Fusion of Multi Color Space for Human Skin Region Segmentation

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***Abstract*—This paper proposes a technique to extract human skin color regions from the color images based on combination of both RGB and YU'V color spaces. Since skin pixels can vary with ambient light, to find the range of values for which most skin pixels fall in the skin color space becomes a hard task. Therefore, other techniques based on normalized rg, HSV, YUV, YIQ, YCbCr, RGB, YCbCr-YU'V color spaces are presented and compared in this paper in order to select the appropriate control limits for the purpose of skin color segmentation. From the experimental results, the skin detection results obtained by the proposed technique based on RGB-YU'V color model is found to be the most appropriate color model compared to other methods.**

***Index Terms*—Skin color segmentation, color space, control limits, YCbCr- YU'V.**

I. Introduction

Skin color contains relatively concentrated information in human's faces color images. A skin color detection system is always used in many vision systems, such as gesture recognition, hand tracking, video indexing, region of interest extraction and face detection.

The main work of skin color detection is to build a noise filter for removing the non-skin color pixels, so that the remaining skin color pixels will fall in the given color space. A color space is a specification of a coordinate system where each color is represented by a single value. Various color spaces are used for processing digital images. A face detection method based on YCbCr is proposed in [1]. In their method, skin color regions are extracted which excludes the non-skin color regions using the sigma control limits for color variations. This skin color detection system is very efficient in accuracy. Apart from this method which utilizes merely one color space, there are also methods which employ more than one color space.

Two major methods utilizing more than one color space are based on combination of YCbCr-YU'V and RGB-YU'V color spaces. Both YCbCr-YU'V and RGB-YU'V color spaces are shown to be robust and reliable for human skin color detection. These two approaches are based on saturation parameter control limits.

In this paper, a series of skin color segmentation methods based on normalized rg, HSV, YUV, YIQ, YCbCr, RGB, YCbCr-YU'V, RGB-YU'V color models are introduced and compared with each other. The proposed skin color regions segmentation technique is based on combination of RGB and YUV color models. The experimental results show that the proposed approach can detect skin color regions more accurately than other methods.

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II. Skin Color Segmentations Methods

A. Skin Color Segmentation in Normalize rg Color Model

The normalized rg color space is one of the most widely used color spaces for processing digital image for skin color detection. There is one method of skin color segmentation which is introduced in [2]. In this method three spectral components R(red), G(green), B(blue) and I(brightness) are normalized as follows:

$$r=\frac{R}{R+G+B},\ g=\frac{G}{R+G+B}\ ,b=\frac{B}{R+G+B} \quad (1)$$

where, $r+g+b=1$, so that the normalized color values can be expressed only with r and g. Another example using similar method is introduced in [3] and [4]. The skin color pixels are detected using thresholds of $0.360 \leq r \leq 0.465$ and $0.280 \leq g \leq 0.363$. The experimental results of this method are shown in Fig. 1 (a). Some non-skin regions are also represented as the skin region.

B. Skin Color Segmentation in HSV Color Model

This color model is used in [5] and the threshold values for H(hue), S(saturation) and V(value) are set to $0 \leq H \leq 50$, $0.20 \leq S \leq 0.68$, and $0.35 \leq V \leq 1.0$. Fig. 1 (b) shows the skin segmentation results of this method, and some non-skin regions are also classified as skin region sometimes.

C. Skin Color Segmentation in YUV and YIQ Color Models

YUV and YIQ color models are used by Yao and Gao [6]. Skin color pixels are obtained by using $V$and Icomponents of YUV and YIQ color models, respectively. The skin segmentation results of these two color models are shown in Fig. 1 (c) and Fig. 1 (d). As can be observed from the figure, there are still a lot of non-skin regions are segmented as skin regions.

D. Skin Color Segmentation in YCBCR Color Model

One skin color region segmentation method based on YCbCr color model is used in [1]. Sigma control limits are used in statistical sampling and the threshold values for Cb and Cr are $97.5 \leq Cb \leq 142.5$ and $134 \leq Cr \leq 17$, respectively. This technique is found to be very efficient in accuracy as the results shown in Fig. 1 (e).

E. Skin Color Segmentation in RGB Color Model

This method is introduced in [7]. Skin color is classified by heuristic rules that take into account two different conditions: uniform daylight and flash or lateral illumination. The chosen skin cluster or RGB is [7]: R>95 and G>40 and B>20 ; max{R,G,B}−min{R,G,B}>15 ; |R−G|>15 and R>G and R>B. In case of flashlight or daylight lateral illumination, (R,G,B) is classified as skin if R>220 , G>210 , B>170| R-G | ≤ 15 , B<R , B<G. where R,G,B = [0,255]. The results of this method are shown in Fig. 1(f).

F. Skin Color Regions Segmentation in YCBCR –YU'V and RGB-Y U'V Color Spaces

Different from all above methods, a technique to skin color regions segmentation based on combination of two color spaces is proposed. Due to the efficiency of skin segmentation results, YCbCr and RGB color spaces are chosen to be the appropriate color spaces. Besides the control limits in these two color models, another filter is used to further remove noise pixels here. Saturation parameter 'ch' in YUV color model is used to produce more accurate detected skin in [8]. Similarly, 'ch'' represents the saturation in YU'V color space. These YU'V color space and 'ch'' are defined as follow:

$$\begin{bmatrix} Y \\ U' \\ V \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ 0.147 & -0.289 & 0.436 \\ 0.615 & -0.515 & -0.100 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (2)$$

$$ch' = \sqrt{U'^2 + V^2} \quad (3)$$

Threshold value for $ch'$is $30 \leq ch' \leq 220$. Then one skin color space is built with combination of YCbCr and YU'V, while another one is built with combination of RGB and YU'V. The skin color segmentation results are shown is Fig. 1 (g) and Fig. 1 (h). We may observe that both of these two techniques perform well and better than other color spaces mentioned earlier.

TABLE I: COMPARISON OF AVERAGED RUNNING TIME AND ORIGINAL SKIN AREA TO SEGMENTED SKIN AREA RATIO FOR VARIOUS SKIN SEGMENTATION METHODS

Skin Color Segmentation Methods	Averaged Running Time (*sec*)	Averaged Original Skin Area to Segmented Skin Area Ratio
YCbCr	0.110	1: 2.1434
YCbCr-YUV	0.173	1: 1.9810
RGB	1.111	1: 1.6826
RGB-YUV	1.179	1: 1.5291

III. EXPERIMENTAL RESULTS AND DISCUSSIONS

According to Hiremath and Danti [1], the skin segmentation methods based on YCbCr color space is more robust than methods based on single color space like normalized rg, HSV, YUV and YIQ. The comparative analysis results of the methods based on YCbCr, RGB, YCbCr-YU'V and RGB-YU'V are shown in Table 1. All experiments are implemented using MATLAB 2009b which operates on a Pentium IV @ 2.6GHz PC.100 images of multi race people from web pages are used for testing and analysis.

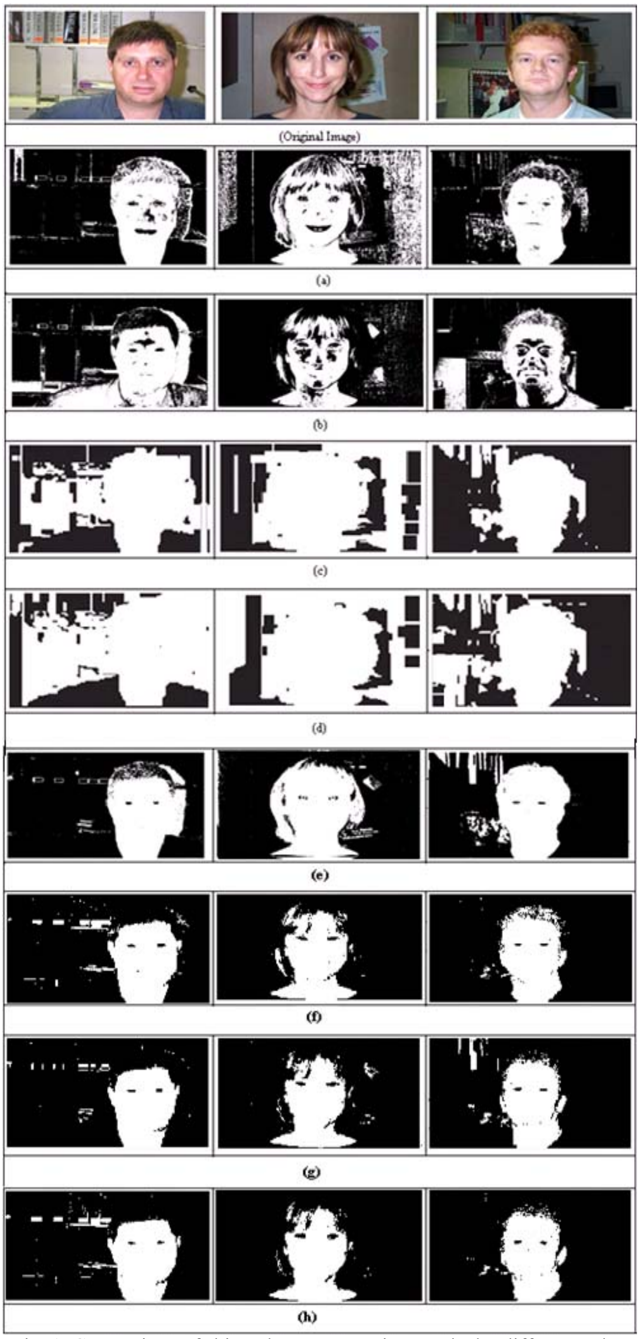

Fig. 1. Comparison of skin color segmentation results by different color models; (a)Normalized rg, (b)HSV, (c)YUV, (d)YIQ, (e)YCbCr, (f)RGB, (g)YCbCr-YU'V and (h)RGB-YU'V (proposed method) using CalTechDatabase

IV. CONCLUSION

This paper introduced a total of eight 8 methods for skin color segmentation based on different color space model. The proposed method is a fusion of two color spaces RGB and YUV. Since control limits of RGB and saturation parameter control limits of YU'V are efficient in removing non-skin pixels, it is shown empirically that these two control limits can be utilized for better skin color segmentation. From the segmentation results shown in Table 1, it can be concluded that the proposed technique using RGB-YU'V can segment the skin color region from complex image background more accurately compared to the other 7 methods tested in the experiments .

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