Preferred Skin Color Reproduction for Color Image Quality Enhancement

Do-Hun Kim, Sung-Il Chien, Heung-Sik Tae
School of Electronic & Electrical Engineering, Kyungpook National University
1370 Sangyuk-dong, Buk-gu, Daegu 702-701, South Korea
Phone: +82-53-950-5545, E-mail: sichien@ee.knu.ac.kr

Abstract

The skin color of a human being is the important memory color influencing image quality for color display. Therefore, in this paper, the preferred skin color axis is defined on HSV color space by analyzing some previous research, and the preferred skin color reproduction algorithm is performed by rotating the center axis of skin distribution of an input image to the preferred skin color axis.

1. Introduction

The observer's preference is an important measure to evaluate the quality of an image in display devices. The preference indicates the degree of satisfaction of observer with respect to an image. The memory color is widely used for the evaluation of preference and the reproduction of preferred color. In particular, the skin color of a human being is regarded as one of the most important memory colors in color display [1-2].

In this paper, a new method is proposed to enhance the quality of color image by analyzing some previous research and considering of the preferred skin color. The preferred skin color points in different color space of the previous works are converted to the CIE 1976 (u',v') chromaticity coordinates, what is called the device independent color space. In addition, the preferred skin color reproduction algorithm is proposed by rotating the center axis of the distribution of the skin color of an input image to the preferred skin color axis in HSV color space.

2. Preferred Skin Color Analysis in (u',v') Chromaticity Coordinates

The study of the preferred skin color has occupied an important part for color reproduction, and proceeded with much research [1-4]. The preferred skin color points of previous researches are shown in Fig. 1. The three ellipses in Fig. 1 indicate the preferred skin color areas that are ordered: Caucasoid, Mongoloid, and Negroid from the left with the Demas's preferred skin color [3]. So, in this paper, the center points of these ellipses are decided to the preferred skin colors. In case of Lee's preferred skin color [4], the points are used without any adjustment because those are presented accurately in the original paper. Moreover, in case of the preferred skin color of Demas and Lee, the center point of the preferred skin color is classified by an ethnic group which is also ordered Caucasoid, Mongoloid, and Negroid from the left, respectively. In case of the preferred skin color proposed by the Samsung [1], the point in YC_bC_r color space is transformed to the (u',v') chromaticity coordinates. At this occasion, the reference white (D_{65}) and the NTSC primaries are used for the transformation. In addition, the preferred skin color point of the ETRI [2] is converted from the $L^*a^*b^*$ color space to the (u',v') chromaticity coordinates by using the value of (a^*,b^*) introduced in this research and by setting L^* properly through the experiments.

As shown in Fig. 1, most of the preferred skin color points are located within Demas's preferred skin color region, but Lee's preferred skin color points are positioned far from the region. Specifically, the preferred skin color points of Demas are closer to the reference white than the preferred skin color of the others. That is mainly because Demas's experiment is performed in Japan but the others are carried out in South Korea. It may reflect the cultural difference between the Korean and the Japanese. In case of the preferred skin color proposed by the ETRI, their position is similar to that of the Samsung as shown in Fig. 1. However, the preferred skin color point of the ETRI is dependent on the setting of L^*. The higher L^* is applied, the closer to Demas's preferred skin color the position is. In addition, the lower L^* is set, the closer to the preferred skin color of the Samsung the position is.

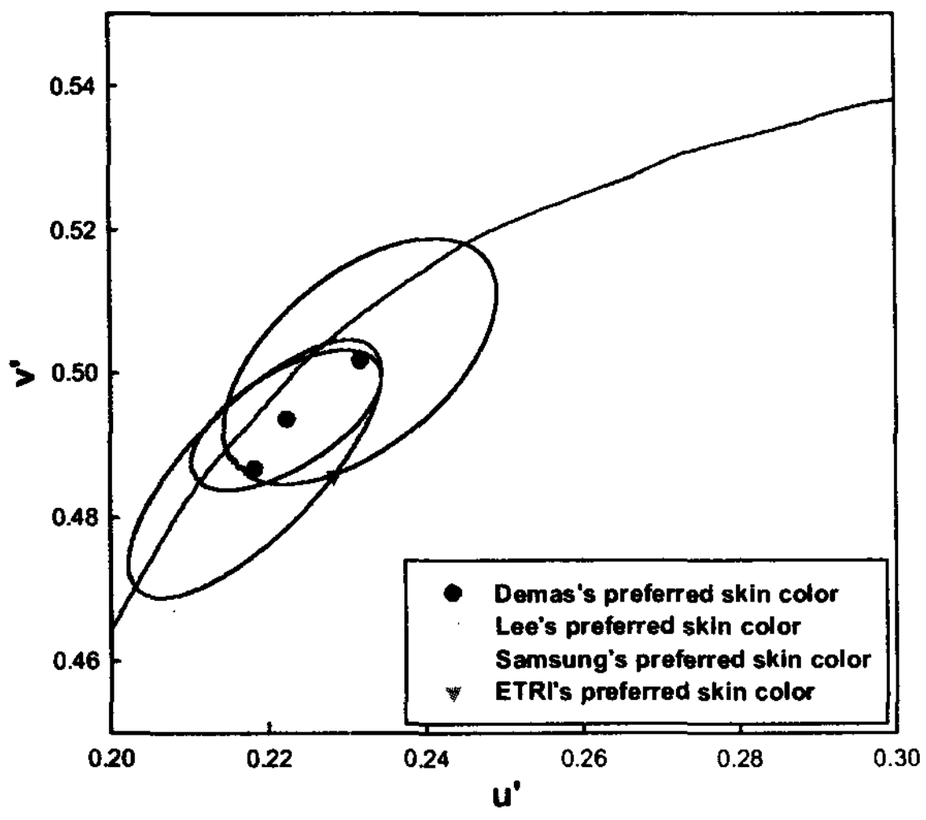


Figure 1 (u',v') chromaticity coordinates of preferred skin colors

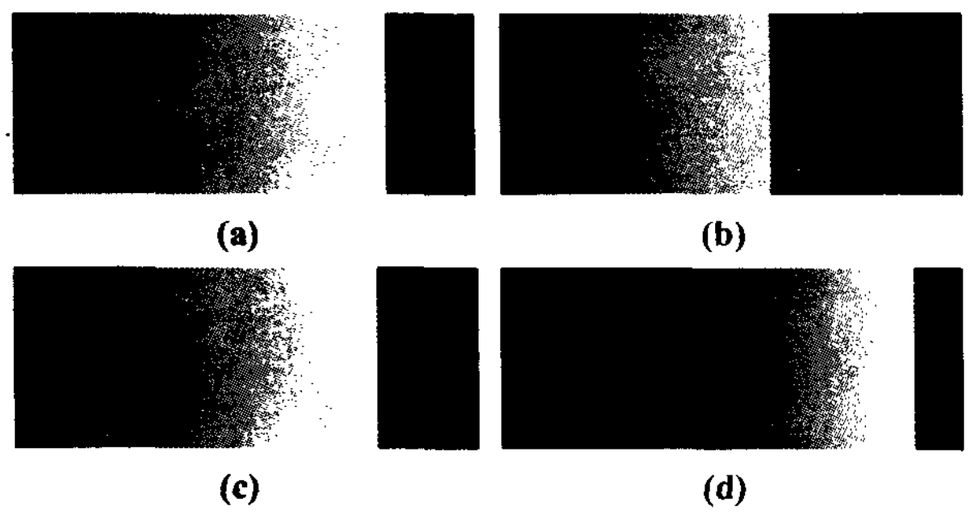


Figure 2 Color gradation images with respect to preferred skin color proposed by (a) Demas (Mongoloid), (b) Lee (Mongoloid), (c) Samsung, and (d) ETRI

Figure 2 shows a gradation image for the preferred skin color. Each of them is generated by varying the luminance value in the (u',v') chromaticity coordinates. The black band on the gradation images is appeared due to the color gamut problem. That indicates the part of odd value beyond the expressible color when using the NTSC primaries and the reference white (D_{65}). Figure 3 shows the expressible color with respect to the luminance values in the (u',v') chromaticity coordinates by using the NTSC primaries and the reference white. As shown in Fig. 3, the expressible color area tends to be shrink according as the luminance value increases, and is gradually converging into the reference white. In case of Lee's preferred skin color, the expressible luminance value is much lower than that of the others, because the points are relatively far from the reference white. These color gamut problem according to the luminance value is quite important for the color reproduction. Unless the luminance value is considered during the color reproduction, the colors out of the expressible area can be noise signals and they may result in deteriorating of image quality.

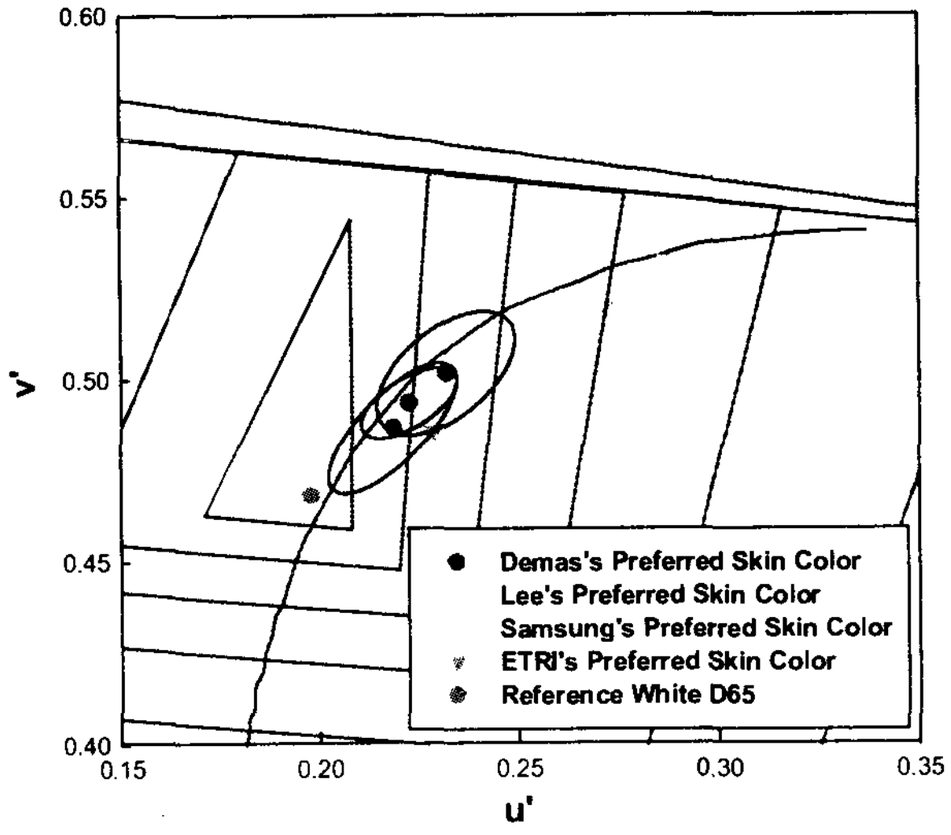


Figure 3 NTSC color gamut at varying luminance Y from inner color gamut to outer color gamut, where Y is 90, 80, 70, 60, 50, and 40, respectively

3. Preferred Skin Color Reproduction in HSV Color Space

The preferred skin color area in Fig. 1, the deviation of saturation is much larger than that of hue. This fact shows that people has relatively similar preference about hue but the tendency of various favorites about saturation. Therefore, we propose the preferred skin color reproduction method considering hue having relatively common preference to the preferred skin color as well as removing unnaturalness according to the transition of saturation. HSV color space works better for human eyes system than commonly used RGB color space. Moreover, HSV color space has a tremendous advantage. It is because human vision system looks at the objects in this way, i.e., it recognizes the hue and saturation.

Figure 4 shows an implementation example of the proposed algorithm, which illustrates the overall flow chart of the preferred skin color reproduction method

in HSV color space. The proposed algorithm is composed of three main procedures of the color space conversion, the skin color pixel detection, and the rotation of hue distribution. In the color space conversion procedure, the color information received from red, green, and blue of an input image is transformed to hue (H), saturation (S), and value (V). In the skin color pixel detection procedure, the skin color pixels are detected by using the transformed hue, saturation, and value [5]. The subtraction value of the preferred skin color axis, denoted by ΔH, is computed by applying the Eq. (1) to the obtained skin color pixels, calculated in this manner. The skin color distribution of the input image is now converted, in order to mainly align the preferred skin color axis, by applying ΔH to the skin color pixels. The proposed method preserves skin color distribution of the input image and modifies the center axis of the distribution as shown in Fig. 5. Thus, the proposed method has an advantage that the naturalness of the original image can be maintained after converting the skin color into the preferred skin color.

$$\Delta H = H_{prefer} - \frac{\sum_{i=1}^{n} H_{seg}}{n} \qquad (1)$$

$$H_{out} = H_{in} + \Delta H$$

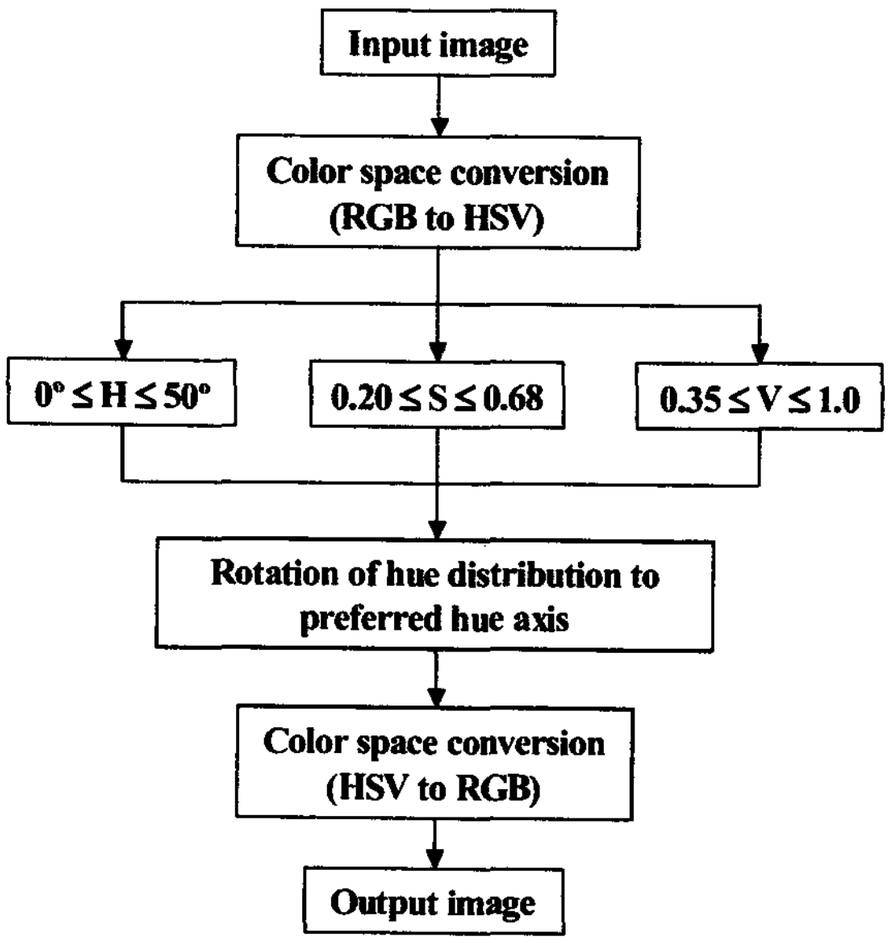


Figure 4 Flow chart of proposed algorithm

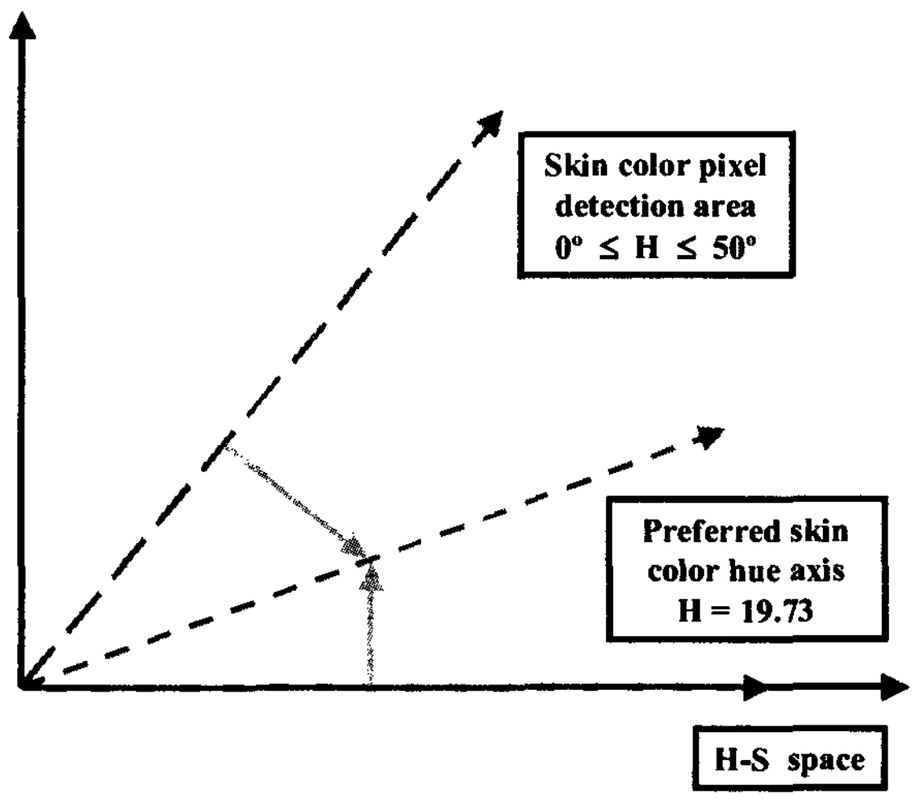
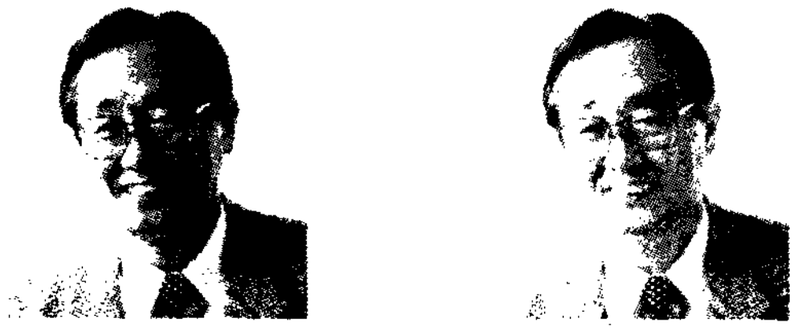


Figure 5 Preferred skin color reproduction in H-S Space (preferred skin color axis was calculated by Samsung's preferred skin color)

4. Experimental Results and Discussions

Figure 6 shows the resultant portrait images of the proposed algorithm. The original input image is rather unnatural due to excessive scarlet color pixels as shown in Fig. 6(a). This abnormal skin colors are corrected by the proposed method using the hue axis calculated from the preferred skin color proposed by (b) Demas, (c) Lee, (d) Samsung, and (e) ETRI. In case of the preferred skin color proposed by Demas and Lee, the point with respect to Mongoloid is used. The result image based on Demas's preferred skin color in Fig. 6(b) becomes white because the preferred skin color of Demas is the nearest one to the reference white, as mentioned in Chapter 2. In case of the result using the preferred skin color of Lee, compared with the others, there is a big difference in the (u', v') chromaticity coordinates. However, in HSV color space, the difference of hue is not great though the gap of saturation is relatively wide. Eventually, the result images in Fig. 6 are fairly similar. The primary reason is that the proposed algorithm only considers the distribution of hue. Exceptionally the result image with respect to Demas in Fig. 6(b) shows remarkable dissimilarity due to the cultural difference between the Korean and the Japanese. In addition, the result of using Demas's preferred skin colors is possible to include some errors, because the preferred skin color point is arbitrarily regarded as the center point of the ellipse area not considering whole the points there.



(a) (b) (c) (d) (e)

Figure 6 Preferred skin color reproduction images with proposed algorithm: (a) Original image, (b) reproduced image by Demas's preferred skin color, (c) reproduced image by Lee's preferred skin color, (d) reproduced image by Samsung's preferred skin color, and (e) reproduced image by ETRI's preferred skin color

5. Conclusion

The appropriate points of the preferred skin color are used to improve the quality of color image by analyzing and considering some previous research. Each of them is restricted to the expressible colors with respect to varying the luminance value in the device independent color spaces, and their saturations are widely distributed. Therefore, we do not consider luminance and saturation for the preferred skin color reproduction.

The proposed method reproduces the preferred skin color using the hue axis in HSV color space. And this method has an advantage that the naturalness of the original image can be maintained after converting the skin color into the preferred skin color.

6. Acknowledgement

This work was supported by grant No. (R12-2002-055-02002-0) from the Basic Research Program of the Korea Science & Engineering Foundation.

7. References

[1] Moon-Cheol Kim and Jae-Hwan Oh, "Skin Tone Enhancement Based on Human Favorite Skin Color," in Proc. of IEEK Summer Conference, pp. 5-8 (2002).

[2] Dae-Hee Kim, Sang-Gi Hong, Jae-Young Jung, and Maeng-Sub Cho, "A Study on the Observer Preferable Colors of Natural Objects on PDP (Plasma Display Panel)," Journal of Korean Society of Color Studies, Vol. 16, No. 2/3, pp. 69-75 (2002).

[3] Demas Sanger, Takuya Asada, Hideaki Haneishi, and Yoichi Miyake, "Facial Pattern Detection and Its Preferred Color Reproduction," in Proc. IS&T and SID's 2nd Color Imaging Conference, pp. 149-153 (1994).

[4] Eung-Joo Lee and Yeong-Ho Ha, "Automatic Flesh Tone Reappearance for Color Enhancement in TV," IEEE Trans. on Consumer Electronics, Vol. 43, No. 4, pp. 1153-1159, (1997).

[5] Yanjiang Wang and Baozong Yuan, "A Novel Approach for Human Face Detection from Color Images under Complex Background," Pattern Recognition, 34, pp. 1983-1992 (2001).