Face Detection in Skin-Toned Images Using Edge Detection and Feature Extraction Using R and G Channels through Wavelet Approximation

H. C. VijayLakshmi and S. Patilkulkarni

***Abstract*—Face detection and localization in complex skin toned background is a highly challenging problem. In this paper, use of combination of color spaces and edge detection in red and green channels is proposed for segmenting out the skin-tone regions. Wavelet approximations are used for the extraction of prominent features of face. Experimental results are shown to yield the improved false acceptance rates (FAR) over the algorithms that either use grey scale image for segmentation and the algorithms that do not use any edge detection.**

***Index Terms*—Face detection, localization, edge, wavelet, r and g channel.**

I. Introduction

Face detection and localization is the task of checking whether the given input image contains any human face, and if so, returning the location of the human face in the image. Face detection is difficult mainly due to a large component of non-rigidity and textural differences among faces. The great challenge for the face detection problem is the large number of factors that govern the problem space [1], [2]. The long list of these factors include the pose, orientation, facial expressions, facial sizes found in the image, luminance conditions, occlusion, structural components, gender, ethnicity of the subject, the scene and complexity of image's background. The scene in which the face is placed ranges from a simple uniform background to highly complex backgrounds. In the latter case it is obviously more difficult to detect a face. Faces appear totally different under different lighting conditions. A thorough survey of face detection research work is available in [1],[2]. In terms of applications, face detection and good localization is an important preprocessing step in online face recognition.

II. Challenges

For the problem of face detection involving colour images having complex scenes, the use of skin pixel properties for segmentation reduces the search space to a greater extent [3]. Most of the detection algorithms have considered images having non-skin tone background, people wearing non-skin tone dresses etc. If images contain skin tone background, then the entire region is identified as skin region "Fig. 1a" and "Fig. 1b". In order to locate faces present in the segmented regions calls for additional face localization process. While segmenting faces of people wearing skin-tone dresses using skin pixel segmentation preprocessing technique, the entire image of the person with skin-tone dress is detected as the face region and hence requires a further face localization step. Besides, overlapping face regions also add additional constraints while segmenting the faces. Due to variation in illumination, skin regions may not be identified properly as skin during skin segmentation. Locating faces in these circumstances is more complex as opposed to localizing faces with uniform, non skin-tone background.

Inspite of using combination of different colour spaces during segmentation, it is tedious to demarcate region boundaries between skin and pseudo skin regions and also eliminate these regions from searching process. The use of colour space alone sometimes fails to segment the boundary regions of the image. In order to overcome this problem combination of colour spaces for efficient skin segmentation followed by Canny and Prewitt edge detection to demarcate the region boundary is used for input image segmentation [4].

Fig. 1 a. Input image with skin tone background

Fig. 1 b. Segmented image using HSI and YCbCr combination.

III. Segmentation and Feature Extraction

Segmentation and feature extraction are the two important pre-processing steps that play a vital role in face detection

Manuscript received June 25, 2012; revised July 30, 2012.

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DOI: 10.7763/IJCTE.2013.V5.646

and localisation. Segmentation is a process that partitions an image into regions of uniform intensity. In the problem of face detection, skin segmentation helps in identifying the probable regions containing the faces as all skin segmented regions are not face regions and segmentation aids in reducing the search space. Segmentation of the input image based on skin chromaticity is the first step in detecting and localizing faces in color images. Segmentation of an image based on human skin chromaticity using different colour spaces results in identifying even pseudo skin like regions as skin regions. Hence there is a need for further eliminating these pseudo skin regions. Researchers are working on adaptive skin colour segmentation used for detection [5]. The segmentation using combination of colour spaces combined with Canny and Prewitt edge detection for obtaining the region boundaries segment better when compared with the combination of YCbCr colour space and Robert Cross edge [6],[7].

Fig. 2 a. Input Face image

Fig. 2b. Edges of raw input image

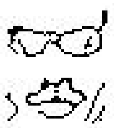

Fig. 2 c. Edges of
Ist level approximation image

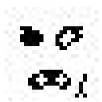

Fig. 2 d. Edges of
2nd level approximation image

Face detection is a classification problem; it calls for classifying the selected segmented region as face or non-face. For efficient classification a robust feature set is very much essential. This calls for an efficient feature extraction method. Two level wavelet decomposition of face images followed by edge extraction for approximation image, results in prominent facial edges which is evident from the images of the facial edges extracted for raw face image “Fig. 2a” and “Fig. 2b”. Edges extracted for the approximation images after first and second level wavelet decomposition “Fig. 2c” and “Fig. 2d” respectively. The edges extracted for the second level approximation eliminates all unwanted noisy edges present in the image and also reduces the size of the edge feature set to $1/16^{th}$ of the original size due to two level wavelet decomposition of the input image. Colour contains extra dimensions which can help differentiate between two regions which may contain similar gray information but appear very different in colour space. In order to efficiently make use of the colour information, the edge information associated with the image in R and G channels are extracted after the input image is split in to R G B channels. As the R and G channel account for the most skin chromaticity in the facial region, edges extraction of only these channels are considered. Since the contribution due to B channel is noisy, it can be excluded for the purpose of edge detection and feature extraction to minimize the computation and dimension.

IV. Proposed Algorithm

In this paper, a combination of colour spaces (HSI and YCbCr) to identify the skin regions combined with Canny and Prewitt edge detection algorithm for better boundary separation is used. For a detailed survey of colour spaces refer [8]. After segmentation Morphological operations are carried out to erase smaller regions than certain size to eliminate redundant regions from the search process to improve the speed. As all the skin segmented regions are not face regions, each segmented region has to be checked whether the segmented region contains face or not the following algorithm is proposed. The proposed algorithm precisely locates where exactly the actual face lies in each skin segmented region as the entire segmented region does not represent the face. The R component generally represent the skin colour better as human skin colour is dominated by blood is rich in Red colour component. The proposed algorithm considers the edge extraction of the input image in R and G channels separately. This algorithm is implemented in two phases namely *Feature extraction* and *Testing phase*.

A. Feature Extraction Phase

For feature extraction, images with only dominant facial features eyes, nose and mouth with variations in pose and expressions which fit in to a window of size 88 X 80 are considered. The face images with only prominent facial features with slight variation in pose and expression considered for feature extraction are separated in to R G B channel images.

Step 1: Wavelet decompose each channel face image up to second level, retain only approximation image and discard the horizontal, vertical and diagonal details .

Step 2: Apply Canny and Sobel edge detection algorithm separately on the second level approximation images of every training image considered for feature extraction. This procedure is carried out on the second level approximation images of the R G channels separately.

Step 3: For both R and G channel, combine the Canny and Sobel edges of the second level approximation images obtained in Step-2, into a single edge image using pixel by pixel image multiplication. On this edge image perform morphological operations such as erosion and dilation to extract the prominent facial edge features. Thus features are extracted in R and G colour channels.

Step 4: The extracted edge feature is stacked into an edge data matrix as column vectors. PCA is applied for further dimensionality reduction and Eigen edges are obtained.

B. Testing Phase

Step 1: Segment the input colour image using the algorithm proposed by the authors [4]. Select the segmented regions satisfying constraints like aspect ratio, area greater than 800 pixels, having holes due to the presence of eyes and mouth as the probable face regions and omit other segmented regions.

Step 2: If the size of the selected segmented region is larger than the size of the face with prominent facial features, use a sliding window technique in order to locate the face in the segmented region. We have considered a window of size 88 X 80. Place the fixed size window on the selected segmented regions. If the length of the segmented region is larger than the window size slide the window horizontally, slide the window vertically if the width of the segmented region is larger, slide both horizontally and vertically if both the length and width are larger.

Step 3: As the window slides across the selected segmented regions, illumination compensate the window contents and separate the window contents into R G B channel images and then wavelet decompose R and G channel image up to second level. Retain only approximation image and discard the details.

Step 4: Apply Canny and Sobel edge detection algorithm separately on the second level approximation images of the two level wavelet decomposed window approximation image. Repeat this on R and G channel approximation images separately.

Step 5: Combine the Canny and Sobel edges of the approximation window image into a single image using pixel by pixel multiplication. On this perform morphological operations such as erosion and dilation to extract the prominent edge features of the wavelet decomposed window content. This procedure is also repeated on R and G channels separately.

Step 6: The edge features obtained in step-5 is projected onto the Eigen-edges obtained in the Feature extraction phase.

Step 7: Compute the row sum and column sum of each projected and reconstructed window approximation edges of R and G channels. Classification is performed by calculating distance between row sum and column sum of each projected and reconstructed window approximation edges with the corresponding row sum and column sum original window wavelet approximation edges using 'City block' similarity measures.

V. RESULTS

In the experiments, face images of size 88 X 80 were used for extracting second level approximation feature set edges in R and G channels. We have not considered B channel image for feature extraction and classification as it was found to be inconsistent and noisy. When experiment was tried with face image size less than 80 X 80 pixels for extracting feature edges, the false detection rate was higher. Group images containing faces with variation in pose, having moustache, structural components and slight variation in expressions were used for testing. In [9] approximation coefficients were used without extracting edges. The number of false acceptances was higher in skin-tone regions and there were false rejections in skin-tone images with complex background. The number false acceptances and false rejections were reduced considerably when the edge strength of the second level approximation was used as the feature set.

In the proposed method, there are few false rejections and the number of false acceptance is minimized as the window contents are checked for the presence of face in two different channels (R and G) for matching edge strength. False acceptances are noticed only when approximation images produce similar edges at identical positions. When the same algorithm was tried after converting the input image into gray scale followed by histogram equalization and edge extraction the number of false positives are found to be more [10]. The result is tabulated in Table 1. In [3], due to the presence of structural components, varying pose and bright sunlight, the number of false rejections was higher when similarity measure was computed using city block distance. False rejections were reduced, when Bhattacharya distance was used for computing the distance, however Bhattacharya distance is computationally expensive. The proposed algorithm was tried on a number of group images with variations in illumination, pose and structural components. Cumulative false rejection and acceptance cases are tabulated in Table I for various sliding window contents. False rejections were noticed for face images with wide variations in facial expressions as evidenced by "Fig. 3f" of "Fig. 3c", while the face in the image "Fig. 3h" of "Fig. 3d" was properly localized as there was less variation in expression. Use of only wavelet approximation coefficients without edge extraction sometimes reported false acceptance even for window contents of "Fig. 3 g".

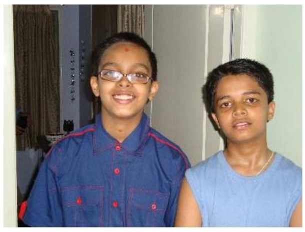

Fig. 3 a. Input Image

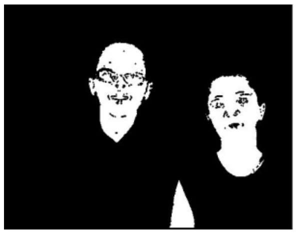

Fig. 3 b. After Segmentation

Fig. 3 c.

Fig. 3 d. Selected Segmented Region for face localisation

Fig. 3 e.

Fig. 3 f. Sliding window contents of Figure 3c

Fig. 3 g.

Fig. 3 h. Sliding window contents of Fig. 3d

VI. CONCLUSION

In this paper an efficient algorithm that uses a combination of wavelet and edge detecting techniques to detect and localize faces in colour images with skin-tone regions was proposed and experiment was conducted on several colour images. Results showed a considerable improvement in false acceptance rates compared to the algorithm that uses the gray scale edge detection and the algorithm without using edge detection operations. False rejection rates are also improved as compared to algorithms without any edge detection. For robust classification the use of Neural Network with back prorogation algorithm is the future work under consideration.

TABLE I: FALSE POSITIVES OF HISTOGRAM AND EDGE EXTRACTION

Method	Distance Measure	Windows Tested	False Positive	False Rejection
Proposed Method	Cityblock	2800	18	8
Approximation image with Gray Scale Edges	Cityblock	1700	30	3
Approximation Image without Edge Extracion	Bhattacharya Distance	1500	128	20
	Cityblock	1500	44	38

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