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Skin Detection for Face Recognition Based on HSV Color Space

Miss.Snehal Manjare[*1], Dr.Mrs.S.R.Chougule[2]
[*1,2]Department of E&TC, Shivaji University, Kolhapur, India
manjaresnehal1991@gmail.com

Abstract

Skin color has proven to be a useful and robust cue for face detection, localization and tracking. Image content filtering, content aware video compression and image color balancing applications can also benefit from automatic detection of skin in images. Numerous techniques for skin color modelling and recognition have been proposed during several past years. This work describes an implementation for skin detection which relies on the H channel to characterize the skin color range. The open Cv library is used for image processing. The program initially converts RGB images to HSV one. The H channel is used to characterize the color range for skin detection. To illustrate the approach we compare this with others. However, a comprehensive survey on the topic is still missing. We try to fill this vacuum by reviewing most widely used methods and techniques and collecting their numerical evaluation results.

Keywords: HSV, color segmentation, color space, model selection, skin detection

Introduction

Detection of the human face is an essential step in computer vision and many biometric applications [1] such as automatic face recognition, video surveillance [2], human-computer communication and large-scale face image retrieval systems. The first and foremost important step in any of these systems is the accurate detection of the presence and the position of the human faces in an image [3] or video. The main challenges encountered in face detection is to cope with a wide variety of variations in the human face such as posture and scale, face orientation, facial expression, ethnicity and skin color [3,4,5]. External factors such as occlusion, complex backgrounds [6,7,8] inconsistent illumination conditions and quality of the image may also contribute significantly to the overall problem. Face detection in color images [1,9] has also gained much attention and notice in recent years. Color is known to be a useful cue to extract skin regions [2,10,11] and it is only available in color images. This allows easy face localization of potential facial regions without any consideration of its texture and geometrical properties [8,12]. Most techniques up to date are pixel-based skin detection methods [13], which classify each pixel as skin or "non-skin" individually and independently from its neighbours. Some of the early methods used various statistical color models such as a single Gaussian model [14], Gaussian mixture density model [15] and histogram based model [16].

Various color spaces provides us various discriminality between skin pixels and non-skin pixels over various illumination conditions. Skin color models [17] that operate only on chrominance subspaces such as the Cb-Cr [18, 19, 20] and H-S [21] have been found to be effective in characterizing various human skin color. Peer et al.[22]constructed a set of rules to describe skin cluster in RGB space while Garcia and Tziritas [23] used a set of bounding rules to classify skin regions on both YCbCr[28] and HSV spaces.

In this paper, we present a skin color model RGB-HSV for human face detection. This model utilizes the additional hue and chrominance information of the image on top of standard RGB properties to improve the discriminality between skin pixels and non-skin pixels.

In our approach, skin regions are classified using the RGB boundary and also additional new rules for the HSV subspaces. These rules are constructed based on the skin color distribution obtained from the training images. The rest of the paper is organized as follows: Section 2 briefly describes the various models for face detection system. Section 3.presents proposed method for this paper. and system overview which represents system in detail. Section 4 gives Distributation Of Skin Color In Simple RGB Color Space. Section 5 gives the system Experimental results.

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Color Spaces used for Skin Modelling

Colorimetry, computer graphics and video signal transmission standards have given birth to many color spaces with different properties. A wide variety of them have been applied to the problem of skin color modelling. We will briefly review the most popular color spaces and their properties.

RGB

RGB is a colorspace originated from CRT (or similar) display applications, when it was convenient to describe color as a combination of three color rays (red, green and blue). It is one of the most widely used color spaces for processing and storing of digital image data. However, high correlation between channels, significant perceptual non-uniformity (see section 2.6 for perceptual uniformity explanation), mixing of chrominance and luminance data make RGB not a very favourable choice for color analysis and color based recognition algorithms. This colorspace was used in [Brand and Mason 2000], [Jones and Rehg 1999].

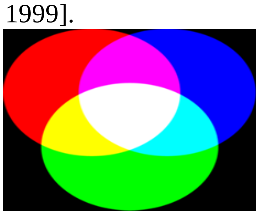

Figure No. 1 RGB Space Model

Normalized RGB

Normalized RGB is a representation that is easily obtained from the RGB values by a simple normalization procedure:

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

As the sum of the three normalized components is known ($r + g + b = 1$), the third component does not hold any significant information and can be omitted, reducing the space dimensionality.

The remaining components are often called ”pure color”, for the dependence of r and g on the brightness of the source RGB color is diminished by the normalization. A remarkable property of this representation is that for matte surfaces, while ignoring ambient light, normalized RGB is invariant (under certain assumptions) to changes of surface orientation relatively to the light source [Skarbek and Koschan 1994]. This, together with the transformation simplicity helped this colorspace to gain popularity among the researchers [Brown et al. 2001], [Zarit et al. 1999], [Soriano et al. 2000], [Oliver et al. 1997], [Yang et al. 1998]

HSI, HSV, HSL:

Hue Saturation Intensity (Value, Lightness)

Hue-saturation based color spaces were introduced when there was a need for the user to specify color properties numerically. They describe color with intuitive values, based on the artist’s idea of tint, saturation and tone. *Hue* defines the dominant color (such as red, green, purple and yellow) of an area, *saturation* measures the colorfulness of an area in proportion to its brightness [Poynton 1995]. The “intensity”, “lightness” or “value” is related to the color luminance. The intuitiveness of the colorspace components and explicit discrimination between luminance and chrominance properties made these colorspaces popular in the works on skin color segmentation [Zarit et al. 1999], [McKenna et al. 1998], [Sigal et al. 2000], [Birchfield 1998], [Jordao et al. 1999]. Several interesting properties of Hue were noted in [Skarbek and Koschan 1994]: it is invariant to highlights at white light sources, and also, for matte surfaces, to ambient light and surface orientation relative to the light source. However, [Poynton 1995], points out several undesirable features of these color spaces, including hue discontinuities and the computation of”brightness” (lightness, value), which conflicts badly with the properties of color vision.

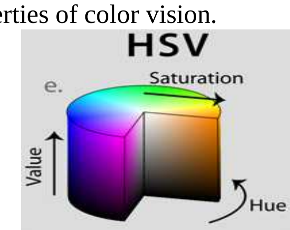

Figure No. 2 HSV Space Model

$$H = \arccos\{[(1/2)((R-G)+(R-B))]/[((R-G)2+(R-B)(G-B))]^{1/2}$$
$$S = 1-3[\min(R,G,B)/(R+G+B)]$$
$$V = 1/3[(R+G+B)]$$

An alternative way of hue and saturation computation using log opponent values was introduced in [Fleck et al. 1996], where additional logarithmic transformation of RGB values aimed to reduce the dependence of chrominance on the illumination level. The polar coordinate system of Hue-Saturation spaces, resulting in cyclic nature of the colorspace makes it inconvenient for parametric skin color models that need tight cluster of skin color for best performance. A different representation of Hue-Saturation using Cartesian coordinates can be used [Brown et al. 2001]:

$$X = S\cos H, \quad Y = S\sin H$$

TSL:

Tint, Saturation, Lightness

A normalized chrominance-luminance TSL space is a transformation of the normalized RGB into

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more intuitive values, close to hue and saturation in their meaning.

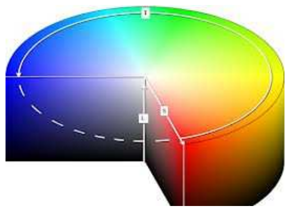

Figure No. 3 TSL Space Model

S = [9/5(r'2+g'2)]1/2

T =arctan(r'/g')/2p +1/4, g' > 0

arctan(r'/g')/2p +3/4, g' < 0

0, g' = 0

L = 0.299R+0.587G+0.114B

where r0 = r−1/3, g0 = g−1/3 and r, g come from averaging.

YCrCb:

YCrCb is an encoded nonlinear RGB signal, commonly used by European television studios and for image compression work. Color is represented by luma (which is luminance, computed from nonlinear RGB [Poynton 1995]), constructed as a weighted sum of the RGB values, and two color difference values Cr and Cb that are formed by subtracting luma from RGB red and blue components.

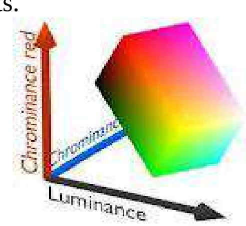

Figure No. 4 YCrCb Space Model

Y = 0.299R+0.587G+0.114B

Cr = R−Y (9)

Cb = B−Y

The transformation simplicity and explicit separation of luminance and chrominance components makes this colorspace attractive for skin color modelling [Phung et al. 2002], [Zarit et al. 1999] [Menser and Wien 2000], [Hsu et al. 2002], [Ahlberg 1999], [Chai and Bouzerdoum 2000].

Proposed Work

In this paper, from different models HSV model is used. For this first input image is converted to HSV model. So that it's easy to use HSV model to find skin details.

The goal of skin color detection is to build decision rule that will discriminate between skin and non-skin pixels. A skin detector typically transforms a given pixel into an appropriate color space and then uses a skin classifier to label the pixel whether it is a skin or a non-skin pixel [9]. The skin detection algorithm produces a mask, which is simply a black and white image. The black pixel values are 0 (false) and the white pixel values are 1 (true). This mask of ones and zeros acts as a logic map for skin detection (i.e., if a pixel is 1 this pixel location is likely skin).The simplest way to decide whether a pixel is skin color or not is to explicitly define a boundary. RGB (Red, Green, Blue) matrix of the given color image can be converted into different color spaces to yield distinguishable regions of skin or near skin tone. Mainly two kinds of color spaces are available HSV (Hue, Saturation and Value) and YCbCr(Yellow, Chromatic Blue, Chromatic red) spaces. For this work HSV color space is chosen. It is experimentally found and theoretically proven that the distribution of human skin color constantly resides in a certain range within the color space [1]. Yang and Waibel [10] are able to achieve skin tracking by dimensional reduction of the available color space.

In this work, skin detection is performed using HSV color space. For this convert RGB image into HSV color space. In HSV, responsible vales for skin detection are Hue & Saturation so extract the Hue and Saturation dimensions into separate new variables (H & S). For skin detection threshold should be chosen as [H1, S1] & [H2, S2]. A pixel is classified as skin pixel if the values [H, S] fall within the threshold. Threshold is predefined range associated with the target skin pixel values. Most of the researchers determined threshold as h_range = [0, 0.11] and s_range = [0.2, 0.7]. Sobottaka and Pitas [11] defined a face localization based on HSV. They found that human flesh can be an approximation from a sector out of a hexagon with the constraints: Smin= 0.23, Smax =0.68, Hmin =00 and Hmax=500

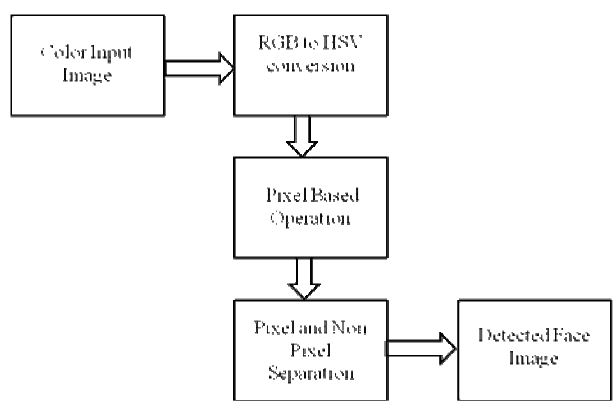

Figure No.5 Overview of Face Detection System

Fig:1 shows the system overview of the proposed face detection system, which consists of a conversion stage and detection stage. In our color-based approach to face detection, prior formulation of the proposed RGB-HSV skin model is done using a set of training images. Two commonly known color spaces– RGB, HSV are used to construct the proposed hybrid model.

In the first step face detection, conversion of RGB plane to HSV plane. After that, pixel based HSV skin detection will done. A combination of morphological operations is applied to the extracted skin regions to eliminate possible non-face skin regions. Finally, the last step labels all the face regions in the image and returns them as detected faces. In our system, there is no pre-processing step as it is intended that the input images are thoroughly tested under different image conditions such as illumination variation and quality of image. Since we emphasize on the use of a skin color model in this work, our system is restricted to color images only.

Result of skin detected mechanism is shown below in figure no 8 and 9.

Figure no. 8 Input Image

Figure No. 9 Separated skin and non skin pixels

Distribution Of Skin Color In Simple RGB Color Space

Figure no shows the distributation of skin color. As skin color differs from black to white, i.e. zero to one. Though the skin color is a combination of red, green and blue but it contents more red and green component more, as compared to blue color. This phenomenon is used to separate the three component and to use for different applications like steganography, so that it gives best outputs.

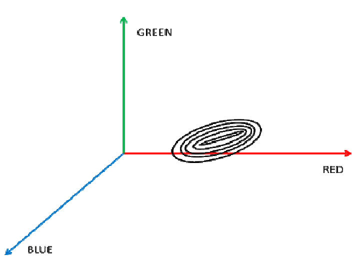

Figure No.10 Distributation of skin color in RGB plane

Simulation Results

In this paper, this section focus on simulation results for proposed system. This has been implemented using MATLAB R2009.

Figure no. 11 Face Detected Image

Figure No. 12 Face detected image 2

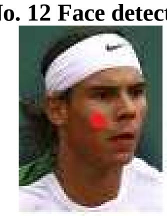

Figure No. 13 Face detected image 3

Figure No.11 to 13 shows the results for input image, which gives skin detected pixels, which results into face detection.

Conclusion

Even though there are many modern and accurate softwares today yet in this paper, we have presented a novel skin color model, RGB-HS-CbCr to detect human faces for students with minimal knowledge in image processing. The Skin region segmentation was performed using combination of RGB, HS and CbCr subspaces, which demonstrated evident discrimination between skin and non-skin regions. The experimental results showed that our new approach in modeling skin color was able to achieve a good detection success rate. This project would serve as a stepping stone for future improvements and modifications. As it is simple to understand hence it will readily understood by students who then will be encouraged to make modifications and create a more sophisticated project.

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This paper presented and compared both a color based algorithm (using RGB, HSV and YCbCr representation spaces) and a texture-based algorithm (using the Spectral Variation Coefficient) for skin detection on color images. Although most work on skin detection is based on modelling the skin on different color spaces, we have explored the use of texture as a descriptor for the extraction of skin pixels in images.

The accuracy provided by each segmentation feature based algorithm (color versus texture) is shown under different hand-segmented images. The skin detection texture-based approach reduces in average a 13.6% the misclassified skin pixels with respect to the colour-based approach for the considered test images. A necessary future work is to validate the proposed algorithms using a standard skin database like the ECU dataset (Phung et al., 2005). This will permit to compare our recognition results with those presented by other authors for the same test images. Another improvement will consist in adapting our algorithms to detect skin in black or Asian people (not only white Caucasian).