Face Detection By Finding The Facial Features And The Angle of Inclination of Tilted Face

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Abstract

Face is a popular topic of research in computer vision, image analysis and understanding. This paper proposes a method to detect straight posed face as well as tilted face in colour images. Algorithm first detects skin colour region and then skin region is further processed by finding connected components and holes. Each connected components is tested to extract facial features and Y-value of each holes. If features exist in the connected component then the component is concluded as face. The Y-value of both eyes are compared to find whether the face is straight or tilted. For tilted face, the angle of tilt is determined and the input image is rotated by the angle of tilt to straighten up the face. After straightening the face, the rectangle is drawn to enclose the face. The dimension of drawn rectangle is obtained by using the distance parameter of the line between two eyes.

Keywords: *Normalization, Skin Colour, Holes, Connected Components, Y-Value, Tilt Angle.*

1. Introduction

Recognizing faces is a difficult problem in the area of computer vision. The first step of face recognition is the detection of human faces in images. When faces are located exactly in any image, the face recognition step would not be so complicated.

Some facial detection algorithms identify facial features by extracting landmarks, or features, from an image of the face. The method finds the position, size, and shape of the eyes, nose, cheekbones etc. These features are used to find other images with matching features for face recognition.

Human face detection is useful in applications such as surveillance of video, human computer interface, recognition of face and management of image database. Face detection is a prerequisite for face recognition and facial expression analysis.

Anthropometry features can be used to detect facial features. Anthropometry is a biological science that deals with the measurement of the human body and its different parts.

The task of human face detection is to determine in an arbitrary image whether or not there are any human faces in the image, and if present, localize each face and its extent in the image, regardless of its three dimensional position and orientation. Such a problem is a very challenging task because faces are non-rigid forms and have a high degree of variability in size, color, shape and texture.

1.1 Background

Face detection in color images [1] detects skin regions over the entire image, and then creates face candidates based on the arrangement of the skin patches. The algorithm generates eye, mouth, and boundary maps for verifying each face candidate.

Face detection and facial feature extraction using color snake [2] is composed of three main parts: the face region estimation part, the detection part and the facial feature extraction part. In the face region estimation part, images are segmented based on human skin color. In the face detection part the template matching method is used. Color snake is then applied to extract the facial feature points within the estimated face region.

In Face Detection Based on a New Color Space YCgCr [3], a new color space YCgCr is described and applied for face detection. The required decision values, which determine the decision thresholds are modeled and represented in the Cg-Cr plane. Based on the representation of the experimental results, the decision thresholds are modified. The segmentation results achieved with this new color space are compared with those obtained in YCbCr.

Domain Specific View for Face Perception [4] performs a skin color analysis of the image and random measurements are generated to populate the entrant face region according to the face anthropometrics using the eye location determined from the YCbCr color space.

Face Detection using Rectangle Features and SVM [5] is based on the characteristics of intensity and symmetry in eye region. Three rectangle features are developed to measure the intensity relations and symmetry. The found eye-pair-like regions and SVM are used to find the face candidates.

Automatic Facial Features Localization [6] determines the facial features automatically, without the participation of a human. This method uses the Active Shape Models and Strategies, to find the facial features in images of faces in frontal view automatically.

A simple and efficient eye detection method in color images [7] detects face regions in the image using a skin color model in the normalized RGB color space. Then, eye like region are extracted within these face regions. Finally, using the anthropological features of human eyes, the pairs of eye like regions are selected.

Fast Head Tilt Detection for Human-Computer Interaction [8] is based on Foreground and background segmentation. It is composed of four steps. Firstly the method performs the analysis of the motion of the occluding boundary of the face to get head tilt estimate. Then analysis of the motion of the center of the face is done to compute angle estimate. Finally, analysis of the confidence factor that determines the weighting of the two estimates in computing the final head tilt estimate.

An efficient algorithm for human face detection and facial feature extraction under different conditions [9] detects location of face regions using the genetic algorithm and the Eigen face method. The genetic algorithm is useful to look for possible face regions in an image, while the eigenface procedure is used to find out the fitness of the regions. Face candidates are then further verified by measuring their symmetries and determining the existence of the different facial features.

1.2 Our Approach

The proposed method finds the facial features for the detection of straight head posed face and tilted face. The process flow diagram is shown in Fig 1. The main steps of the approach are as follows, and are described in their corresponding subsections in greater detail:

1. Noise Removal.
2. Skin color detection.
3. Find connected components and test each connected component.
4. Rejecting the region, having less than two holes.
5. Each accepted region is tested for features extraction.
6. Feature extraction is done by performing the following test:
   i. Hole location test to find the xy coordinates of the holes.
   ii. Circularity test to find circle shaped holes.
   iii. Sum, Area, Black pixel count is determined for each hole and compared with other holes.
   iv. Two holes having similar feature values may be concluded as eyes.
7. Compare Y coordinate value of one hole with that of other holes, which is confirmed as eyes. If y-value of both eyes are not lying in the same range value then, face may be the tilted face. To rotate the face, the angle of rotation is to be determined by drawing the line between two eyes, horizontal line from left eye and vertical lines from the right eye.
8. The tilted component is rotated by the angle of rotation found in previous step.
9. Draw rectangle enclosing the face based on the distance parameter between eyes.

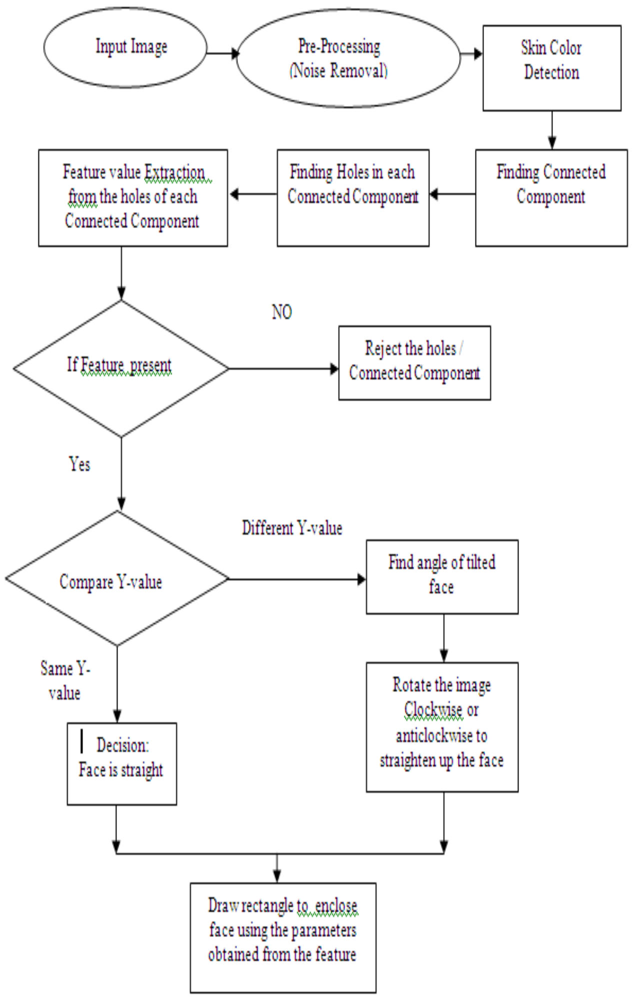

Fig. 1 Process Flow Diagram

2. Proposed Technique

2.1 Noise Removal

Median filter is used to remove noise from image. The median filter works by moving through the image pixel by pixel, replacing each value with the median value of neighboring pixels. The pattern of neighbors is called the "window", which slides, pixel by pixel over the entire image pixel. It examines the neighborhood pixel values, sort the pixels and replace the current pixel value by the median value.

2.2 Skin Color Detection

Image is segmented by separating human skin regions from non-skin regions based on color. A reliable skin color model [10] that is adaptable to people of different skin colors and to different lighting conditions is used. The common RGB representation of color images is not suitable for characterizing skin-color. In the RGB space, the triple component (r, g, b) represents color and luminance. Luminance varies in faces due to the ambient lighting and is not a reliable measure in separating skin from non-skin region. Luminance is removed from the color representation by using chromatic color space [11]. Chromatic colors are also known as "pure" colors are obtained by normalization process. The chromaticity r, g and b are defined as-

$$r = R/(R+G+B)$$
$$b = B/(R+G+B)$$

We use only r and b to describe the skin color, given that the third component depends on the other two (g = 1-r -b).

Skin color model is created using 11 different images of varying colors to create skin model. Crop small portion of skin from each image. Convert the colors into chromatic color space to eliminate luminance. Each sample was low pass filtered to remove noise. The low pass filter is determined by:

$$1/9 \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

The sample images are converted from RGB to YCbCr space and luminance Y component is discarded. Then the testing sample average for both Cb and Cr components and the covariance matrix are computed in order to fit the data into Gaussian Model. The Normal distribution is also known as the Gaussian distribution and the curve is also known as the Gaussian Curve, named after German Mathematician-Astronomer Carl Frederich Gauss. The probable skin regions in original image using this distribution are obtained by:

$$P(r,b) = \exp[-0.5(x-m)^T C^{-1}(x-m)]$$

Where $x = (r,b)^T$ and T denotes matrix transpose, C= covariance, m = mean .

This algorithm determines the probability of one pixel being a skin region based on the skin region model. Create a grayscale image giving the probability based on the gray level as shown in Fig 2.

Fig. 2 Skin Color Image

2.3 Finding Connected Components and Holes

In image processing, connected components labeling [12,13] scans an image and groups its pixels based on connectivity feature, i.e. all pixels in a connected component share similar pixel intensity values and are in some way connected with each other. Find all such connected component and then label each pixel with a gray level or a color (color labeling) according to the component it was assigned to. A connected component means finding regions of connected pixels which have the same value. The connected components may be face or other skin area of human like hand, neck etc. Each connected component is tested to find whether the region contains face or not.

Now we find number of holes [12] in each connected component to detect whether the connected component contains face or not. Hole is an area of dark pixels surrounded by lighter pixels is shown in Fig 3. Dark pixels are black color pixel and lighter pixel means white color pixel. If the connected component contains more than one holes then the region may contain face, is accepted for further processing otherwise the region is rejected.

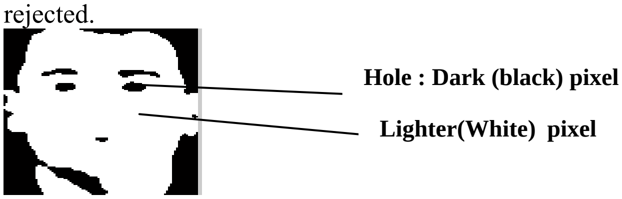

Fig. 3 Connected component and Holes

2.4 Feature Extraction

Each connected component has to undergo the following test individually for the feature extraction.

i. Hole Location test: The location of holes can be detected by finding connected component in the negative image of bounding box as shown in Fig 4(a) and 4(b).

Fig 4(a). Connected component

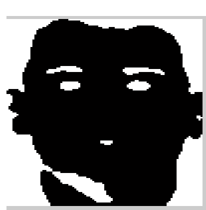

Fig 4(b). Negative image Connected component

ii. Circularity test: The circularity test is performed on each internal holes i.e. connected component in negative image.

$$\text{Circularity} = \text{Perimeter}^2 / 4*pi*\text{Area} = (2*pi*r)^2/4*pi*pi*r^2 = 4*pi^2*r^2/4*pi^2*r^2 = 1$$

Circularity is equal to 1 for the circular objects. If the circularity value is in the range from 0.5 to 1.2, we can conclude that this is closer to circle shape. The holes concluded as circle has to undergo further testing for eye feature extraction [14].

iii. Reject the holes which are not confirmed as circle.

iv. Find the Sum of pixel, Area, Black pixel count of each circular hole in that connected component is determined.

v. Find Y-value (y coordinate value) of each circular hole in the same connected component. Holes Y-value means minimum and maximum y coordinate value in Fig 5.

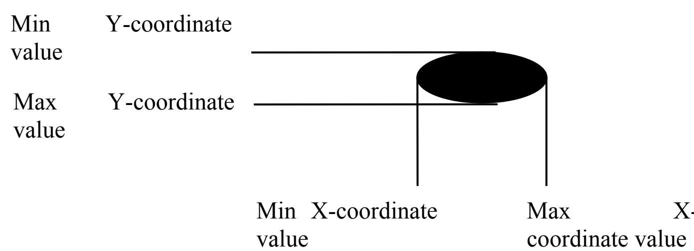

Fig. 5 Holes coordinate value

Table 1: Feature Comparison

S.No.	***Feature Value***	***Left Eye Brow***	***Right Eye Brow***	***Left Eye***	***Right Eye***
1	Circularity Value	1.3259	1.3260	1.3258	1.3259
2	Black Pixel Count	56	60	47	44
3	Sum of pixel	90	90	90	90
4	Area	107128	107116	107133	107123
5	Y-value	Same Y value			

vi. The two eyes are almost equal in area, sum of pixel and black pixel count. The difference of all the features of two holes from feature Table 1 should be less than threshold value. Threshold

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value is decided by performing sample test of two eyes of various images. Based on the values of feature mentioned in Table 1, find the two similar holes having values lying in the range of threshold value is confirmed as eyes for the straight head posed face as shown in Fig 6..

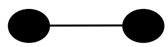

Fig. 6 Box with eyes

If we get two such holes having all the feature values of Table 1 are satisfied except the Y-value, it means these holes Y-value does not lie in the same range then we can conclude that the face is actually tilted.

2.5 Angle of Tilted Face

The two holes which satisfies the conditions of Circularity Value, Black Pixel Count, Sum of pixel and Area but not satisfying the Y-value condition mentioned in Table 1. , then we can conclude that the head pose is not straight. It is tilted by an angle. To detect face [8], the head should be rotated by an angle to make the head straight. The angle of rotation is determined by drawing lines between two holes and a horizontal line from left hole. By these two lines, we can find the angle of rotation Ə as shown in Fig 7(a). In the figure L is Left eye, R is Right eye and M is point of intersection of vertical line from right eye and horizontal line from left eye. The coordinate values of left eye is L(Lx, Ly), right eye is R(Rx, Ry) and point of intersection is M(Mx, My) as shown in Fig 7(b).

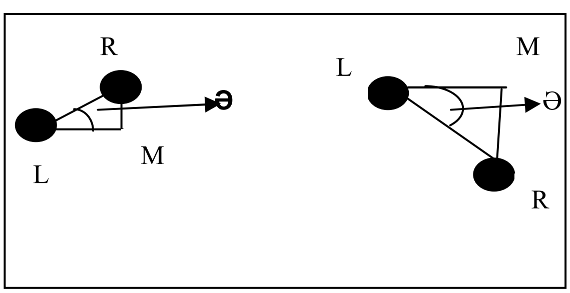

Fig. 7(a) Angle of tilt

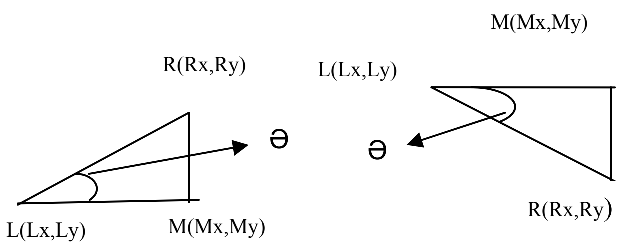

Fig. 7(b) Angle of tilt

The coordinate values of eyes are obtained by finding the midpoint of min and max coordinate value as shown in Fig 5. If the left eye's x and y coordinate value is Lx and Ly respectively, then

Lx= (Max X-coordinate value - Min X-coordinate value)/2

And

Ly= (Max Y coordinate value + Min Y coordinate value)/2

Similarly, the right eye's x and y coordinate value is Rx and Ry is determined. Mx and My are the coordinates of M, where

Mx=Rx,

My=Ly

The angle Ə is obtained by:

Ə=cos^{-1} (LM /LR)

LR is distance between two eyes, LM is base of the triangle LMR and RM is perpendicular length from right eye to M.

$$LR=Sqrt((Rx-Lx)^2+(Ry-Ly)^2)$$
$$RM=Sqrt((Rx-Mx)^2+(Ry-My)^2)$$
$$LM=Sqrt((Lx-Mx)2+(Ly-My)2)$$

If Ly>Ry and Lx<Rx as shown in Fig 8., then the image is rotated clockwise by an angle of rotation Ə about L to straighten up the face .

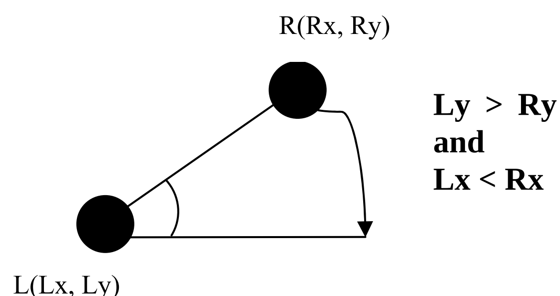

Fig. 8 Clockwise rotation by angle Ə

If Ly<Ry and Lx<Rx as shown in Fig 9, then the image is rotated anti-clockwise by an angle of rotation Ə about L to straighten up the face.

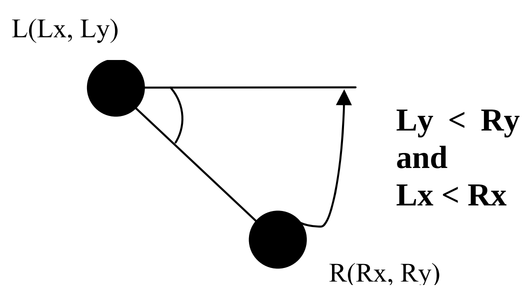

Fig 9. Anticlockwise rotation by angle Ə

2.6 Enclosing the Face by Rectangle

Draw line between two eyes LR i.e. L left eye and R right eye. If the length of LR is X then by testing many sample faces, the dimensions of rectangle is concluded as shown in Fig 10**.** Draw vertical line PQ of length 2.5X passing through the midpoint of LR i.e. M and the length of PM is kept as X. Draw the line AB passing through Q of length nearly equal to 2.5X to 3X and Q is midpoint of AB. Complete the rectangle using these parameters to enclose the face.

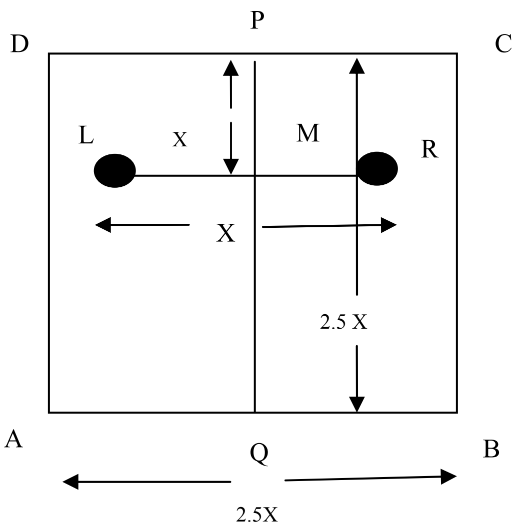

Fig 10. Rectangle enclosing the face.

3. Experimental Results

Experiments are performed on 25 images containing straight posed face and 25 images containing tilted face images to verify the effectiveness of the method. The tilt angle computation, Coordinates of eyes before and rotation is shown in Table 3 and 4. The rectangle box coordinate computation of its vertices is shown in Table 5, Table 6 and Table 7. The proposed method shows reasonably good result for detecting face on image containing straight posed face and tilted face. This method has failed in some cases where there is problem in detecting exact eye location of two eyes. Due to which false detections still exist. The statistical data is shown in Table 2.

Table 2: Statistical Data

Face Type	*Straight posed face*	*Tilted Face*
Face Numbers In A Photo	1	1
Photo Numbers	25	25
Face Numbers	25	25
Hits	23	21
Wrong Selected	1	3
False Detection Rate	4%	12%
Missed Rate	4%	3%
Detection Accuracy	92%	85%

Table 3: Tilt Angle computation

S. No.	***Figure no.***	***Distance1 (LR)***	***Distance2 (RM)***	***Translation -tx -ty***	***Radians***	***Angle in degrees (ə)***
1	13	44.6542	25	-22 -22	0.97	55.95
2	14	47.7074	40	-24 -24	0.57	33.02
3	15	12	62.16	-6 -6	1.37	78.87

Table 4: Coordinates of eyes before and after rotation

S. no.	***Figure no.***	***Coordinates of eyes Before Rotation***		***Coordinates of eyes after rotation***	
		Left eye (Lx, Ly)	***Right eye (Rx, Ry)***	***Left eye (Lrx, Lry)***	***Right eye (Rrx, Rry)***
1	13	(58,114)	(83,77)	(127,113)	(171,113)
2	14	(87,121)	(127,95)	(157,148)	(206,148)
3	15	(155,88)	(167,149)	(114,130)	(177,130)

Table 5: Rectangle box parameter

S. no.	*Figure no.*	*Mid point coordinate value of Left Eye and Right Eye (Midx,Midy)*	*distance between two eyes X=Rrx-Lrx*	*Width of Rectangle box =2.5 X*	*h= 2.5X/2*
1	13	(149,113)	44	110	55
2	14	(182,148)	49	123	62
3	15	(146,130)	63	158	79

Table 6: Rectangle coordinate computation

S. No.	*Figure no.*	*A's X coordinate value*	*A's Y coordinate value*	*B's X coordinate value*	*C's Y coordinate value*
		Ax=Mid x-H	*Ay=Mid y+ 1.5x*	*Bx=Mid x+H*	*Cy=Mid y-x*
1	13	94	179	204	69
2	14	120	222	244	99
3	15	67	225	225	67

Table 7: Coordinates of Vertices of Rectangle

S.No.	*Figure no.*	*Rectangle Vertices*			
		A	*B*	*C*	*D*
1.	13	(94,179)	(204,179)	(204,69)	(94,69)
2.	14	(120,222)	(244,222)	(244,99)	(120,99)
3.	15	(67,225)	(225,225)	(225,67)	(67,67)

Fig 11 (a) input image, (b) detected skin Region (c) binary image after skin region detection, (d) Cropped output face

Fig 12 (a) input image, (b) detected skin Region, (c) binary image after skin region detection, (d) Cropped output face

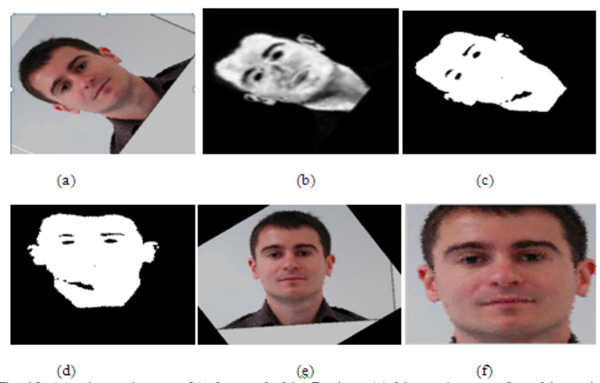

Fig 13 (a) input image, (b) detected skin Region, (c) binary image after skin region detection, (d) Binary image after rotation (e) Input image after rotation (f) Cropped output face.

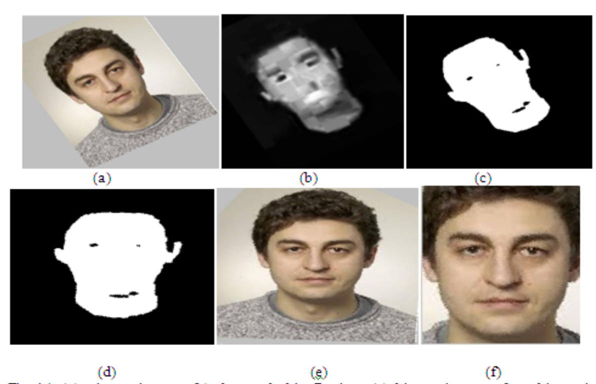

Fig 14 (a) input image, (b) detected skin Region, (c) binary image after skin region detection, (d) Binary image after rotation (e) Input image after rotation (f) Cropped output face.

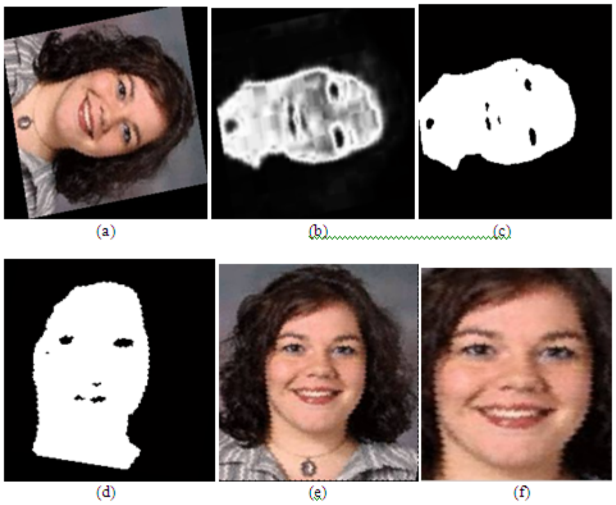

Fig 15(a) input image, (b) detected skin Region, (c) binary image after skin region detection, (d) Binary image after rotation (e) Input image after rotation (f) Cropped output face.

4. Conclusions

This paper first reviews the existing face detection techniques in the literature for automatic face detection in 2D face images and then proposes a technique for the same. The proposed technique detects face in the image containing single straight posed human face and tilted face without any user interaction. This method detects tilted face whose angle of inclination is less than 90 degrees. This technique is tested on 100 images and found to be giving 92% accuracy for images containing straight posed face and 85% accuracy for images containing tilted face. The proposed technique can be extended for the detection of face by extracting other facial features to achieve better performance and further reduce the false detection rate in dealing with images with more complex background.

References

[1] Rein-Lien Hsu, Mohamed Abdel-Mottaleb, and Ani1 K. Jain, " Face Detection In Color Images", IEEE 2001.

[2] Kap-ho seo, Won kim, Changmok oh, Ju-Jang Lee, "Face detection and facial feature extraction using color snake," IEEE 2002.

[3] Juan José de Dios Narciso García, "Face Detection Based On A New Color Space Ycgcr," IEEE 2003.

[4] Mary Metilda and T. Santhanam, "Domain Specific View for Face Perception", Information Technology Journal 7(1), 2008, pp 105-111.

[5] Qiong Wang, Jingyu Yang, and Wankou Yang, "Face Detection using Rectangle Features and SVM," International Journal of Intelligent Systems and Technologies, 2006.

[6] Vittorio Zanella, Héctor Vargas, Lorna V. Rosas, "Automatic Facial Feature Localization", IEEE 2005.

[7] D. Sidibe, P. Montesinos, S. Janaqi, "A simple and efficient eye detection method in color images", International Conference Image and Vision Computing, New Zealand, 2006.

[8] Benjamin N. Waber, John J. Magee, and Margrit Betke, "Fast Head Tilt Detection for Human-Computer Interaction", 2005, Springer-Verlag Berlin Heidelberg, HCI/ICCV 2005, LNCS 3766, pp. 90–99,.

[9] Kwok-Wai Wong, Kin-Man Lam, Wan-Chi Siu, "An efficient algorithm for human face detection and facial feature extraction under different conditions", 2001 Pattern Recognition Society. Published by Elsevier Science Ltd.

[10] Quan Huynh-Thu, Mitsuhiko Meguro, Masahide Kaneko, "Skin-Color-Based Image Segmentation and Its Application in Face Detection" MVA2002 IAPR Workshop on Machine Vision Applications 2002, Japan.

[11] Tarek M. Mahmoud, "A New Fast Skin Color Detection Technique," World Academy of Science, Engineering and Technology, 43, 2008.

[12] A. Rakhmadi, M. S. M. Rahim, A. Bade, H. Haron, I. M. Amin, "Loop Back Connected Component Labeling Algorithm and Its Implementation in Detecting Face", World Academy of Science, Engineering and Technology 40, 2010.

[13] Jean V. Fonou Dombeu and Jules-R. Tapamo, "Validation of Detected Facial Components For an Accurate Face Recognition", Proceedings of Pattern Recognition Association of South Africa(PRASA), 2007.

[14] Cooray, Saman H. and O'Connor, Noel E. , "Facial feature extraction and principal component analysis for face detection in color images", International Conference on Image Analysis and Recognition ICIAR, 2004, Porto, Portugal.

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