# The Facial Skin Color Reproduction for a Liquid Crystal Display

*Yukio Okano and Kunio Yamane*
*Sharp Corporation, System Technology Development Center*
*Yamatokoriyama, Nara, Japan*

## Abstract

The facial skin colors appeared in internet web site are examined. It is shown that the skin colors in $a^*b^*$ color space are existed in the lower region between $+a^*$ axis and $+b^*$ axis and have higher values in lightness $L^*$. The LCD(Liquid Crystal Display) panels make bluish color reproduction. The facial skin colors reproduced on LCD become bluish. The compensation method of bluish reproduction for achromatic color is effective for skin color reproduction.

## Introduction

The facial skin color is one of the memory colors and its reproduction is important for display devices. The skin colors appeared in internet web site are examined. It is shown that the facial skin colors in $a^*b^*$ color space are existed in the lower region from yellow axis to magenta axis through red region and those values are in $-5<a^*<30$ and $-10<b^*<30$. The lightness $L^*$ for skin colors have higher values. It becomes clear that the distribution of skin colors are spread wider than those of printings.

The chromaticity change according to the variation from white point to primary color is useful index of high lightness color imaging. The chromaticity change for red is examined from the view point of skin colors reproduction.

In case of facial skin color reproduction on LCD(Liquid Crystal Display), LCD panels make bluish color reproduction. The facial skin colors reproduction on LCD become bluish. It is shown that the compensation method for bluish reproduction for achromatic color is effective for the facial skin color reproduction.

## Distribution of Facial Skin Colors in Web Site

There are many portraits in internet web site. The facial color distribution of the portraits is little known. The facial skin colors in many cases with cosmetic color for Japanese people are measured. The sample number is 52 portraits. The ($RGB$) data for cheek and forehead are collected.

The ($RGB$) data for portraits, if not specified by the ICC-profile, are imaged on standard sRGB monitor. The digital ($RGB$) data values can explicitly expressed as the device independent color space ($XYZ$). The conversion formula from ($RGB$) color space to ($XYZ$) color space is as follows,

$$X = 0.4152R + 0.3576G + 0.1805B \quad (1)$$

$$Y = 0.2126R + 0.7152G + 0.0722B \quad (2)$$

$$Z = 0.0193R + 0.1192G + 0.9505B \quad (3)$$

The conversions from ($XYZ$) color space to uniform chromaticity scale ( $u'v'$) is expressed as[1] ,

$$u' = 4X / (X + 12Y + 3Z) \quad (4)$$

$$v' = 9Y / (X + 12Y + 3Z) \quad (5)$$

The uniform color space ($L^*a^*b^*$) is given by the formula[1]

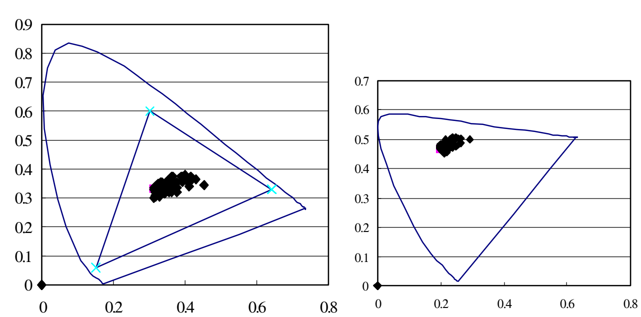
$$L^* = 116( Y / Yn)^{1/3} - 16 \quad (6)$$

$$a^* = 500\{( X / Xn )^{1/3} - ( Y / Yn )^{1/3}\} \quad (7)$$

$$b^* = 500\{( Y / Yn )^{1/3} - ( Z / Zn )^{1/3}\} \quad (8)$$

The measured ($RGB$) data were plotted. Figure1shows the distribution of facial skin colors on ($u',v'$) color space

Figure 1 show the facial skin color distributions plotted on ($xy$) chromaticity diagram and ($u'v'$) chromaticity diagram.




*(a) xy chromaticity diagram* *(b) u'v' diagram*

*Figure 1. Distribution of facial skin colors*

Figure 2 show the skin color distribution on (*u'v'*) diagram and the ellipse line indicate the skin color region in printing for the yellow races which was shown by Miyake.[2] The chromaticity of facial skin color of portraits appeared on web site are distributed broader than those of printings.

Figure 3 show the distribution of skin colors on (*a*b**) chromaticity diagram and histogram of lightness L*. It is shown that the facial skin colors in (*a*b**) color space are existed in the lower region from yellow axis to magenta axis through red region and those values are in $-5<a^*<30$ and $-10<b^*<30$. The lightness $L^*$ for skin colors have higher values. The lines in Figure 3(a) show the locus of varying the input digital level from white to yellow. red and magenta.

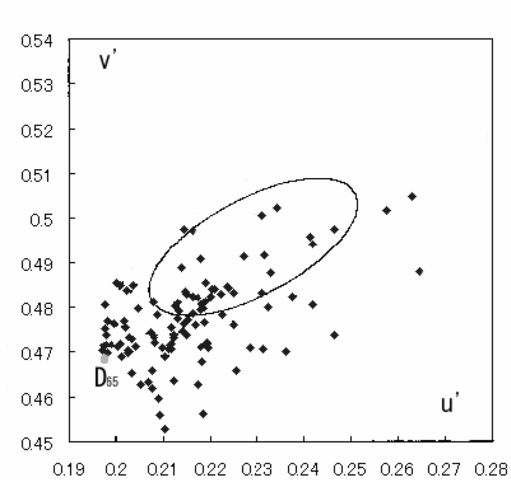
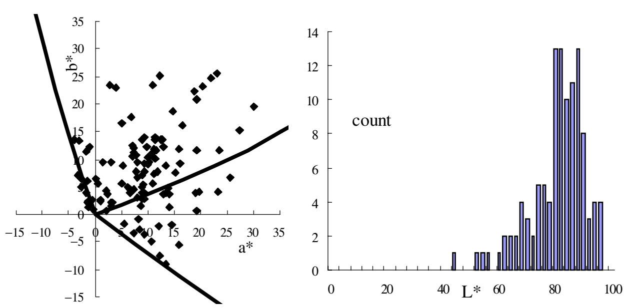



*Figure 2. Facial skin colors for Japanese plotted on (u'v') chromaticity diagram and skin color region (ellipse) on printing[2]*

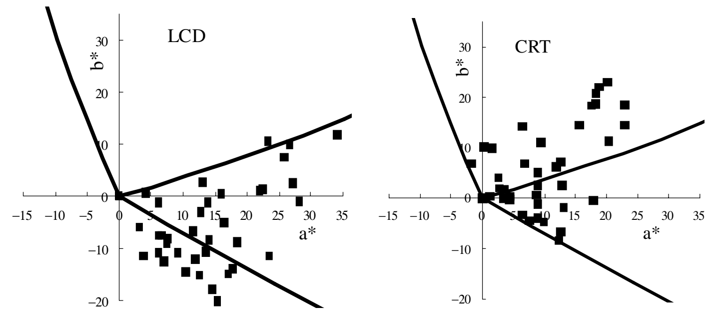



*(a)* *(b)*

*Figure 3. (a)Facial skin colors plotted on (a*b*) chromaticity diagram and (b)Histogram of lightness L*.*

## Facial Skin Colors on LCD

The facial skin color patches displayed on LCD(Sharp LL-M1500A) are measured by using colorimeter (Minolta CS-100A). For comparison, facial colors on CRT(Cathode Ray Tube, Barco PCD321PLUS) which is considered as sRGB standard monitor are also measured. Figure 4 show the distribution of measured (*a*b**) values. In Figure 4(a), facial colors displayed on LCD are shift toward blue direction. So, the facial skin colors on LCD becomes magentaish color.



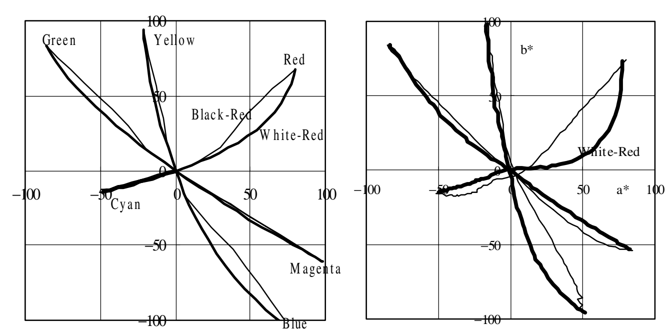

*(a) LCD* *(b)CRT*

*Figure 4. Chromaticity distribution for skin tone patches. Sample number is 37. (a)LCD display (b) sRGB standard CRT.*

## Chromaticity Locus of an LCD

The locus of varying the input digital level from black to primary colors (or complimentary color) is different from those from white to primary colors (or complimentary color). Figure 5 show the locus in the (a) standard sRGB, and (b) measured LCD in *a*b** plane. The thick lines indicate the locus from white to to primary colors (or complimentary color),and thin lines show the locus from black to primary colors (or complimentary color)

The chromaticity of portraits are distributed in high lightness and low saturation colors. The LCD color reproductions for high lightness in low saturation are important. So, the behavior of locus from white to red color is important for the reproduction of facial skin color. In Figure 5(b), the locus of red-white for LCD bends toward blue color region.

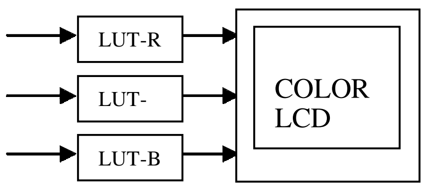



*(a) sRGB* *(b) LCD*

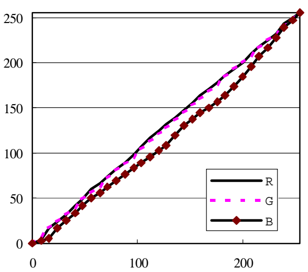
*Figure 5. Chromaticity locus in a*b* coordinates. (a)sRGB standard (calculated). (b) an LCD monitor(measured)*

## Compensation of LCD's Blue Shift [3]

The LCD has the blue shift tendency. The lower the input digital level, the higher the correlated color temperature for achromatic colors. The compensation of LCD's blue shift is done by using LUTs placed in the input signals for LCD panel.[3] Figure 6 show the schematic diagram and compensation LUTs. This compensation makes the correlated color temperature constant in spite of the digital input level. This method is achromatic compensation for LCD's blue shift.




*(a)*

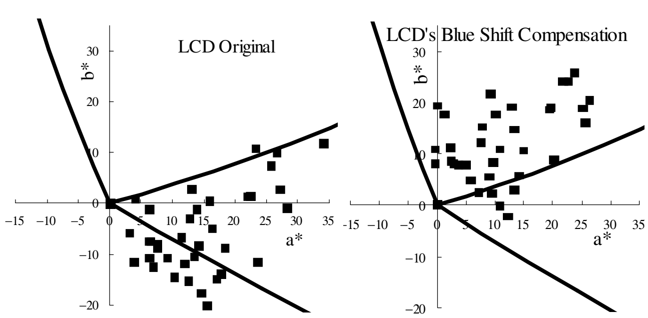



*(b)*

*Figure 6. Compensation of LCD's blue shift. (a)schematic diagram, (b)compensation LUTs*

## Blue Shift Compensation for Portrait in LCD

Figure 7 show the measured facial skin color distribution. Figure 6(a) shows the distribution of original LCD, and Figure 6(b) shows the distribution of compensated LCD. The compensated skin color distribution shown in Figure 6(b) is similar to sRGB standard CRT shown in Figure 4(b).




*(a) Original LCD* *(b) Compensated LCD*

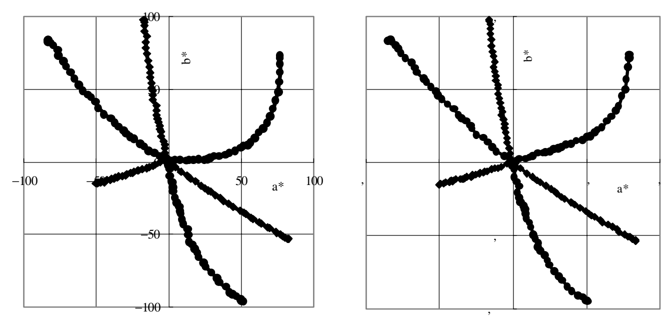
*Figure 7. Compensation of facial skin colors. Sample number is 37. (a)Original LCD, (b)Compensated LCD*

When we compensate the LCD's blue shift, the facial skin colors which shift toward blue direction are also compensated. The magentaish facial skin colors become normal colors distribution, as shown in Figure 6.

## Color Reproduction for High Lightness and Low Saturation

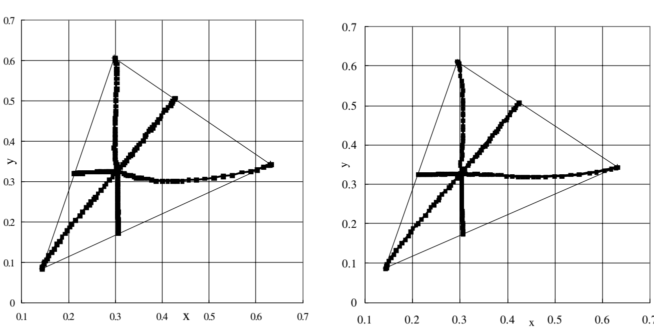
The reproduction of high lightness and low saturation colors should be expressed by the locus varying from white to primary and to complimentary colors. The blue shift compensation affects the red locus curve. The gradient for red and for cyan becomes almost same by the blue shift compensation, as shown in Figure 8(b). The color reproduction for high lightness and low saturation becomes similar to the sRGB reproduction as in Figure 5(a).

Figure 9 show the locus varying from white to primary and to complimentary colors in (*xy*) color coordinates. It is difficult to find the red locus compensation.




*(a) Original LCD* *(b) Comp ensated LCD*

*Figure 8. Locus from white to primary colors and to complementary colors in a*b* plane. (a)Original LCD, (b)Compensated LCD*




*(a) Original LCD* *(b) Compensated LCD*

*Figure 9. Locus from white to primary colors and to complementary colors, in (xy) coordinates. (a)Original LCD, (b)Compensated LCD*

## Conclusions

(1). The facial skin colors in (*a*b**) color space are existed in the lower region from yellow axis to magenta axis through red region and those values are in $-5<a^*<30$ and $-10<b^*<30$. The lightness $L^*$ for skin colors have higher values.
(2). Chromaticity of facial skin color of portraits appeared on web site are distributed broader than those of printings.
(3). The locus of low color saturation in (*a*b**) diagram is different from that of primary colors.
(4). The red color reproduction locus of high lightness and low saturation for LCD is shift towards blue direction.
(5). The blue shift skin colors caused by LCD panel can compensate by the achromatic compensation method which makes the correlated color temperature constant.

## References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2. Yoichi Miyake, Analysis and Evaluation of Digital Color Images, University of Tokyo Press, Tokyo, Japan, 2000, pg. 172-175.
3. Yukio Okano, Color Reproductions Varying the Input Level on a Liquid Crystal Display Panel, Proc. IS&T/SID's 7th Color Imaging Conference, pg. 233. (1999).


## Biography

**Yukio Okano** received his B.S. degree in Applied Physics from the Osaka University in 1967 and a Ph.D. in Information Science from Chiba University in 1999. From 1967 to 1997, he worked at Minolta Corporation in Osaka, Japan. Now he has worked at Sharp Corporation in Nara, Japan. His primarily interest is focused on the image processing and color science. He is a member of the IS&T and the SPSTJ, and an expert of ISO/TC42/WG18.