Color Detection for Indian Skin

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***Abstract*— In this paper, Indian Skin Color from an image is detected using image processing techniques. For color detection HSV color space is being used. Histogram equalization technique is implemented to suppress illumination variance. Then Morphological operations are applied on the image to detect the exact shape of object. A camera is used to capture the images with different quality (low and high resolution). Obtained image or video will be processed using MATLAB to obtain and display the results. This approach is successful with a wide range of Indian Skin colors with diverse illumination conditions as well as images of different resolutions. The used approach has more accuracy and less processing time as compared to existing research work mentioned in literature survey.**

Keywords— RGB; HSV; Histogram Equalization; Morphological Operations

I. INTRODUCTION

Skin detection means searching skin-colored regions or pixels in an image or a video. Skin detection is generally used as a preprocessing step in order to find regions that have human faces or limbs in an image. Skin color detection is useful in face recognition, human-computer interaction, skin disease detection, gesture recognition, sign language recognition as done in [6], [15]-[19], and a wide range of image processing applications [1], [5]. Sharmila[12] has used hsv model for American sign language detection. Kavi Mahesh[13] has used canny edge detection and boundary tracing for skin colored object detection. Lokhande[14] have done segmentation using HSV color model. Human skin color is the main deciding factor in skin recognition. But this task is tedious as skin tone varies widely among different races across the world. In India, skin tone of people varies from very fair to darker shades as we move from north to south in the country. The existing research work related to skin color detection becomes insufficient to include this wide range of skin tones. Therefore, this paper considers threshold limits for Indian skin color range.

To achieve skin color detection the image is broken down into individual pixels and these pixels are then classified into skin colored and non-skin colored category as referred from [7]. This can be done by checking if each skin pixel falls into a defined color range (threshold) in some coordinates of a color space. There are many color spaces available, like RGB, HSV, YCbCr, YIQ, YUV, etc. as used in [4], [8]. In this paper, HSV color space for skin color segmentation is used.

II. METHODOLOGY

A. Appropriate Input Image

The input images are captured using any kind of camera. The captured image is an RGB image. An image stored in .jpg or .png can work as an input. This image is resized to 224x224 for optimum results and then used for further processing.

B. Color Model

RGB model (Red, Green, and Blue) fails to detect skin color accurately as it is affected by brightness effects. In HSV color model, color information is represented by Hue (color-depth), Saturation (color purity) and Value (color-brightness). Hue signifies the basic colors from red, blue and green and ranges from 0 to 360. Saturation implies concentration of the color and ranges from 0 to 100%. Value represents brightness of the color. It is a non-chromatic aspect of the image.

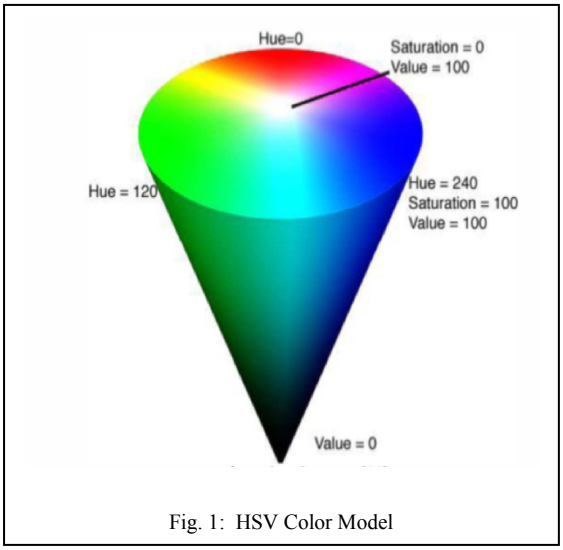

Fig. 1: HSV Color Model

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C. Histogram Equalization

The results of skin color detection are affected by many factors like background color, light conditions while capturing the image etc. Histogram equalization involves adjustment of contrast in an image using the histogram of that image as described in [2], [3]. By using this method, global contrast of many images can be increased especially when closer contrast values represent the usable data of the image. These intensities are better distributed through this adjustment on the histogram as done in Fig.5. Due to this, areas having low local contrast acquire a higher local contrast. To achieve this, histogram equalization spreads out the highly frequent intensity values effectively. Histogram equalization on V component makes image invariant of illumination changes.

D. Thresholding

Skin color is estimated using HSV color cone as referred in Fig. 1 and accordingly, the range of pixels is calculated. Skin color can be in general represented in the middle of red and yellow. In the cone from Fig. 1, red and yellow colors lie in the range of 0 to 120 degrees. Thus, the threshold for hue is decided to be less than 0.29 (104.4 degree). Similarly, the saturation threshold is limited from 0.148 to 0.98.

E. Conversion to binary image and application of Morphological operations

When an image is captured, there are various objects in its background. If their color lies in the threshold, they are also classified as skin color. To avoid this, image is converted to a binary image and is passed through median filters and a series of morphological operations as referred in [11]. This process causes elimination of any background noise which is present and only the desired object is retained as a binary image.

1) Median Filter: Median filter is the most widely used filter in image processing technique. It is a smoothing filter with egde preservation. It works best for salt and pepper noise in image as mentioned in [9]. In this paper, a 2D median filter is used as shown in Fig. 9 to removes unrelated small background details which potentially fall in skin color range. The filter strength depends on the shape and size of the window chosen. This window is traversed on the entire image. The centre pixel in the window is replaced by the median of all the pixels in that window.

2) Morophological operations: These operations are used to reduce structural discontinuties in an image as observed in Fig. 10. They consist of a combination of dilation and erosion as per the requirement of current application. The strength of dilation and erosion is determined by a structural element. It is a small matrix which can be designed specific to the current application. In this paper, morphological operations are carried out on median filtered binary image.

a) Dilation: Dilation is used to make objects more visible. It adds white pixels at the boundaried of existing objects in an image. This also helps to fill the holes or bridging the gaps in an image.

b) Erosion: It is used to remove small un-necessary objects in an image. Erosion removes white pixels from the boundaries of objects. This removes the islands and only substantial objects are retained in the image.

F. Regeneration of RGB Image

The R, G, B components of original image are multiplied with median filtered image components of binary image for background elimination. The resultant image is RGB image and consists of only skin color pixels present.

III. Implementation

The implementation of this project is explained by the flowchart given below.

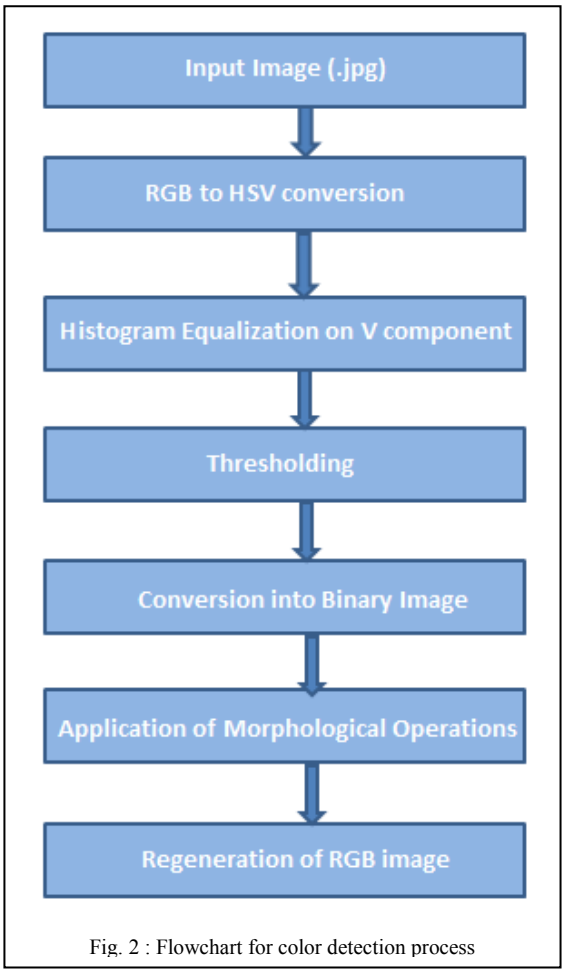

Fig. 2 : Flowchart for color detection process

IV. RESULTS

The algorithm was first tested with different thresholds for hue and saturation values for HSV image until the optimum results were obtained. Some of the results are shown in Table 1.

Table 1

Sr. No.	Hue Threshold	Saturation Threshold	Skin Color detected Output image
1.	0 <= h <= 0.04	0.148 <= s <= 0.98	
2.	0 <= h <= 0.7	0.148 <= s <= 0.98	
3.	0 <= h <= 0.29	0.01 <= s <= 0.98	
4.	0 <= h <= 0.29	0.58 <= s <= 0.98	
5.	0 <= h <= 0.29	0.148 <= s <= 0.98	

This algorithm was applied and tested on a numerous images. These images were captured for various people with different backgrounds and different illumination conditions. This method detected skin colored pixels from the input image successfully.

Fig.3, Fig.4, Fig.5 and Fig.6 show effect of histogram equalization on the image.

Fig. 3: Original Image

Fig. 4: Histogram equalized image

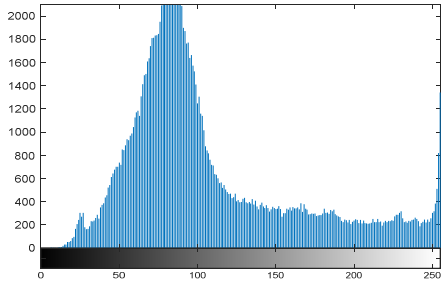

Fig. 5 Histogram of Original Image

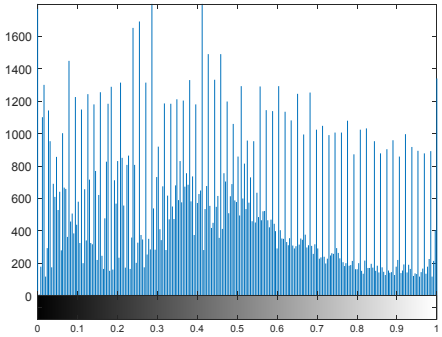

Fig. 6: Equilization of histogram

The histogram equalized image looks bright and thus detection accuracy improves for further stages.

Fig. 7 is HSV image on which thresholding is applied. The resultant image is converted to binary as shown in Fig. 8. Median filters followed by morphological operations are applied on it as shown in Fig. 9 and Fig. 10 to obtain resultant image- Fig. 11.

Fig. 7: HSV image

Fig. 8: Binary image

Fig.9: Median Filtered Image

Fig. 10: Morphological operations

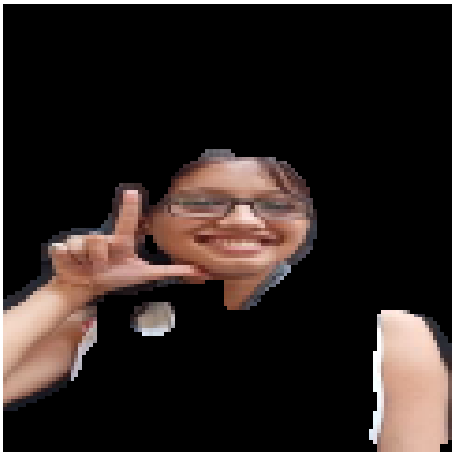

Fig. 11: Final Image

Thus skin color detection is achieved for this image with 94.5% accuracy.

Fig. 12 to Fig. 20 represents results for different input image.

Fig. 12: Original Image

Fig. 13: Histogram equalized image

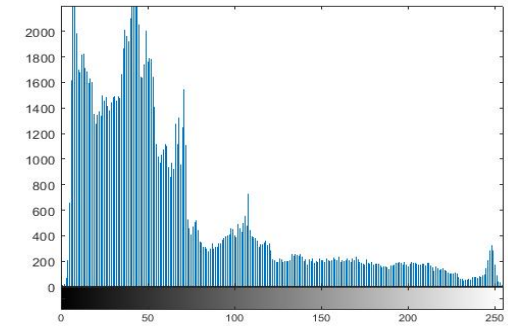

Fig. 14 Histogram of Original Image

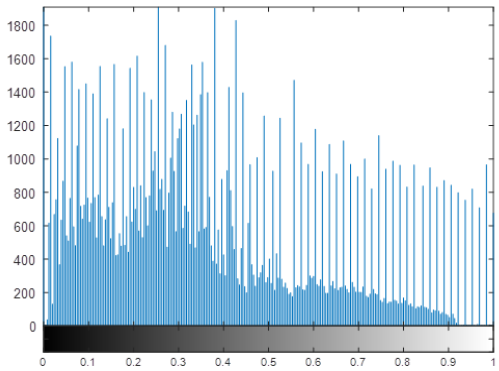

Fig. 15: Equilization of histogram

Fig. 16: HSV image

Fig. 17: Binary image

Fig.18: Median Filtered Image

Fig. 19: Morphological operations

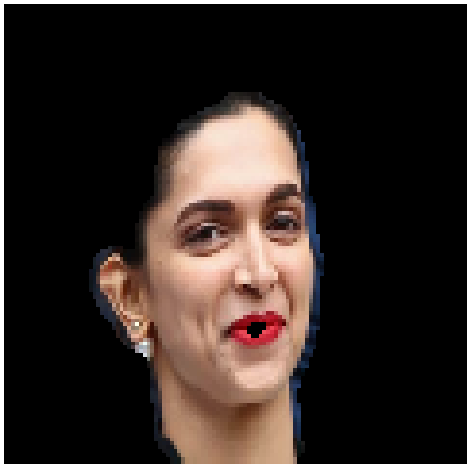

Fig. 20: Final Image

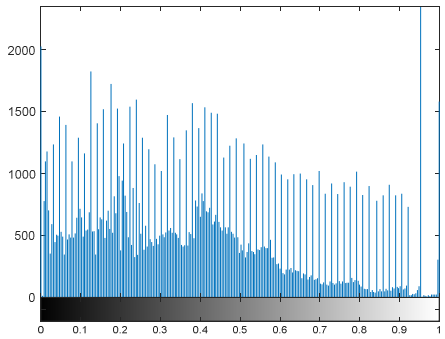

Fig. 24: Equilization of histogram

Thus skin color detection is achieved for this image with 93% accuracy.

Fig. 21 to Fig. 29 represents results for different input image.

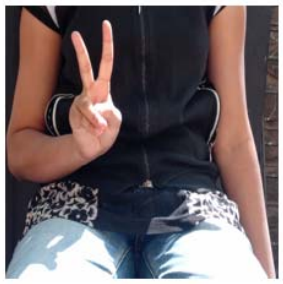

Fig. 21: Original Image

Fig. 22: Histogram equalized image

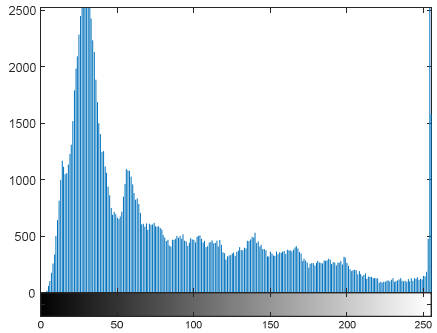

Fig. 23 Histogram of Original Image

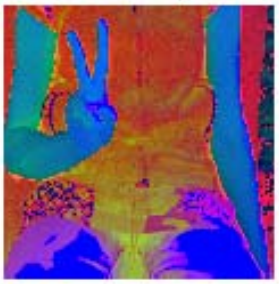

Fig. 25: HSV image

Fig. 26: Binary image

Fig.27: Median Filtered Image

Fig. 28: Morphological operations

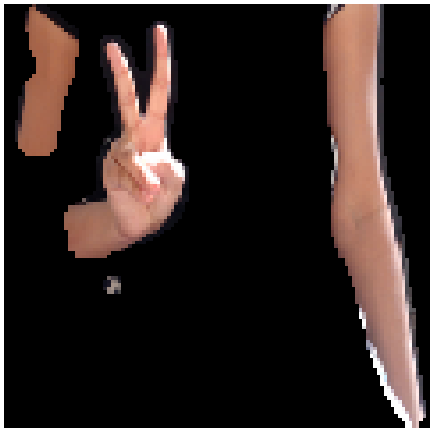

Fig. 29: Final Image

Thus skin color detection is achieved for this image with 93.1% accuracy.

V. CONCLUSION

Recognition of Indian skin is achieved by using HSV color space. The result has primary impact of appropriate threshold values. HSV color space works very efficiently for color based separation of pixels in an image when the background has a controlled noise. This approach is successful under uneven lighting conditions due to application of histogram equalization. The accuracy of this approach is more than 93% which is better than existing approaches mentioned in literature survey for different resolutions of images. Processing time taken is also lesser as compared to existing techniques. So this method is applicable to the images having even or uneven illumination and fairly controlled noisy background.

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