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GAUSSIAN SKIN COLOR MODEL BASED FACE DETECTION FOR HUMAN COMPUTER INTERACTION

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Abstract

Human Computer Interaction (HCL) demands the study, design, drafting evaluation and needs of the interaction between people and computers. HCI must understand the people in a group to decide the end effect respective to their nature and characteristics. To know the details from the group image, face is a major cue for analysis. Hence, a foremost step is to identify the faces of human in a picture. Detection of face strongly depends on visual properties such as color; complex background and face pose variation. To sort out these issues, a face detection algorithm using color and appearance based edge distribution is proposed which shows good tolerance to illumination, scale and complex back ground. Techniques for detection of faces in mug shots or group photo under wild conditions are proposed in this paper. The proposed method uses a Gaussian skin color model using HSV color space for skin region detection which helps for face localization. Detected skin regions are verified as whether face and non-face using edge features. Edge based feature vectors are adopted for reducing the false positive rates and false negative rates.

Keywords: Human Computer Interaction (HCI), Feature Vectors, Face detection.

1. INTRODUCTION

For example, in a museum, investigation of the viewer in terms of gender, age group and emotions can be accomplished by HCI. Based on these, the automated system will react. For gender discrimination and age group estimation, face detection is a preprocessing step. Face detection is a well-known pattern recognition problem. It is the foremost step for various applications like tracking of face, recognition of face, facial expression recognition, and gender, age estimation. Although many approaches have been proposed over the last few years it still stays as an extremely difficult problem because of distinct face appearance changes, like pose (frontal, non-frontal), occlusion, image orientation, lighting conditions and facial expressions as shown in Fig.1

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Fig. 1 Face images with variations in pose, expression, lighting condition, occlusion etc.

2. SIMILAR WORKS

Detection of face is the foremost step for various application related to face like Face localization, tracking of face, face expression and face recognition. Detection of face is an extremely challenging problem because the faces are non- rigid objects. Face appearance may vary between two photos of the same person depending on the emotional stage, lighting conditions and pose. So, many works have been created in last years. Hence, the goal is to identify the faces in cluttered backgrounds very quickly. This situation can be found in many applications as surveillance of public places, common Access Control conditions and etc. Thus far learning-based approaches have been the most effective and have therefore attracted a lot of attention the last years. The authors in [1] introduced an impressive face detection techniques and methods which are capable of detecting frontal-view faces in reality. Ada Boost learning algorithm is presented by [2] and the response of simple features used in [1]. Hundreds of features can be quickly calculated by introducing fresh picture called Integral Image. The Ada Boost algorithm successively builds a strong classifier into linear combination of “weak” classifier.

Detection of face algorithms are on the basis of face pattern which have been presented to manage a variety of situations, like rotation of face and complicated background. Human face detection from color photos under difficult situations, including arbitrary image background, was proposed by the authors in [3]. Decomposition of wavelet is done to every regions of face in the image once the face-like regions have been proposed to identify feasible component of face and to resolve whether there is an eye in the image. Human faces are recognized as eye region or other components of faces distributed over according to a specified model of face.

4] Proposed a color image face detection system with variable illumination states and a background that is complicated. The program on the basis of a nonlinear transition to the YCbCr color space and a unique lighting adjustment mechanism. They started by detecting regions where is skin to create face candidates, which were later confirmed using eye, mouth, and border maps. In [5,] using a combination of RGB, YCbCr, and HSI color spaces new skin color based detection of face algorithm is presented. To segment skin regions, MBD face detection approaches generally use color space transformations and are on the basis of single or multiple ranges of threshold and morphological operations, as shown above. The benefit of clearly specifying the boundaries of a skin cluster is that it allows for very efficient categorization because of simple skin detection techniques. However, in order to improve recognition accuracy using this method, empirically determined threshold values and proper decision rules are required. In [6] proposed an algorithm on modeling the color of the skin using facial detection and distance of the altered Hausdorff. The pixel probability of skin color is calculated based on learned skin's covariance matrix and mean value. Predetermined threshold is used to decide the skin color pixels. The morphological operations are performed sequentially inorder to eliminate the noise and to calculate the possible split up face candidates. Using the modified Hausdorff distance, a template based classifier is ultimately used to categorize whether the candidate's skin color is a face or a non-face one. Sobel edges template is used for the computation.

In [7] depth map is used for fast face detection. The human face was first detected by Haar wavelets and later its location is rectified by structured light analysis. In [8] the texture and stereo disparity details are inspired by biologically combined depiction which is employed as facial detection multi- view. The achieved result is done by performance of the improved detection and computational reduced complexity. A technique which employs many strong features with boosting for detection of face in the wild is proposed in [9].With the features of global normalization the HOG and the LUV color space combinations are presented using the face detection techniques. Totally 22 different templates are used for effective face detection. In [10] a multi task deep CNN is proposed to get the low level features for multi view detection of faces. Two techniques such as ReLU and dropout to prevent over fitting and provided better results in the FDDB dataset.

3. METHODOLOGY

Face detection is a technique to find any face present in a picture also, in that case, returning the corresponding picture's location along with the extent of each face. While it may appear to be a simple task for humans, it is a difficult one for computers, and it has been one of the most researched academic issues in recent decades. Only when computers have a good understanding of facial expressions will they be able to properly comprehend people's thoughts and intentions.

In the literature, a number of strategies for face detection have been presented, and they can be parted into four sections: template matching methods. Invariant feature methods, knowledge-based methods, and appearance-based methods. Among the four categories, invariant feature-based method is used in which skin color is considered as a detection cue. In uncontrolled circumstances, the use of color information can help with face localization. In uncontrolled circumstances, the use of color information can help with face localization. Color provides for quick processing and is very tolerant to face design geometric variances. Color provides for quick processing and is very tolerant to face design geometric variances.

In the presented method, the target is to find whether there are faces in the picture with the help of skin color model on the basis of Hue and Saturation points , skin likely-hood, operations of morphological techniques ,Segmentation and face verification by PPED feature vector and aspect ratio. The outline of the proposed system of face detection is represented in Fig. 2.

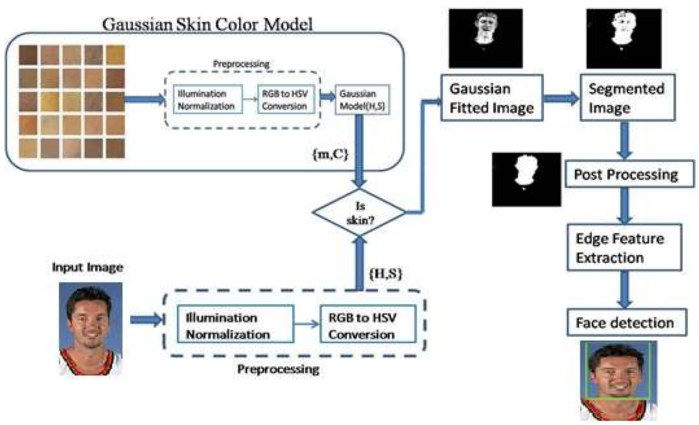

Fig.2 Overview of the proposed system

i. Illumination Normalization

The RGB input image is normalized using the following method in each channel.

ii. Gaussian Skin Color Model

Human regions where skin is present are to be fragmented from the non-skin region on the basis of color to locate the face region. This requires extremely robust models based on skin-color which is suitable for dissimilar lighting conditions and their skin.3354 Skin patches of 25x25 size are collected from the SFA database in order to construct Gaussian skin model. Some of the skin patches are shown in Fig. 3. Before skin model construction, the RGB input skin patches are converted into HSV (Hue-Saturation-Value) color space.

Fig. 3 Samples of skin patches

1. RGB to HSV conversion

The selection of color space for skin color modeling is an important on task since, in primary color space, the thin color regions were not distinguished properly in all the three channels and also the lighting conditions of the RGB components the face detection may fail if the lighting condition changes. To extract chromatic colors of skin region, transformation of color representation from the RGB space to the HSV space is applied, where H represents Hue differentiating pure colors such as red, green, purple and yellow. S represents Saturation defining, how far color is from a gray of equal intensity, and V represents Value referring the lightness or intensity. In HSV space, the H (Hue) and S (Saturation) channel shows significant discrimination of skin color regions.

The literature indicates that the performance of HSV-based skin models outperform RGB-based skin models in skin pixel classification [11].

Gaussian skin model

Skin detection reduces search space area for face detection and in turn reduces computational time and this has motivated to use skin detection in face detection. However, finding the pixel range of a skin is a difficult task as skin range varies with respect to race and ethnicity. Several skin color models are proposed as RGB, HSV. Lab, YCbCr etc. Among these color models, the HSV color model much resembles color sensing properties of human vision and also device independent. Separation between chrominance and luminance components can be achieved with HSV color space which makes easier to search specified color and also invariant to illumination effect. Therefore, the HSV color space is chosen for constructing skin color model. The human skin color distribution is clustered in a small region in the HSV space. The skin-color distribution is modeled using 2D Gaussian Model of (H. S) components. It is well-known that H represents angle and S represents distance.

A skin color distribution can be represented by a 2D Gaussian model N (m, C), where:

With this Gaussian fitted skin color model, an image's likelihood value of any pixel can be obtained. The pixel transformation from RGB to HSV color space which has a pair value of (H, S), the likelihood of skin for certain pixel can be computed as follows.
This model can transform into gray scale image from a color image so the gray value at each pixels shows the likelihood of the pixel belonging to the skin.

iii. Face Localization by Segmentation
With mean gray level thresholding, the gray scale images can then be further transformed to a binary image showing skin regions as pixel 1 and non-skin regions as pixel 0.

iv. Refinement by Morphological Operations
Skin segmentation followed by mean gray level Thresholding isolates face, non-face and many other skin-like objects (i.e., those with similar skin color). This kind of regions can be considered as noise because it will give false positive detection result.

Morphological operations are used to extract all the objects individually from the skin as a post processing step for further classification. Morphological operations like erosion, dilation and hole filling as given in expression 3.9 and 3.10 are applied to prune the face region segmentation. The blob with area less than 1000 pixels are removed since they are very compact to be a face region.

v. Face Verification
The two feature vectors are generated from a 128x128-pixel input image in two directions in which edges are extracted. Each feature vector represents the distribution of edges to corresponding directions as shown in Fig. 3. The manually cropped 100 face images are used to generate the Projected Principal Edge Distribution (PPED) feature vector. To find edges in two directions, prewitt edge operator is used. The average PPED (APED) feature vector is obtained from PPED feature vector of 100 face images by accumulating all together. The APED feature vector is normalized. The geometrical parameter i.e. aspect ratio (ratio of width to height) is also used to verify the segmented region. The segmented image's PPED feature vectors is put in comparison with average PPED feature vectors of the cropped face picture to judge whether region which is fragmented is a face or non-face. The skin like regions are eliminated using this approach there by reducing the false positive rate and increases the accuracy.

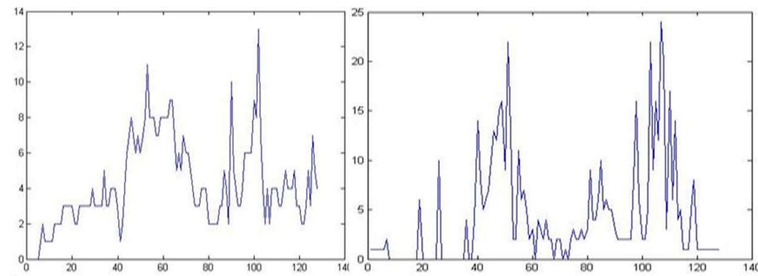

Fig. 4 Face image and its horizontal and vertical edge distribution

4. Results and Discussion:

The proposed method is tested on color face images with a dynamic background and a wide range of facial poses. Additionally, changing lighting conditions, different ethnicities, expression of face, and minor variations like moustache, beard or goggles are all taken into account. The results are taken from the two standard databases: CALTECH face database and LFW face database. The RGB input images are transformed to HSV color space. The Hue and Saturation channels are considered for skin color model. The Gaussian skin model is developed from skin patches. The Hue (H) color expresses the true color of the object and Saturation (S) determines colorfulness of an object. The shades of skin regions are characterized by the joint probability Gaussian distribution with μ_H=0.0677, σ_H=0.0008 and μ_S=0.399, σ_S=0.0116. After skin segmentation. Mathematical morphological operations are performed to refine the segmentation process. Fig. 5 and Fig. 6 express the result of proposed face detection approach even with occlusion and variation of poses. Multiple face images are also detected by this approach as seen in Fig. 4.

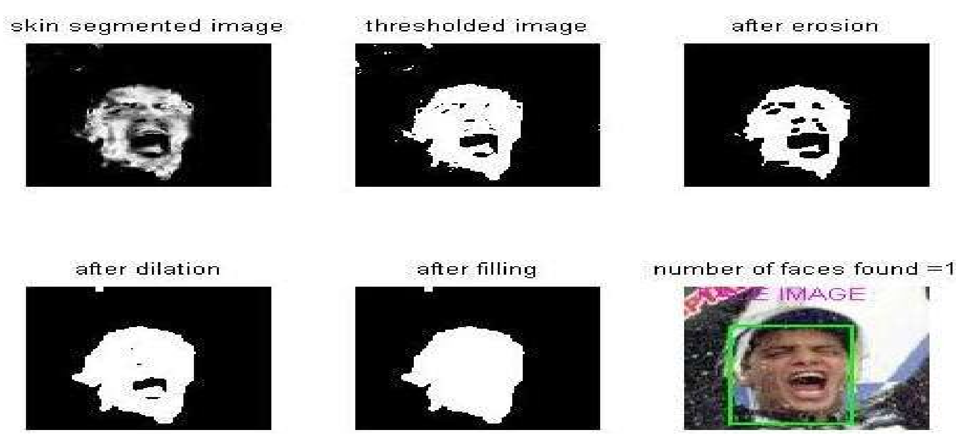

Fig. 5 Face detection even in occlusion

Fig. 6 Face detection even in pose variation

(a) (b) (c)

Fig. 7 Successful face detection even in (a) occlusion (b) Multiple face images detection (c) pose variation

The proposed method is also applied to detect multiple face images in the group photo. It successfully detected all face images from the input image displayed in Fig. 8

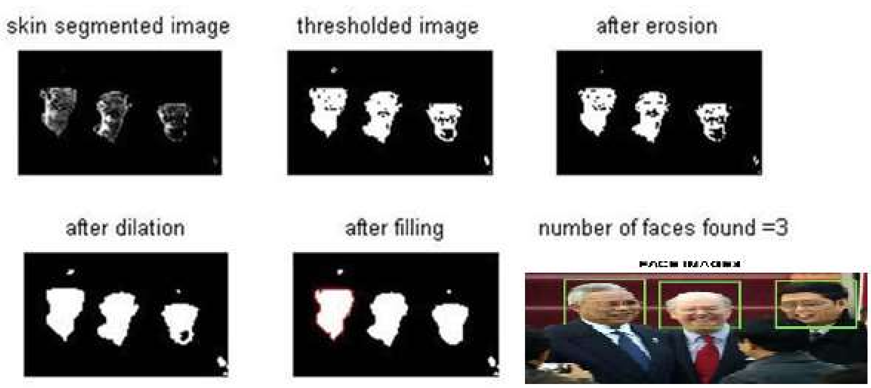

Fig. 8 Face Detection Results

From LFW database, 2000 images were collected and used to analyze the performance of proposed method. Out of which 1730 faces are detected correctly from the given images.

Hence the detection rate achieved is86.5% and false alarm rate achieved is 13.5%. The proposed algorithm is also tested on the transgender database comprising 300 images and results are presented in table 3.1 and in figure 3.17. The algorithm could achieve a detection rate of 85.3 %.

Table 1 Face detection result on various databases

Database	**# Images**	**Hit**	**Miss**	**Detection rate**	**False alarm rate**
LFW	2000	1730	270	86.5%	13.5%

5. CONCLUSION

A face detection algorithm has been implemented based on the color and edge distribution. The HSV color model is employed for skin color detection since HSV color model is most adaptable techniques in the perception of a human system. Both hue and saturation channels are considered for skin color model. The 2DGaussian skin color model is constructed using skin patches of 25×25 size. The likelihood of skin and non-skin pixel is identified by applying the input image into a Gaussian skin model. The Gaussian fitted image is then binarized by mean gray level thresholding method. After segmentation, there may be more number of blobs present in the resultant image. The unwanted detected blobs are eliminated by performing morphological operations as wellas based on area. The remaining blobs are considered as Region of Interest (ROI) and edge features are extracted from them and verified as face or non- face region according to the edge distribution feature vector obtained from Collection of 100 face images and aspect ratio. The proposed algorithm evaluated on CALTECH face images and LFW face database. Therobustness of the algorithm against the variance of illumination, focus, occlusion and scales has been demonstrated for a number of sample images.In future, traditional feature extraction and machine learning algorithm can beused to improve the detection rate.

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