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Face detection using color models

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Abstract

The use of computer vision in the security aspects has initiated research in the field of face detection. Human face detection in video sequences is a challenging problem in computer vision. It has wide range of applications in human detection/recognition, human computer interaction (HCI), video surveillance etc. The attempt to automate human recognition initiated the research in the field of face detection. The existence of variable illumination, complex background and pose variation adds constraints to efficient and robust face detection system. In this paper human face detection using multiple skin color models and haar feature extraction is described. The method described detects skin regions in the entire image and then locate face region in the skin color patches. Experimental results shows successful face detection in images of varying scale, pose, expression and illumination for different individuals.

Keywords: Face detection, histogram equalization, filtering,

INTRODUCTION

In any detection system the very first stage is to choose the features that uniquely and truly characterizes the target. The literature shows that there are many parameters that can be used for human detection. Face is an important part of human anatomy and can be used for human identification and recognition. Face detection is the first step in many applications like face recognition, face retrieval, face tracking, video surveillance, HCI, etc. The aim of face detection is to classify the segment of image as face or non-face. The task of describing the human face is difficult due to the fact that the image varies based on external factors like viewpoint, scale, different individual, occlusion, lighting, environmental conditions and internal factors like facial expression, beard, moustache, glasses.

The system should be adaptive and robust to these internal and external factors. With concern to video streams, the detection algorithm must be fast and optimized for high performance. Images are captured in *RGB* space. The skin pixel detection in *RGB* space is difficult as it is not perceptually uniform and the color components are very sensitive to the intensity. The YC_bC_r and *HSV* color spaces has separate luma and chroma components. The method presentedin this paper uses two color models YC_bC_r and *HSV* combining advantages of both the color spaces.

The rest of paper is organized as: Section II describes the previous work carried in the face detection field. The proposed method is described in section III where each color model is described in detail. Results are summarized in the Section V. Finally the conclusions are presented in section VI.

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RELATED WORK

In the recent years the face recognition and identification has gained popularity with the emergence of different methodologies. Chiunhsiun Lin [1] introduced skin pixel detection using *RGB* color image. Bae et.al. [2] proposed*R-G*, *R-B* and *G-B* probability image sub-spacefor face detection. In [3] the difference of normalized *R*,*G*, *B* color values is used to classify pixel as skin or non-skin.Siroheyet. al. [4] represented average histogramof normalized image by the Gaussian distribution toclassify pixels as skin and non-skin. Yang et. al. [5]used *HSV* color space to detect skin pixels. To locateface Li Xiaoet. al. [6] used the information fromthe central region of a face and the context information from the contours and the surrounding region. A face canbe represented with the eigenvectors of the covariancematrix of the set of face images. [7]. Human face detectionusing the genetic algorithm and eigenface technique isdescribed in [8]. Another approach which uses eigen mapwith wavelet transform to extract features is given in[9]. A method based on wavelet transform is describedin [10].

Phimoltares et. al. [11] proposed edge basedapproach using canny edge detection. Edge face templateis scanned over image to detect face. In [12] edge imagesare extracted using the Difference of Exponential (DOE)method. Huayiet. al. [13] proposed the method that uses colorimages to find the gradient image using sobeloperator. In[14]the edge information is used with integrated motionenergy classifier and cascade-structured classifier. Ishiiet. al. [15] used four directional features in horizontal,vertical and along both diagonals extracted using Prewittoperator for face detection. Template matching methodsfor face detection are presented in [16,17].

FACE DETECTION

Human skin color ranges from very dark to pinkishwhite. The human skin has two important propertiesskincolor cluster in a small regions and differ more inbrightness than in colors. Thus color information can beused to locate human being in the view. The color modelis the way of representing the distribution of color inan image. The face detection methods are categorized asfollows [11]:

1. *Skin Color Based*: The color of human skin is usedto separate skin pixels. It is simple and requiresless computation. But it is difficult to locate facein the presence of complex background and poor illuminations.
2. *Geometry Based*: These methods utilize geometricalinformation of face region. It represents face usingshapes like ellipse. It cannot handle large intensityvariations, occlusion and noise.
3. *Appearance Based*: Gray values are the most importantparameter for the face detection. Face detectionperformance is affected by light intensity and occlusions.
4. *Edge Based*: The edge information is extracted and used to detect face. These methods can handlelarge variations of the face images but requires preprocessingfor illumination normalization.

The method described here is skin color based facedetection. It requires fewer calculations and robust to poseand scale variation. The method is described below.

HSV Model

Hue (H) is a measure of the spectral composition ofa color and represented as an angle, which varies from 0to 360^0. Saturation (S) refers to the purity of colors andintensity of pixel is defined by the value (V), which valuesranges from 0 to 1 [18,19]. HSV model is related tohuman color perception. Conversion from *RGB* to *HSV*color system is done using following equations:

$$H_1 = \cos^{-1} \frac{0.5[(R-G)+(R-B)]}{\sqrt{(R-G)^2+(R-B)(G-B)}} \quad (1)$$

$$H = H_1 \quad if \quad B \le G \quad H = 360^0 - H_1 \quad if \quad B > G \quad (2)$$

$$S = \frac{Max(R,G,B) - Min(R,G,B)}{Max(R,G,B)} \quad (3)$$

$$V = \frac{Max(R,G,B)}{255} \quad (4)$$

Skin pixels are detected by thresholding$H$ and V valuesshown in Figure 1. The experimental study shows that theskin pixels have the H component value in the range 0 to0.175 and S component value in the range 0.04 to 0.40.

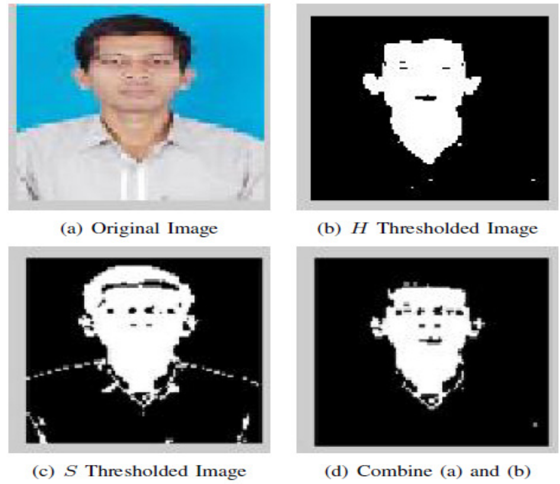


Fig 1. Face Detection using HSV Model

***YC_bC_r* Model**

The mostly used color space is YC_bC_r where Y isluminance component, C_b is blue chrominance and $C_r$is red chrominance [20,21]. The chroma component isrepresented only by blue and red as the sum of chromavalue of red, green and blue component is always constant.

The separate luma and chroma component makesthis model illumination invariant. The conversion from*RGB* to YC_bC_r is done using following equations:

$$Y = 0.299R + 0.587G + 0.114B \quad (5)$$

$$C_b = 128 + (-0.169R + 0.331G + 0.5B) \quad (6)$$

$$C_r = 128 + (0.5R - 0.419G - 0.081B) \quad (7)$$

Experimental results show that skin pixel has C_r valueabout 100 and C_b value about 150. Pixel is classified asskin or non-skin pixel using Eq. (8).

$$(R,G,B) = \begin{cases} 255 & if\ C_r \in [80,120]\ and\ C_b \in [133,165] \\ 0 & if\ C_r \notin [80,120]\ or\ C_b \notin [133,165] \end{cases} \quad (8)$$

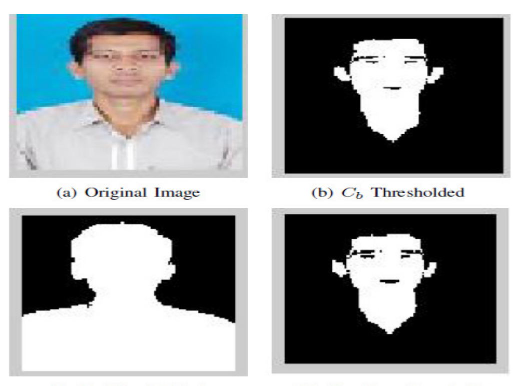
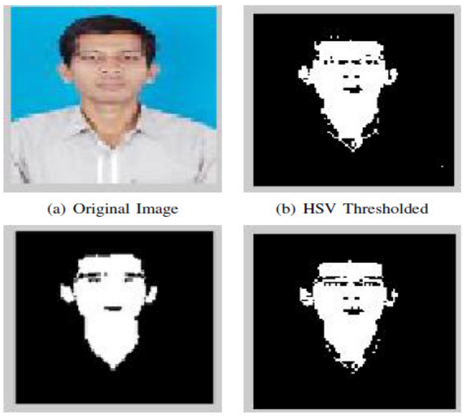


Fig 2. Face Detection using YC_bC_r Model

Results are shown in Figure 2. The area of skin otherthan face region is comparatively small and is eliminated using the morphological operations - erosion and dilation.The use ofindividual method for face detection reducesthe illumination effect but still there exists effects due togreater illumination or large reflection on faces.

The useof combine methods reduces these effects to greater extentshown in Figure 3. The color of the arm and clothing maybe or be similar with skin-color. To remove these regionscriterion like area and ratio of length to width is used.Table 1 gives summary of skin color based face detectionmethods.



(a) Original Image (b) HSV Thresholded

(c) YC_bC_r Thresholded (d) Combine (a) and (b)

Fig 3. Combine *HSV* and YC_bC_r Models

HAAR-LIKE FEATURES

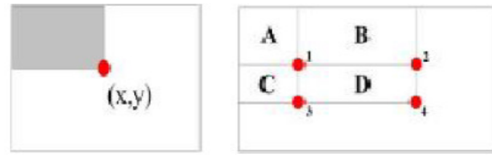
Our proposed algorithm is compared with the Viola's[29] face detector that uses haar features for face detection.The detection technique is based on the idea of thewavelet template that defines the shape of an object interms of a subset of the wavelet coefficients of the image.Haar-like features are computed at any scale or locationin constant time using the integral image representationof images [6,29]. The four variance based Haar-Likefeatures are shown in Figure 4. The regions within theserectangle features have the same size, shape and arehorizontally or vertically adjacent.

The value of a tworectanglefeature Feature1 and Feature2 are the differencebetween the sum of variance value within two rectangularregions. A three-rectangle feature Feature3 computes thesum of variance values within two outside rectanglessubtracted from the sum of variance values in a centerrectangle. And a four-rectangle feature Feature4 computesthe difference of the sum of variance values betweendiagonal pairs of rectangles. For given image $f(x,y)$, theintegral image $I(x,y)$ and squared integral image $I^2(x,y)$are obtained as follow:

$$I(x,y)=\sum_{m=1}^{x}\sum_{n=1}^{y} f(m,n) \tag{9}$$

$$I^2(x,y)=\sum_{m=1}^{x}\sum_{n=1}^{y} f^2(m,n) \tag{10}$$

where$I(x,y)$ and $I^2(x,y)$ indicate the sum and the sumof squared of the pixels above and to the left of x, y(Figure 5).



(a) Integral Image (b) Sum of the Pixels within D is $1+4-2-3$

Fig 5. Integral Image for Haar Features

Integral image and squared integral image are used forcalculating the values of $E(X^2)$, $\mu$and variance at anyposition in an image using following equations:

$$\mu=\frac{1}{N}(I_1+I_4-I_2-I_3) \tag{11}$$

$$E(f(x,y)^2)=\frac{1}{N}(I_1^2+I_4^2-I_2^2-I_3^2) \tag{12}$$

$$Var(f(x,y))=E(f(x,y)^2)-\mu^2 \tag{13}$$

where$N$ is number of elements within region D.

Using the integral image $I(x,y)$, any rectangular sumcan be computed in four array references (Figure 5). Thesum of the pixels within rectangle D can be computedwith values at four positions 1, 2, 3, 4. The value of theintegral image at location 1 is the sum of the pixels inrectangle A. The value at location 2 is $A+B$, at location3 is $A+C$, and at location 4 is $A+B+C+D$. So, thesum within region D can be computed as 1+4-2-3.

(a) Feature1 (b) Feature2 (c) Feature3 (d) Feature4

Fig 4.Haar Features

Table 1. Summary of Color Models

Author	Model	Criteria
Chen et. al. [3]	Normalized RGB	r>100, 10<r-g<70, 24<r-b<112, 0<g-b<70
Wang et. al. [5]	Normalized RGB	0.36≤r≤0.456, 0.28≤g≤0.363
Aldasouqi et. al.[121]	HSV	0.1>H>1.8
Zhang et. al.[10]	HSV	H=60 S=0.45
Sirohey et. al. [4]	HSV	0≤H≤50, 0.20≤S≤0.68, 0.35≤V≤1
Vranceanu et. al. [17]	HSV	0.05<*H* <0.2,0 0.15<*S*<1, 0.3<*V*<1
Vranceanu et. al. [17]	YC_bC_r	*Y*>90, 85<*Cb*<135, 135<*Cr*<180
Tang et. al. [11]	YC_bC_r	$90\le C_r\le 125$, $135\le C_b\le 165$
Huang et. al.[15]	YC_bC_r	80≤Cr≤120, $133\le C_b\le 165$
Yap et. al. [16]	YC_bC_r	$100\le C_r\le 135$, $125\le C_b\le 160$, 26≤Hue≤226
Ming et. al. [14]	YC_bC_r	$80\le C_r\le 127$, $137\le C_b\le 165$

RESULTS

Skin color based method works well for still images.The proposed skin color based approach can be applied tolive videos as it requires very small computational time.The images were scaled to 100×100 pixel resolutionto reduce computation time. The algorithm was testedover 50 different color images with varying pose andskin color. Out of 50 images the algorithm detected facecorrectly in 44 images. The haar algorithm from OpenCVwas used to compare with our proposed method. The haaralgorithm is incapable of handling pose variation and thesize of image affects its performance.

CONCLUSION

Face detection is an emerging field which can havegreat impact in making security systems more reliableand developing HCI applications. This paper presentsmethod for face detection using color models. For facedetection a skin detector must discriminate skin and non-skinpixels for various skin colors from white to black.

This is the simplest method for face detection. Skin colorbased method proposed in this paper is resistive to poseand illumination variation and requires less computationtime than haar method. The system implemented by theproposed algorithm can be used to track human in realtime.

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