non skin regions. After detection of pixels

which represents the skin region, the next task is to classify the pixels which represent the faces and non faces.

II. FACE DETECTION SYSTEM

Face detection is an interdisciplinary field which integrates different techniques such as (i) image processing, (ii) pattern recognition, (iii) computer vision, (iv) computer graphics, (v) physiology, and (vi) evaluation approaches. In general, the computerized face recognition/face detection includes four steps. (i) Face image is acquired, enhanced and segmented. (ii) face boundary and facial features are detected. (iii) the extracted facial features are matched against the features stored in the database. (iv) the classification of the face image into one or more persons is achieved.

Figure 1 shows the basic block diagram of face recognition system. The first step of face recognition is to acquire an image either online or offline. After acquisition of image, preprocessing operation is carried out. The unique features of the image are extracted with the help of different image processing algorithm. After the features are extracted, it is matched with the feature database and the final result is obtained.

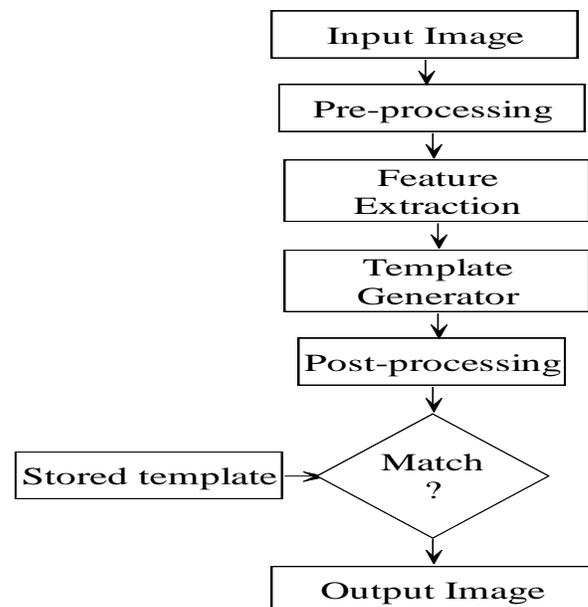


Figure 1: Block diagram of face detection/face recognition system

There are different approaches for face detection system. Mainly these are divided in to four parts i.e. (i) knowledge based (ii) feature based (iii) image or appearance based (iv) template based which is shown in figure 2.

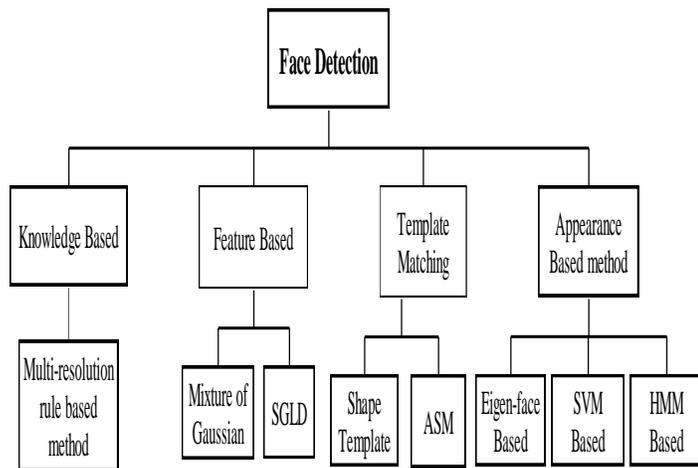


Figure 2: Types of face detection system

III. RELATED WORK

Sung and Poggio [1] proposed and successfully implemented Gaussian clusters to model the distribution of facial and non face patterns. Rowley et.al [2] used artificial neural network for face detection. Yang et.al [3] classified face detection methods in four categories. (i) Knowledge based (ii) feature invariant (iii) template matching (iv) appearance based. Lu et.al [5] used parallel neural network for face recognition. Zhao et.al [6] proposed Linear Discriminant Analysis (LDA) for face recognition.

Face Databases

There are different standard face databases available in internet. This section shows some of the standard face databases.

Yale Database [7]: It consists of a set of standard 165 black and white images of 15 different people (11 Images per Person) taken from Yale university standard database for use in facial algorithm. All the images are properly aligned and taken in same and good lighting and background conditions. Resolution of each image is taken as 320x243 pixels. Figure 3 shows some of the faces of Yale database.



Figure 3: Faces of Yale Database

Extended Yale Database [8]: It contains 16128 images of 28 human subjects under 9 poses and 64 illumination conditions.

FERET Database, USA [9]: The database contains 1564 sets of images for a total of 14,126 images that includes 1199 individuals. All the images are of size 290x240. This database was cropped automatically and segregated into sets of 250 female and 250 male faces. Figure 4 shows some of the images of the FERET database.



Figure 4: Faces of FERET database

IV. SKIN BASED SEGMENTATION AND FACE DETECTION

Color model is to specify the colors in some standard. Some of the color models used is RGB color model for color monitors, CMY and CMYK model for color printing.

HSV color model is the cylindrical representation of RGB color model. HSV stands for hue, saturation and value. In each cylinder, the angle around the central vertical axis corresponds to "hue" or it form the basic pure color of the image, the distance from the axis corresponds to "saturation" or when white color and black color is mixed with pure color it forms the two different form "tint" and "shade" respectively, and the distance along the axis corresponds to "lightness", "value" or "brightness" or it provides an achromatic notion of the intensity of the color or brightness of the color.

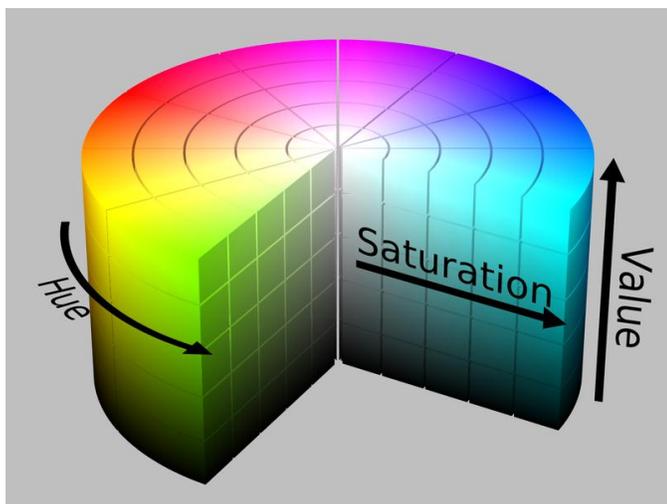


Figure 5: HSV color space

In situations where color description plays an integral role, the HSV color model is often preferred over the RGB model. The HSV model describes colors similarly to how the human eye tends to perceive color. RGB defines color in terms of a combination of primary colors, whereas, HSV describes color using more familiar comparisons such as color, vibrancy and brightness. The color camera, on the robot, uses the RGB model to determine color. Once the camera has read these values, they are converted to HSV values. The HSV values are then used in the code to determine the location of a specific object/color for which the robot is searching. The pixels are individually checked to determine if they match a predetermined color threshold.



(a)



(b)



(c)

Figure 6 (a) (b) (c): RGB image, HSV image and H component of image

HSV color space can be defined as

$$H = \cos^{-1} \left(\frac{\frac{1}{2}((R-G) + (R-B))}{\sqrt{(R-G)^2 + (R-B)(G-B)}} \right) \quad (1)$$

$$S = 1 - 3 \frac{\min(R, G, B)}{R + G + B} \quad (2)$$

$$V = \frac{1}{3}(R + G + B) \quad (3)$$

V. THE PROPOSED ALGORITHM

Color is a prominent feature of human faces. Using skin color as a primitive feature for detecting face regions has several advantages. In particular, processing color is much faster than processing other facial features. Furthermore, color information is invariant to face orientations. However, even under a fixed ambient lighting, people have different skin color appearance. In order to effectively exploit skin color for face detection, a feature space has to be found, in which human skin colors cluster tightly together and reside remotely to background colors.

Skin and Non- skin regions for different color spaces

The first step of face detection is to segment the color image into skin and non skin region. Different color space has different ranges of pixels which represents skin region and non skin region.

Skin region in B color space lies in the following range

$$0.79G - 67 < B < 0.78G + 42$$

Non skin region in B color space lies in the following range

$$0.836G - 14 < B < 0.836G + 44$$

Non skin region in H color space lies in the following range

$$19 < H < 240$$

Skin region in Cb color space lies in the following range

$$102 < Cb < 128$$

From the above ranges the skin and non skin segmentation is performed. So now the output image only shows the skin regions and non skin regions are blackened. After segmentation,

morphological operators are implemented with a structuring element. After application of morphological operators, the standard deviation of the area is calculated and rectangles are drawn in the skin regions. If any unwanted rectangles are created, it is then removed. The complete flow chart of face detection is shown in figure 7.

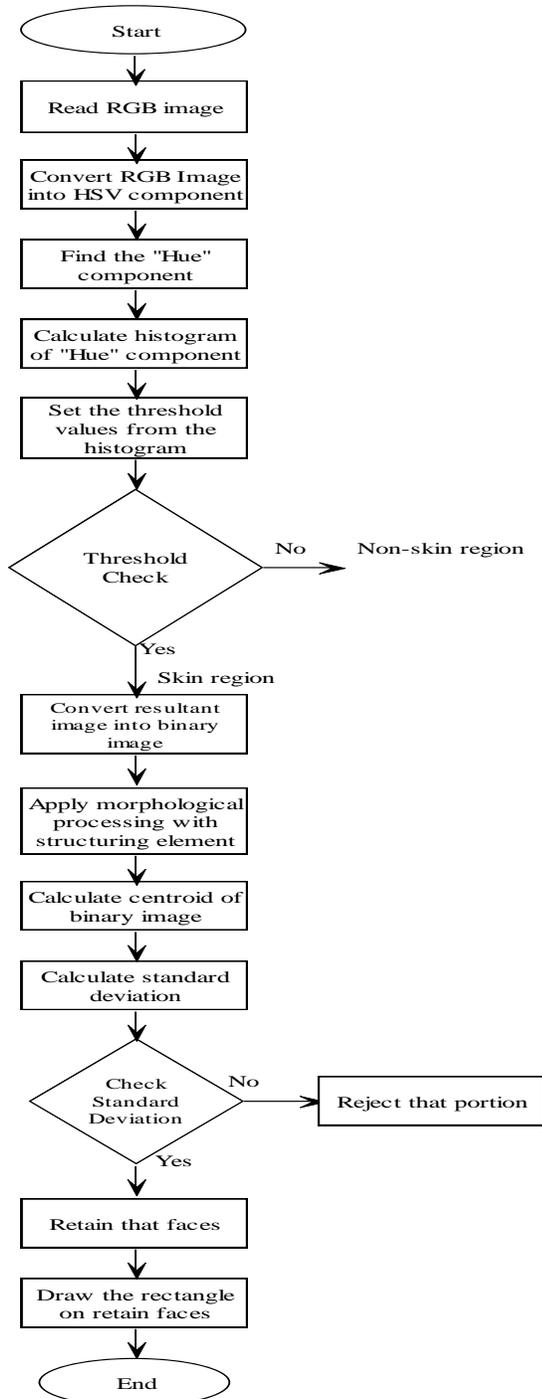


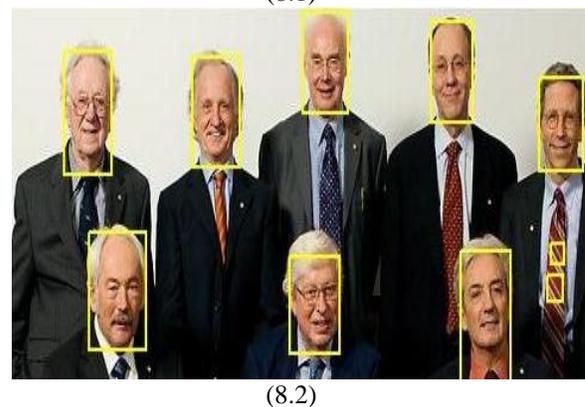
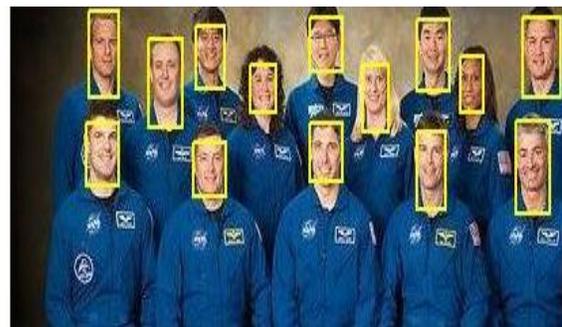
Figure 7: Flow chart of Face Detection

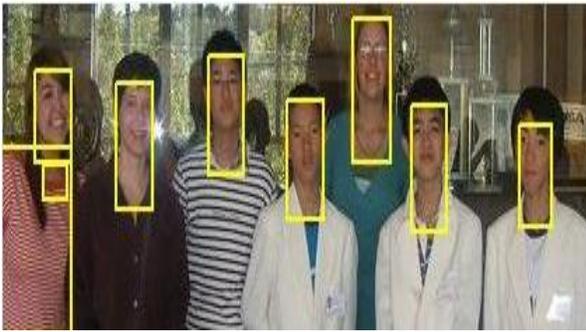
VI. CONCLUSION

The automatic face detection algorithm is applied on a wide variety of images taken under different lighting conditions and with different backgrounds. The images also have areas containing skin from other parts of the body such as hands, necks and areas with color very similar to that of skin. These areas get classified as skin.

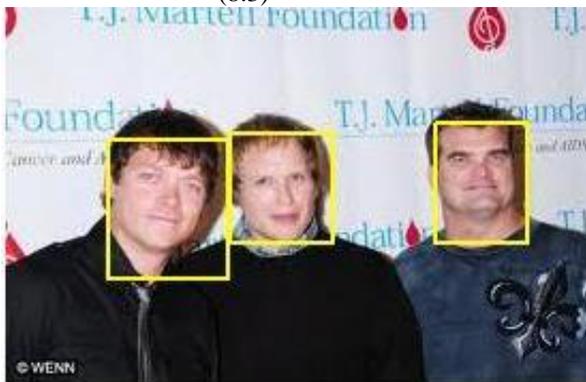
For a 380×270 size of image, the total time taken by the algorithm was 2.30 seconds. The histogram is formed using a training set of over 4,90,000 pixels drawn from various sources on the internet. The training set contained skin pixels of people belonging to different races.

The various stages in the algorithm are explained using the boy image (Fig. 10). First of all the algorithm classifies skin pixels and non-skin pixels using H components of the HSV color space. Figure 10(c) classifies between the skin pixels and non skin pixels. Fig. 10(d) shows the image after applying morphological operators. The remaining part of the algorithm uses the skin detected image and the hue image, finds the skin regions and checks the percentage of skin in that region. For regions classified as faces, it uses the height and width of the region to draw a rectangular box with the region's centroid as its centre. The final result of the algorithm is shown in Fig. 10(e). It is to be noted that the face has been correctly located and almost at the right scale.





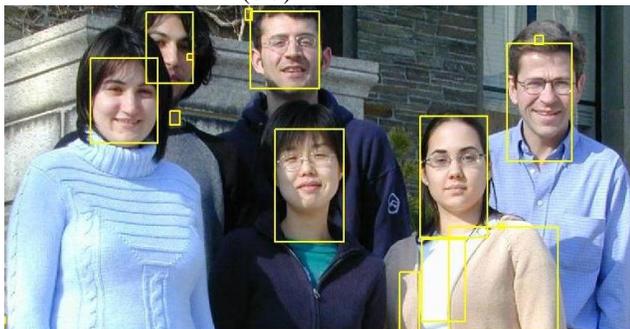
(8.3)



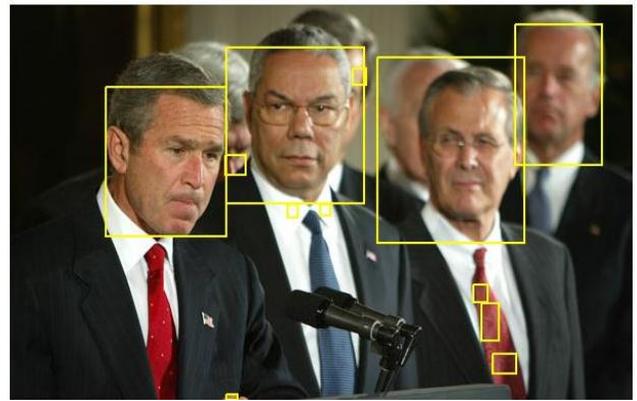
(8.4)



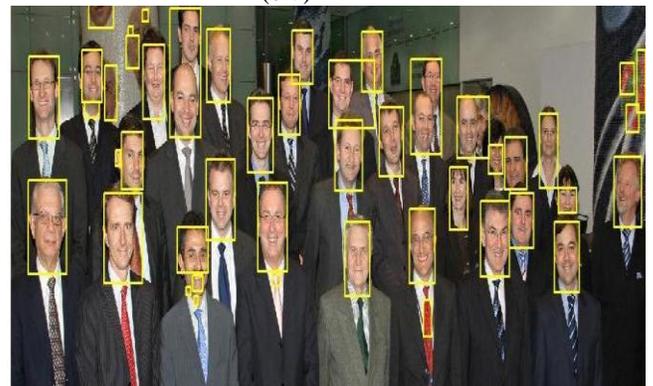
(8.5)



(8.6)



(8.7)



(8.8)

Figure 8: Result of face detection algorithm in different image



(a)

Image with HSV threshold

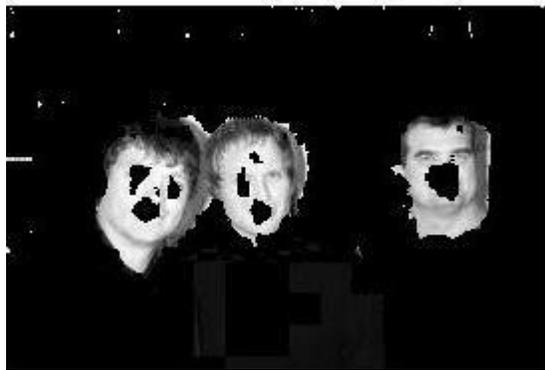


(b)



(c)

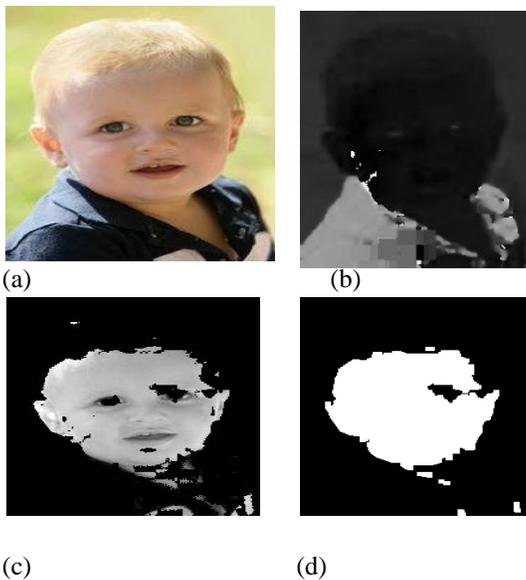
Image with HSV threshold



(d)

Figure 9 (a) (b) (c) (d): RGB image, Skin detected image

Figure 9(a) shows the RGB image and figure 9(b) shows the skin region using color based segmentation. Figure 9(c) shows the RGB image and figure 9 (d) shows the skin region using color based segmentation.

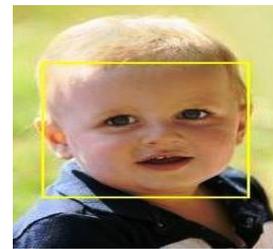


(a)

(b)

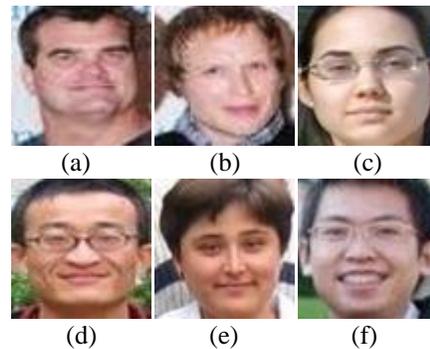
(c)

(d)



(e)

Figure 10 (a) (b) (c) (d) (e): A test image with boy sitting, H Component image, Skin detected image, image after morphology, result of the proposed algorithm



(a)

(b)

(c)

(d)

(e)

(f)

Figure 11 (a) (b) (c) (d) (e) (f): Different training faces for skin color of same size

To evaluate the performance of the proposed algorithm, following parameters are taken in to consideration. The parameters under consideration are number of faces, detected faces, number of repeat faces, false positive, and time to execute the algorithm and accuracy of face detection.

Table 1: Performance evaluation of proposed algorithm

Figure 8.1	Number of faces	14
	Detected faces	14
	Number of repeat faces	0
	False positive (Wrong detections)	0
	Time to execute	1.684 sec.
	Accuracy	100%
Figure 8.2	Number of faces	8
	Detected faces	8
	Number of repeat faces	0
	False positive (Wrong detections)	2
	Time to execute	1.760 sec.
	Accuracy	75%
	Number of faces	7
	Detected faces	7

Example 8.3	Number of repeat faces	0
	False positive (Wrong detections)	2
	Time to execute	1.559 sec.
	Accuracy	71.5%
Example 8.4	Number of faces	3
	Detected faces	3
	Number of repeat faces	0
	False positive (Wrong detections)	0
	Time to execute	1.560 sec.
	Accuracy	100%
Example 8.5	Number of faces	10
	Detected faces	9
	Number of repeat faces	0
	False positive (Wrong detections)	3
	Time to execute	1.671 sec.
	Accuracy	70%
Example 8.6	Number of faces	6
	Detected faces	6
	Number of repeat faces	0
	False positive (Wrong detections)	5
	Time to execute	2.526 sec.
	Accuracy	60%
Example 8.7	Number of faces	4
	Detected faces	4
	Number of repeat faces	0
	False positive (Wrong detections)	7
	Time to execute	1.868 sec.
	Accuracy	42%
Example 8.8	Number of faces	34
	Detected faces	32
	Number of repeat faces	0
	False positive (Wrong detections)	10
	Time to execute	2.518

		sec.
	Accuracy	70.5%

Table 1 shows the performance evaluation of the proposed algorithm and the overall accuracy of the algorithm is found out to be 73.68%

VII. CONCLUSION

In this research paper, the authors propose color segmentation based automatic face detection algorithm. Though there are some cases of false positives, the overall performance of the proposed algorithm is quite satisfactory. The training images on which the algorithm is tested are natural images taken under uncontrolled conditions. The efficiency of the face detection was found to be 73.68%.

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