An Efficient Framework for Detecting Face Region Based on Skin Color Modeling and SVM Classifier

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***Abstract*—Detection of face from a face image is very crucial for fully automated face recognition system for intelligent vision system for the purpose of security and human robot interaction. In this regard, a framework has been proposed in this paper for detection of face region from face images. For detection of face region, color and shape characteristics of face region is utilized. Based on these ideas initially, HSV and YCbCr color models are used to eliminate the illumination sensitiveness for segmentation. In the second step, statistical threshold value is used for color segmentation. Next, labeling and filtering is used to extract the shape. Finally, by using SFTA (Segmentation–based Fractal Texture Analysis) method, texture feature of face region is extracted and fed to SVM to verify the face region. Various face images are used with variety of conditions to test the proposed framework and results are presented to prove the efficiency.**

Keywords— Face Detection, Skin Color, Morphological Analysis, SFTA Method, SVM Classification.

I. INTRODUCTION

During the past few years, people start to pay more and more attention on the advanced, efficient and accurate intelligent vision system. In the field of computer vision or digital image processing, detection of specific object in an image is one of the most difficult topics. Detection of face in a face image is such a topic. Face detection is widely used in human robot interaction, security purposes, video surveillance, biometrics, video coding etc. The face detection task is quite challenging due to presence of structural components like eyeglass, different facial expression, different skin color, occlusions and imaging conditions.

Various face detection method have been developed. This section provides a descriptive summary of some methods that have been implemented and tested for face detection. For example, In [1], proposed a feature based approach uses invariant feature of face such as skin color. Here they use a combination of segmentation in RGB and HSV color spaces, followed by segmentation in YCbCr using elliptical model. There exist some other invariant features of face like eye, eyebrows, nose etc. In [2], skin color based face detection method is introduced. Here RGB color model is used and modified local binary pattern (mLBP) histogram matching and embedded Hidden Markov Model (eHMM) is used for classification. In [3], proposed parallel structure for skin color detection that is based on GMM (Gaussian Mixture Model) and Adaboost training is applied for classification. In [4], proposed a method based on fusion of RGB, YCbCr and CIEL*a*b color model and Hill Climbing segmentation with K-Means clustering.

II. PROPOSED METHOD

Face region of an image is different from other contained region on the basis of color and shape. So color analysis and shape analysis are very important issues for segmentation of the face region from any other region of the image. In this paper we have been emphasized on both color and shape of image to extract face region. The proposed method for detection and verification of face region which consist of four distinct parts is shown in Figure 1.

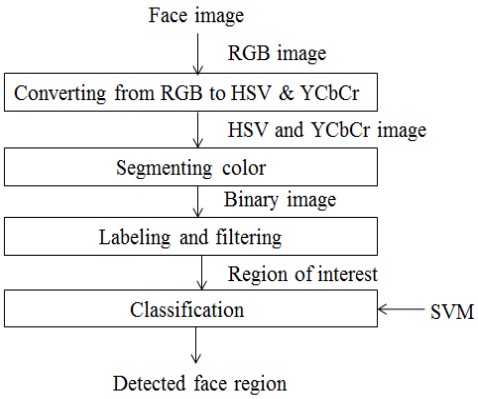


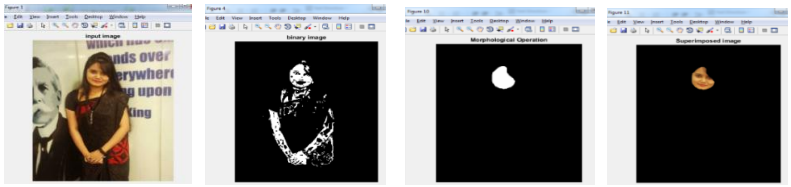
Figure 1: Proposed face detection method

A. Image Segmentation

After the conversion from RGB to HSV and YCbCr, mean and standard deviation of hue, Cb and Cr is calculated from the face region of datasets images. Then a threshold is set using equation (1) and (2). Those regions satisfy the thresholds are considered as skin region and others are non-skin region.

$$T_{low} = \mu^{H+Cb+Cr} - \delta^{H+Cb+Cr} \quad (1)$$
$$T_{high} = \mu^{H+Cb+Cr} + \delta^{H+Cb+Cr} \quad (2)$$

Color segmentation result is shown in Figure 2.



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

Figure 2: Step for proposed face detection: (a) input RGB image, (b) color segmentation result, (c) extracted candidate region after labeling and filtering, (d) superimposed image

B. Labeling and Filtering

The next step of the proposed framework is labeling the connected components. Eight connected components are used for labeling. After this operation, in order to correctly differentiate the face regions from other face-like regions, geometrical features such as the area, euler number, eccentricity and aspect ratio of each region are to be extracted. Region that satisfies the properties mentioned in Table 1 are considered as face region. Figure 2 illustrates the steps of face region extraction.

Table 1: Filtering properties

Filtering Parameter	**Candidate Region**
Area	Region > average skin region
Euler number	1-hole
Eccentricity	Less than 0.89905
Aspect ratio	[2.2,1]

After that, morphological operation is used to refine the region extracted from the filtering step. By performing an erosion after the dilation *i.e* closing, we can reduce distortion of all regions of pixels and removes small holes in the foreground.

C. Classification

SVM (Support Vector machine) is used for classification. Texture features are extracted by using SFTA method. The reason of using SFTA method is that it is faster than Gabor feature and GLCM and also deals with computational cost.

1) Decomposition Method: STTA is consists in decomposing the input grayscale image into a set of binary images. Two-Threshold Binary Decomposition (TTBD) method is used for decomposition. In TTBD, Multilevel Otsu method [6] is applied to each image region until the desired number of thresholds (here 4) is obtained. For 4 thresholds, there are 8 binary images. 4 binary images are obtained by using 4 thresholds. Another 4 are from pairs of thresholds.

Figure 3: Decomposition of face region by using TTBD

2) Extraction Method: After applying TTBD, the SFTA feature vector is constructed. For 8 binary images, mean gray level and area is calculated. Then contour of the image is detected from the resulting 8 binary image. The equation (3) represents the border image.

$$\Delta(x,y) = \begin{cases} 1, if\ \exists(x',y') \in N_8\ [(x,y)] : I_b(x',y') = 0 \cap I_b(x,y) = 1 \\ 0, \quad otherwise \end{cases} \quad (3)$$

Figure 4: Contour detection for each binary image

In the research work, fractal dimension is calculated by using box counting algorithm. For 8 binary images, 3 features (area, mean gray level, fractal dimension) are calculated. So, there are 24 features. After extracting features of face and non-face database, SVM is used for training. Then SVM is used for testing purpose either the test image is face or non-face. There are two classes to be detected. They are face and non-face. Face images are defined as 1 and non-face images are defined as 2.

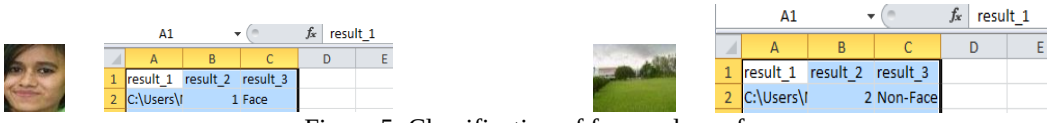


Figure 5: Classification of face and non-face

III. EXPERIMENTAL RESULTS

The input dataset has been collected from different people with various background, camera face pose and illumination conditions. Matlab 2015 is used for implementing our method. Some examples by implementing the proposed method are shown below.

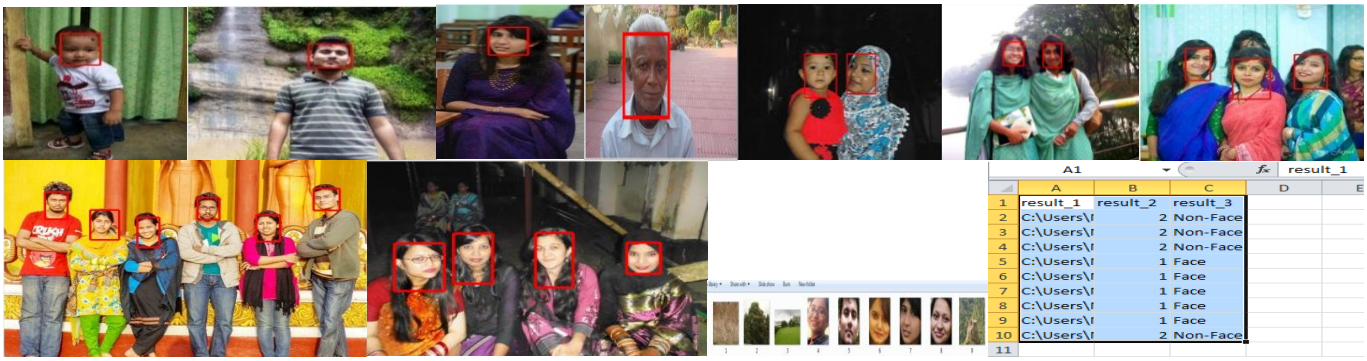


Figure 6: Simulation result of face detection

The proposed system correctly detects 179 face regions out of 186 face region. The precision rate is measured from the equation (4).

$$Precision\ Rate = \frac{Total\ no.\ of\ relevant\ images\ Detected}{Total\ no.\ of\ Images\ Detected} \times 100 \quad (4)$$

Table 2: Detected result of proposed face detection system

Image number	Face number	Hits	Misses	Precision rate
100	186	179	7	96.23%

Table 3: Detected result of proposed classification system

Face or non-face	Number of face or non-face	Hits	Misses	Precision Rate
Face	186	164	22	88.17%
Non-face	20	18	2	90%

Table 4: Comparison with respect to detection accuracy

Method	Precision Rate	False Detection Rate	Missed Detection Rate
Proposed Method	96.23%	0.03	0.01
Existing Method [3]	95%	0.03	0.02

IV. CONCLUSION

This work proposed an improved face detection and classification method. Segmentation of face from given face image using HSV and YCbCr color space with the statistical thresholding allows us to avoid the illumination sensitiveness and choose all face-like color regions. Geometrical shape analysis is used to filter the false alarm from the segmented image in our work. We have used SVM classifier by extracting texture feature using SFTA method. Our experimental result represent that this system is robust because it detects faces with different poses, illumination and skin color which were the big challenges to detect faces. It shows 96.23% of accuracy to detect those types of face from face images. There are still some rooms to introduce a faster detection method which works successfully for multiple faces with skin color background.

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