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Skin Color Based Face Detection

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Abstract— In information technology, biometrics usually refers to technologies for measuring and analyzing human body characteristics such as fingerprints, eye retinas and irises, voice patterns, facial patterns, and hand measurements and especially for authentication purposes. Facial biometric is one of the widely used biometric technologies over the real time data. For implementing facial biometric we need to go through the process of face detection and face recognition process. Face detection is concerned with finding whether or not a face exists in a given image, if face is present, it returns the image location and face size. In the face detection system faces first need to be located properly and look towards further processing to detect facial features accurately for applications, such as digital cosmetics. This paper proposes a skin based segmentation algorithm for face detection in color images with detection of faces and skin regions. Skin color is one of the useful and robust methods for face detection.

Keywords— F***ace detection, Skin color, Color space, LAB Color space***

I. INTRODUCTION

This Face detection is a hard problem that contains finding one or more faces in an image or in a video sequence under different situations. To detect a face from an online surveillance system or from test image, the main feature that should be detected is the skin area.

In Face Detection, we check given input image whether it contains human face or not, if so, then returning the location of the human face. Face detection is used in many tools nowadays mainly in the tools like Picasa, photosplash over the social networking sites like facebook over the android applications like modiface.

As it is very challenging task to detect the face because when we are going to implement face detection in real time data application then we have to face very challenging problems like pose variation, occlusion, and expression variation, illumination conditions. Skin based detection which follows segmentation and enhancement approach has many benefits over other face detection techniques. This method is almost invariant against the changes of size of face, orientation of face. The main aim of skin color based segmentation is to detect the pixels representing the skin regions and non skin regions.

II. BACKGROUND AND RELATED WORK

In the past two decades, face detection has been proven as the most interesting research field from the domain of image processing. Now it may seem very easy but in reality we have to consider many constraints like single face or multiple faces, image rotation, pose etc. So there may arise some false detected regions of an image, which do not contain any face..

The author proposed [1] here improved segmentation algorithm for face detection in color images with multiple faces and skin tone regions. Algorithm combines different color space models, specifically, HSI and YCbCr along with Canny and Prewitt edge detection techniques. Author demonstrates that edge detection when used along with the skin segmentation based on skin chromaticity values from combination of multiple color spaces gives a better segmentation result.

The research on detecting human faces in color image and in video sequence has been attracted with more and more people. Author proposes a novel face detection framework that achieves better detection rates. The new face detection algorithms based on skin color model in YCgCr chrominance space and HSV color space. With from the start author build a skin Gaussian model in Cg-Cr color space and then some constraints are used to get candidates of face. Secondly, a calculation of correlation coefficient is performed between the given template and the candidates. This detection approach initially takes the color image and the color balance model to modify the RGB color space to YCgCr color space [2].

One of the methods for detecting faces in color images using skin color model algorithm merged with skin probability or possibility, skin Segmentation, operation for performing analysis i.e. morphological operation and Template matching. Representing Color images with skin color in the color space YCrCbr, differentiate luminance and chrominance components. A density called as Gaussian probability density is calculated from skin samples and collected from different ethnic group [3].

Propose a fast algorithm for detecting human faces in color images using HSV color model without sacrificing the speed of detection. Here author proposed algorithm has been tested on various real images and its performance is found

to be quite satisfactory[4]. It uses simple formulas to represent skin-color models depending on the HSV values. Additionally as HSV is fast and well matched with human color perception, the overall performance of this algorithm is reasonable. Author proposed algorithm is fast, and become faster more when number of functions becomes less which makes it useful for some real-time applications.

The goal of face detection is to locate all regions that contain a face. Here procedure is based on skin color segmentation and features of human face this paper, author used RGB, YCbCr, CEILAB (L*a*b) and HSV color models for skin color segmentation. These color models with thresholds, help to remove non skin like pixels from an image. Author tasted each skin region, that skin region is actually represents a human face or not, by using human face features based on knowledge of geometrical properties of human face [5].

Color model is to identify the colors in some standard. Some of the color models used is RGB color model for color monitors, CMY and CMYK model for color printing. HSV color model is the cylindrical representation of RGB color model. HSV stands for hue, saturation and value. In each cylinder, the angle around the central vertical axis corresponds to "hue" or it form the basic pure color of the image, the distance from the axis corresponds to "saturation" or when white color and black color is mixed with pure color it forms the two different form "tint" and "shade" respectively, and the distance along the axis corresponds to "lightness", "value" or "brightness". Author proposes a skin based segmentation algorithm for face detection in color images with detection of multiple faces and skin regions [6].

Cb and Cr channel are used to find where the skin color parts are on the photo, then remove noise around the skin parts and finally use morphology technique to detect face part exactly. Their result shows this approach can detect faces and establish a good technical based for future face recognition [7].

Face detection is challenging job to perform. The main part is to detect the face portion from the entire image. YCbCr color space model to detect the skin color of humans by setting appropriate thresholds. The reason for using this color model is to remove the illumination component Y. author implemented a method to locate the face portion of human by determining the number of holes in the skin region using Euler's method and also by taking eye distance [8].

Many existing systems use a window-based classifier that scans the complete image for the presence of the human face and such systems faces the challenges like scale variation, pose variation, illumination changes, etc. Lighting insensitive face detection method is based on the edge and skin tone information of the input color image. This performs skin segmentation in YCbCr and RGB space with image enhancement. The result of skin segmentation is refined using the skin tone percentage index method [9].

Human face detection plays a vital role in many applications such as face recognition, human computer interface, and biometrics, area of energy conservation, video surveillance and face image database management. The selection of accurate color model is the first need of the face detection. Here author compares different color models based on the detection rate of skin regions. Author observation concludes that YCbCr color space compared to other color models yields the best output even in varying lightening conditions [10].

A simple face detection approach which has two important steps, first to segment skin region from an image, and second, to decide these regions contain human face or not. The procedure is based on skin color segmentation and human face features (knowledge-based approach). For skin color segmentation HSV color model has been used. Various color space model along with threshold, helps to remove non-skin like pixels from an image. Furthermore the morphological operations are used to smooth the object boundary without changing their respective area based on shapes. Operations such as erosion, dilation are used to execute the process of face detection which improves the efficiency rate [11].

As we know that color spaces or models provide a rational method to specify order, operate and effectively display the object colors taken into consideration. There are various models based on human perception, on color recognition, on various color components etc. There are also papers on various applications such as lane detection, face detection, fruit quality evaluation etc based on these color models have been published. Author [12] here gives a review on widely used models RGB, HSI, HSV, RGI.

In [13] a new face detection algorithm is proposed. Author proposes skin color segmentation of the color image to skin regions using a new approach to detect the pixels of the skin and the water shed segmentation method. Author presents Gabor filters, combined with a model of face, skin regions are classified into two classes: face and non-face. The combination of these tools in algorithm permits to develop a face detector with very reasonable and efficient performances. Author's results show that this method can achieve high detection rates and low false positives

There are many ways to detect the faces. One of the ways is face detection based on skin color, face shape and corner points. The skin regions are detected by the segmentation of image with a threshold calculated by a combination of rules proposed on elements of the three color spaces RGB, HSV and YCbCr. Next, the geometric constraints (surface, ratio, eccentricity) are applied to eliminate the skin regions detected that do not have a shape similar to a human face. Then the corner points of Harris are used to verify the existence of eyes in the regions detected[14]

Locating and tracking human faces is a precondition for face recognition. In this author propose a faster, yet efficient face detection approach based on mathematical morphology and skin color information. Author applies some simple post-processing rules to eliminate non-face regions from face regions [15].

III. FACE DETECTION SYSTEM

Face detection is an optic task which can be done by humans without any stress or exertion. But if there is a case of information technology regarding with computer vision areas then this job is very difficult.

Face detection is used for self-serviced relocation for person verification, security, image examination etc. The goal of face detection is to identify and locate all of the human faces regardless of their positions, scales, orientations, poses and light conditions and Signal & Image Processing. This is a challenging problem because human faces are highly non-rigid with a high degree of variability of in size, shape, color and texture. The whole process of face detection consists of four steps:

i. ***Input***: - An image passed to the system as input .The image may vary in format, size and resolution.
ii. ***Pre-Processing***:-The image is pre-processed to remove the background noise. This is also called image normalization.
iii. ***Classifier***: - it takes decision whether the image belong to the face or non-face class.
iv. ***Output***: - This indicates the location of the face in the original image input.

Fig 1. Face Detection Process

A. Methods of Skin Color Detection

Face detection based on skin is followed by two techniques i.e one is by Pixel based and second is by Region based method.

1) *Pixel-Based Methods:* This method Classify each pixel as skin or non-skin individually, independently from its neighbors. The color Based Methods fall in this category
2) *Region Based Methods:* This method tries to take the spatial arrangement of skin pixels into account during the detection stage to enhance the methods performance. Additional knowledge in terms of texture etc is required.

In this paper we follow pixel based method for skin color detection. One of the main things behind using this method is that it allows fast processing and robust to resolution changes and geometric variations of the skin patterns. So pixel based method increase the chances of good success rate and decreases the wrong detection rate.

B. Color Space

A color space describes the range of colors that a camera can see. It is a collection of codes for every color. Each pixel in an image has a color that is described in the color space, so this color space can be used for pixel labeling. There are different ways to describe all colors, so there are also different color spaces. Following table shows different kind of color spaces.

Color Space	Description
RGB	In the RGB color space, each color is described as a combination of three main colors, namely Red, Green and Blue. This color space can be visualized as a 3d matrix with the main colors set out on the axis. The values for the main colors vary from 0 to 1.
CMY	This stands for cyan-magenta-yellow and is used for hardcopy devices. A printed color that looks red absorbs the other two components G and B and reflects R.Thus the C-M-Y coordinates are just the complements of the R-G-B coordinates
YCBCR	The YCbCr color space is widely used for digital video. In this format, luminance information is stored as a single component (Y), and chrominance information is stored as two color-difference components (Cb and Cr). Cb represents the difference between the blue component and a reference value. Cr represents the difference between the red component and a reference value.
HSV	HSV is a color model that describes colors (hue or tint) in terms of their shade (saturation or amount of gray) and their brightness (value or luminance).The HSV color wheel may be depicted as a cone or cylinder.
LAB	The L*a*b* color space also known as CIELAB or CIE L*a*b* enables you to quantify visual differences from image. The L*a*b* space consists of a luminosity 'L*' or brightness layer, chromaticity layer 'a*' indicating where color falls along the red-green axis, and chromaticity layer 'b*' indicating where the color falls along the blue-yellow axis.

IV. PROPOSED COLOR SPACE MODEL FOR FACE DETECTION

In this paper LAB color space model is going to use for skin color based face detection. The three coordinates of CIELAB appointed to be the lightness of the color (L* = 0 yields black and L* = 100 indicates diffuse white), its location joining red/magenta and green (**a***, negative values indicate green while positive values indicate magenta) and its location across yellow and blue (b*, negative values indicate blue and positive values indicate yellow).

LAB color space model is used rarely in face detection process. In our proposed LAB color space model we used otsu thresholding method to estimate optimum threshold value. Existing model follows various steps like performing multiplication of binary images every times which seem to be quite hard to processing. Performing such a complicated operation seems to be very tedious one. We propose very simple steps for face detection processing. Existing LAB color space model generally applied on frontal view face images an gives success rate up to 80% rather our method gives success rate of 100% for frontal view image and 80% for pose variation face image.

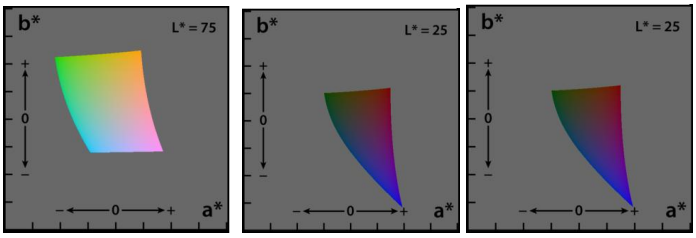

Fig 2. (L*, A*, B*) Color Space (CIELAB), Showing Only Colors That Fit Within the SRGB

A. Mathematical Approach For Lab Color Space

There is no simple formulas for conversion between RGB values to *L*a*b**, because the RGB and color models is device-dependent. The RGB values first must be transformed to a specific absolute color space, such as sRGB.

The L* coordinate ranges from 0 to 100. The possible range of a* and b* coordinates is independent of the color space that one is converting from.

We can represent the conversion in the mathematical form as below

$$L^* = 116f(Y/Yn) - 16$$

$$a^* = 500[f(X/Xn) - f(Y/Yn)]$$

$$b^* = 200[f(Y/Yn) - f(Z/Zn)]$$

$$f(t) = \begin{cases} t1/3 & if\ t > (6/29)3 \\ \frac{1}{3}\left(\frac{29}{6}\right)2\ t + \frac{4}{29} & otherwise \end{cases}$$

here, Xn, Yn and Zn are the CIE XYZ tristimulus values of the reference white point.

Following table shows the converted values of RGB to LAB color model

RGB Valaues		Converted CIE-L*ab Values	
R	1	L	0.274175924239664
G	1	A	0.0000373013175764
B	1	B	-0.0000738057445437

Converted {R:1,G:1,B:0}
Converted {R:1,G:1,B:1}
Converted {L:0,A:-0.999999999999994,B:-0.00007380574454374234}
Converted {L:0,A:6.399e-15,B:-0.00007380574454374234}
Converted {L:0,A:6.399e-15,B:-0.999999999999994}
Converted {L:1,A:6.399e-15,B:-0.999999999999994}
Converted {L:1,A:1.00000000000001,B:-0.999999999999994}
Converted {L:1,A:1,B:-0.999999999999994}
Converted {L:1,A:1,B:-1.99999999999999}
Converted {L:1,A:1,B:-1}
Converted {L:1,A:1,B:0}
Converted {L:1,A:1,B:1}

Following steps are used in skin color face detection.

1) *Image Enhancement:* The principal objective of image enhancement is to process a given image so that the result is more suitable than the original image for a specific application. It accentuates or sharpens image features such as edges, boundaries, or contrast to make a graphic display more helpful for display and analysis.
2) *Skin Color Segmentation:* Many more computer vision and biometric applications allot with the detection and recognition of humans and their activities require the segmentation of skin regions as a pre-processing step for detecting meaningful skin color. Skin color detection may avoid exhaustive search for faces in an entire image. In this step, we describe that how non skin color is rejected from an Image so that the image may contains only skin like areas, which will be our skin color segmented image for further processing.
3) *Image Segmentation:* Image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain characteristics.
4) *Box formation:* In computer vision, the bounding box is nothing but the coordinates of the rectangular border that encompasses a digital image when it is placed over a page, or over a screen or other similar background. In this paper around each white area a box is formed using 8-connectivity nodes called as bounding box. After forming the binary image which is represented in the form of white and black color area, the box is drawn over the white area of image.
5) *Detection of face from image:* The bounding box drawn over a white area of image which shows face from image. Bounding box perform the operation like classifier which classifies face and non face area from the input image. Hence in this way the face area gets detected.

B. Proposed algorithm

Steps for face detection algorithm is given as below

1) Read the particular image
   Input image = imread('image_name');
2) Convert image to L*a*b* color space
   a = makecform('srgb2lab')
3) Computes a global threshold (level) that can be used to convert an intensity image to a binary image with im2bw.
   level = graythresh('image_name');
   BW = im2bw(I, level);
4) Form the bounding box over image to represent detected face .After the step of LAB image formation and gray image formation, the image get converted into binary image where we get the image in white and black pixel. The pixel of white color show the face image and black pixel shows the non face image.
   BB=regionprops(P,'Boundingbox');
   Use the edge color parameter to denote the particular box.
   Rectangle ('position', 'edgecolor', 'r');
5) Crop the image between the bounding box that clearly shows the face. Hence here face detection get successful.
   Cropped_image = imcrop('image_name');

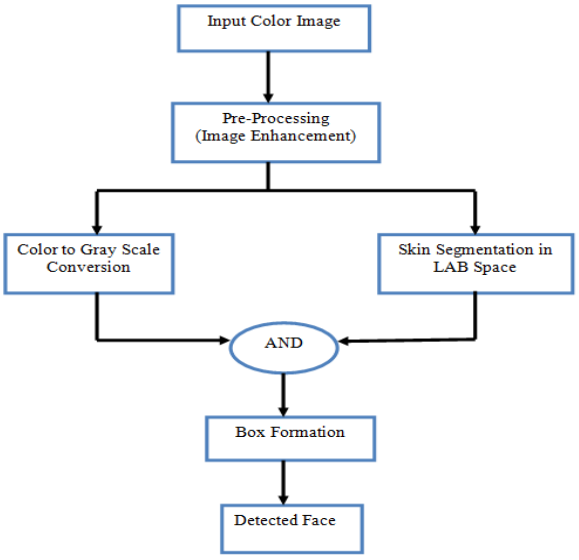

Fig 3. Face detection algorithm

Test image for face detection system from database is given as below

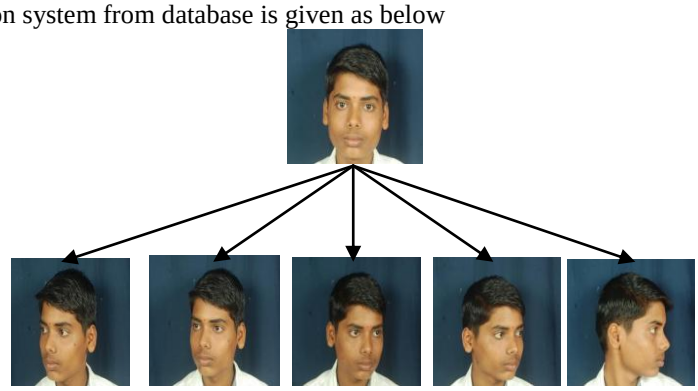

Fig 4. Test image with different pose

These are the images read from our self created database. We applied the proposed algorithm on one of these images. It returns the face from selected image. Detailed pictorial implementation of system is given as below.

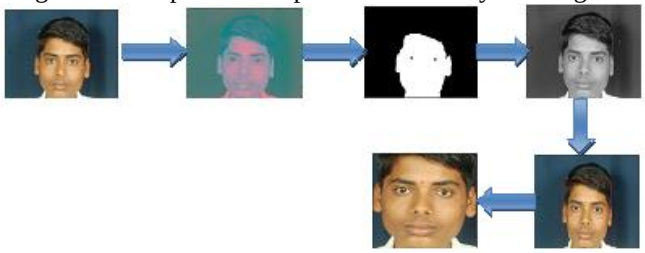

Fig 5. Entire face detection process

V. EXPERIMENTAL ANALYSIS AND RESULT

In this paper we perform face detection using skin color based method. We tested this method on our self created database. In this database we have total 70 images with varying poses. Under standard lighting condition and controlled background .Our method has correct detection rate almost for all images. The position of the face in an image (profile, front), has no impact on the quality of face detection.

Following table shows face detection performance of the proposed method in our face image database. Our method accuracy is good enough, but it also has one problem like in some situation the bounding box is also drawn over the hair of person, the reason behind this is that hair color is same as skin color. So this method also detects hair as a part of face. Apart from this drawback this method gives good enough accuracy for face detection. In our paper this method detects all faces in different poses.

Table1. Face detection performance evaluation

Characteristics of our database			**Face detection with our method**				
Images	No. of images	No. of face	No. of faces detected		No. of faces not detected	No. of false faces	Error rate
Frontal	10	10	10	100%	0	0	0%
Profile	60	60	60	80%	0	0	20%

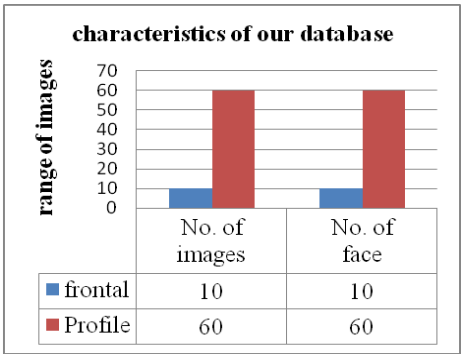

Fig 6. Graphical Representation of Database

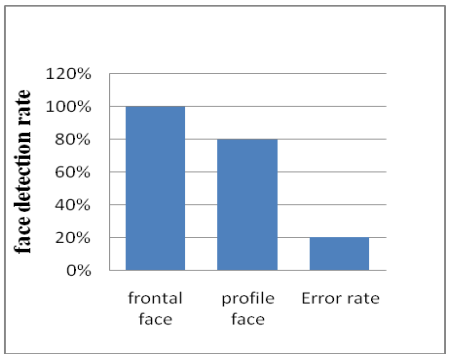

Fig 7. Success Rate of Face Detection

VI. CONCLUSION

We have presented an approach for face detection under varying pose variation. This detection approach initially takes the color image which is in the form of RGB color space and converts it to the LAB color space. Our proposed method is very user friendly and easy to understand. Our method propose novel algorithm for face detection so we got the positive result for every image from our database hence we can say that proposed method is user friendly. Another important thing is that proposed method overcomes the problem of false face detection which usually happens. Proposed method detects only face area and ignore non face area from image. Our method gives correct detection result for both frontal and profile view face image. Skin color based face detection forms the bounding box over the face followed by skin segmentation and image segmentation process. Experimental Results of proposed method achieve satisfactory detection accuracy.

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