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Comparative Study of Skin Color Detection and Segmentation in HSV and YCbCr Color Space

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Abstract

This paper presented a comparative study of human skin color detection HSV and YCbCr color space. Skin color detection is the process of separation between skin and non-skin pixels. It is difficult to develop uniform method for the segmentation or detection of human skin detection because the color tone of human skin is drastically varied for people from one region to another. Literature survey shows that there is a variety of color space is applied for the skin color detection. RGB color space is not preferred for color based detection and color analysis because of mixing of color (chrominance) and intensity (luminance) information and its non uniform characteristics. Luminance and Hue based approaches discriminate color and intensity information even under uneven illumination conditions. Experimental result shows the efficiency of YCbCr color space for the segmentation and detection of skin color in color images.

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Keywords—Skin color; Segmentation; Color space; Luminance; Hue; Saturation; Value; Chrominance

1. Introduction

The objective of the skin detection is to find out skin regions in an image. Skin color detection is the process of separation between skin and non-skin pixels. It is the initial step to find the regions that potentially

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have human faces and limbs in an image. It is difficult to develop uniform method for the segmentation or detection of human skin detection because of color tone of human skin is drastically varied for people from one region to another. For example, the skin color tone of Europeans is completely different from Africans or Asians. The detection and segmentation of skin regions in an image is widely used in many applications such as classification and retrieval of color images in multimedia applications, video surveillance, human motion monitoring, human computer interaction, digital cameras, face detection and recognition, teleconference, hand detection, gesture detection. There are two types of skin detection, either pixel or region based. In the pixel based skin detection, each pixel is classified as either skin or non skin individually from its neighbor. The skin detection based on color fall in this category. In the region based skin detection, the skin pixels are spatially arranged to enhance the performance. This method requires additional information such as intensity, texture are required. In the skin color detection process, it is necessary to consider the following factors. (i) The distinction or separation of skin and non skin pixels in the image. (ii) The device for capture the image. For the same image, different cameras have different output. (iii) Whether illumination varies drastically in the image? (iv) Skin tones vary from one person to others. (v) Movement of object degrades the quality of image due to blurring of colors. (vi) Shadows and lightness has a vital role to change the color of the image. (vii) The color space used for the detection or segmentation. The subsequent sections of this paper are organized as follows. The section 2 briefly describes the concept of skin color detection using different color space. The method for the detection of skin color is given in the section 3. The section 4 describes the experimental results and finally the section 5 concludes the paper.

2. Color Space for Skin Color Detection

Color space is a mathematical model to represent color information as three or four different color components. Different color models are used for different applications such as computer graphics, image processing, TV broadcasting, and computer vision [22][23][24]. Different color space is available for the skin detection. They are: RGB based color space (RGB, normalized RGB), Hue Based color space (HSI, HSV, and HSL), Luminance based color space (YCBCr, YIQ, and YUV), and perceptually uniform color space (CIEXYZ, CIELAB, and CIELUV).The skin color detection based on RGB color space is explained in [4][5].RGB color space is not preferred for color based detection and color analysis because of mixing of color (chrominance) and intensity (luminance) information and its non uniform characteristics. The transformation of RGB to normalized RGB can be obtained by the process of normalization.

$$r = \frac{R}{R+G+B} \tag{1}$$

$$g = \frac{G}{R+G+B} \tag{2}$$

$$b = \frac{B}{R+G+B} \tag{3}$$

$$r + g + b = 1 \tag{4}$$

The component 'b' does not contain any valuable information. If there is any memory constraint, this component can be omitted. In normalized RGB color space, the color information can easily be separated from the intensity information. But under uneven illumination conditions, normalized RGB is not considered for color detection or segmentation. The skin color detection based on normalized RGB color space is explained in [6][7][8][9].

Luminance and Hue based approaches discriminate color and intensity information even under uneven illumination conditions. The conversion from RGB to HSI or HSV will take time and expensive. Moreover, if there is a lot of fluctuation in the value of the color information (hue and saturation), pixels with small and large intensities are not considered. In the case of YCbCr color space, transformation and efficient separation of color and intensity information is easy as compared to HSI or HSV.HSV based skin color detection and segmentation is elaborately described in [7][10][11][12][13][14].The transformation of color images in RGB color space is transformed into HSV color space using (5)(6)(7).

$$H = arccos \frac{\frac{1}{2}(2R-G-B)}{\sqrt{(R-G)^2-(R-B)(G-B)}} \quad (5)$$

$$S = \frac{max(R,G,B)-min(R,G,B)}{max(R,G,B)} \quad (6)$$

$$V = max(R,G,B) \quad (7)$$

YCbCr color space based skin color detection and segmentation is explained in [7][15][16][17]. The transformation of color images in RGB color space is transformed into HSV color space using (8)(9).

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} + \begin{bmatrix} 0.279 & 0.504 & 0.098 \\ -0.148 & -0.291 & 0.439 \\ 0.439 & -0.368 & -0.071 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (8)$$

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1.164 & 0.000 & 1.596 \\ 1.164 & -0.392 & -0.813 \\ 1.164 & 2.017 & 0.000 \end{bmatrix} \begin{bmatrix} Y-16 \\ Cb-128 \\ Cr-128 \end{bmatrix} \quad (9)$$

In computer based applications, the full range of 8- bit is used, without providing space for header and footer. This full-range color format is used for JPEG images. The conversion between RGB color space and YCbCr color space is described by the following equations:

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 0 \\ 128 \\ 128 \end{bmatrix} + \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.169 & -0.331 & 0.500 \\ 0.500 & -0.419 & -0.081 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (10)$$

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1.000 & 0.000 & 1.400 \\ 1.000 & -0.343 & -0.711 \\ 1.000 & 1.765 & 0.000 \end{bmatrix} \begin{bmatrix} Y \\ Cb-128 \\ Cr-128 \end{bmatrix} \quad (11)$$

The information relevant to CIELAB based skin color detection is presented in [7][18]. Neural network based self organizing maps can be applied for the efficient detection of skin regions. This is explained by [19].Automatic segmentation of human face in the complex background scene is explained in [20].The human face detection in color images under complex background and uncontrolled illumination in YCbCr and HSV color space is given in [21].

3. Methodology

Skin detection using HSV and YCbCr color space is based on the threshold value of the individual component of corresponding color space. Due to non-uniform and device dependent nature, RGB color space not widely used for color based analysis. This section explains the methodology used for the skin detection in color images using two different color spaces.

3.1 Skin Detection using HSV Color Space

The algorithm for the detection of human skin color in color images is explained as follows.

1. Input image is obtained from the image database which is the collection of 30 color images.

2. Input image in RGB color space is converted into HSV color space using transformation. HSV image is a collection of three different images as hue, saturation and value.

3. Histogram is computed for all three components and from the histogram, threshold value for three components is determined.

4. Masking is applied for skin pixels in the test image.

5. Threshold is applied to the masked image.

6. Threshold image is smoothened and filtered.

7. The output image contains only skin pixels.

3.2 Skin Detection using YCbCr Color Space

This method is purely based on the threshold value of three different components. When an RGB color image is transformed into YCbCr color image, the resultant image is comprised of intensity component (Y) and chrominance components (Cb and Cr). In our experiment, threshold is applied for chrominance components only as Cr > 150 && Cr < 200 && Cb > 100 && Cb < 150.

4. Experimental Results and Discussion

4.1 HSV Color Space based Skin Detection

Figure 4 shows the experimental result of HSV color space based skin detection. The input image in RGB color space is transformed into HSV color space. So the input image is split into three different components as hue, saturation and value based on color (chrominance) and intensity information. This is shown in Fig. 1(b)-1(d) and their corresponding histogram is shown in Fig 2. From the histogram, corresponding threshold value is determined. Masking of skin pixels is shown in Fig. 1(e). Then threshold is applied for the masked image. The threshold value for this image is selected as 150. The pixel value less than threshold are simply removed. Finally the output image is obtained after smoothening and filtering. The same procedure is repeated for the test image 2 and 3 shown in Fig 3(a) and 5(a) respectively. The threshold value for these two images is 500 to remove the non skin pixels due to its complex background.

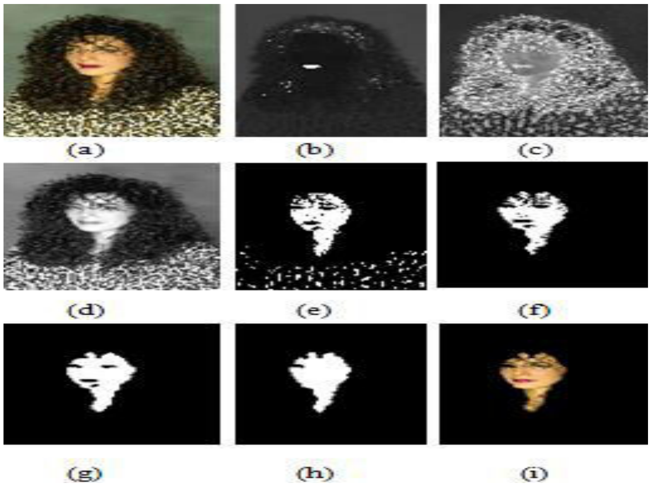

Fig.1. Skin detection using HSV color space (a) test image1 (b) hue image (c) saturation image (d) value image (e) masking of skin pixels (f) threshold image (g) smoothened image (h) regions filled image (i) output image.

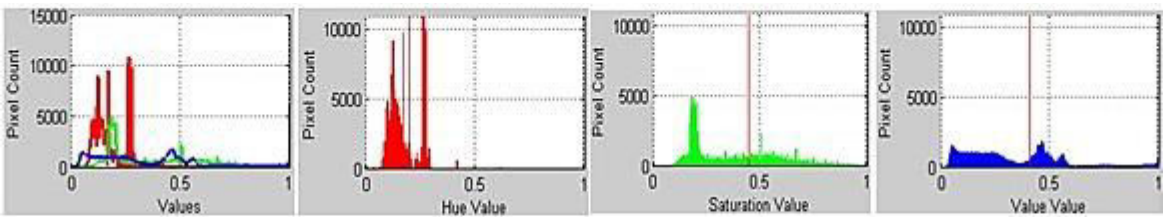

Fig.2. Histogram and threshold value for hue, saturation and value. The vertical red line indicates threshold value.

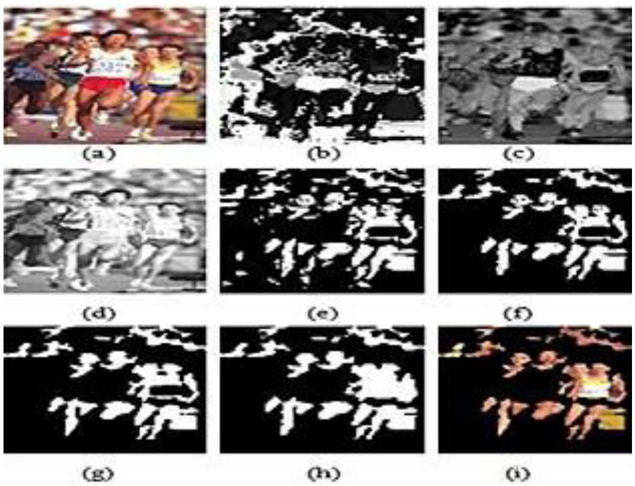

Fig.3. Experimental result on test image 2 (a) test image (b) hue image (c) saturation image (d) value image (e) masking of skin pixels (f) threshold image (g) smoothened image (h) regions filled image (i) output image.

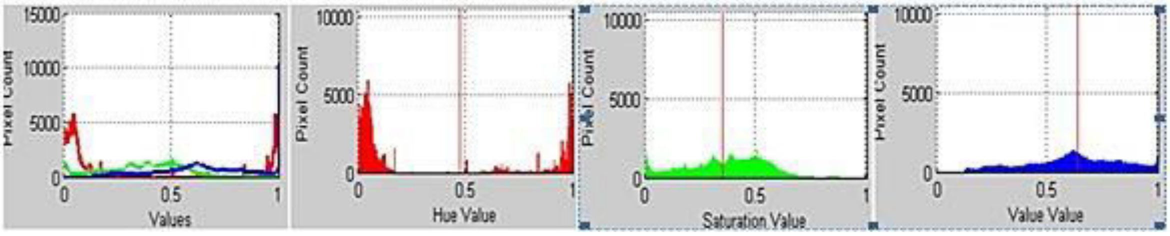

Fig.4. Histogram and threshold value for hue, saturation and value. The vertical red line indicates threshold value.

Fig.5. Experimental result on test image 3 (a) test image (b) hue image (c) saturation image (d) value image (e) masking of skin pixels (f) threshold image (g) smoothened image (h) regions filled image (i) output image.

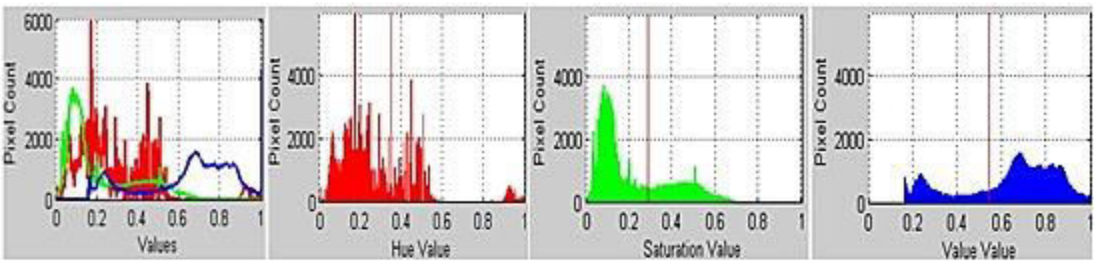

Fig.6. Histogram and threshold value for hue, saturation and value. The vertical red line indicates threshold value.

4.2 YCbCr Color Space based Skin Detection

Figure 7 shows the experiment result of the skin detection using YCbCr color space. This method is purely based on the threshold value of three different components. When an RGB color image is transformed into YCbCr color image, the result image is comprised of intensity component (Y) and chrominance components (Cb and Cr). In our experiment, threshold is applied for chrominance components only as Cr > 150 && Cr <

200 && Cb > 100 && Cb < 150.

(a) (b)

Fig.7. Skin color detection using YCbCr color space (a) test images (b) output images.

5. Conclusion

The detection and segmentation of skin pixels using HSV and YCbCr color space is explained. The result of HSV and YCbCr color space based skin color detection is based on the selection of threshold value. These approaches discriminate color and intensity information even under uneven illumination conditions. The transformation of color images from RGB to HSV is time consuming process. In this, Cartesian coordinate system is converted into polar coordinate system. The HSV based detection is best suited for simple images with uniform background. Moreover, if there is a lot fluctuation in the value of the color information (hue and saturation), pixels with small and large intensities are not considered. In the case of YCbCr color space, transformation and efficient separation of color and intensity information is easy as compared to HSI or HSV. This color space is effective and efficient for the separation of image pixels in terms of color in color images. So YCbCr color space can be applied for the complex color images with uneven illumination.

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