Selective Color Correction for Arbitrary Hues

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Abstract

This paper proposes new selective color correction methods for digital color images, which do not require masking of the correction area. The most commonly employed method can only effectively correct pixels containing one of six specific hues (R,G,B,C,M,Y). In response to this situation, the authors have developed two new selective color correction methods, the HSV method and the RGB subtractive method, both of which can be applied to arbitrary hues within an adjustable hue range. In actual testing, the methods have produced excellent results, and may be expected to make it easier for users to retouch photograph images.

1 Introduction

The retouching of scanned color photographic images is still often performed using either tone reproduction curve control or matrix conversion [1]. The problem in both techniques, however, is that retouching of pixels in one part of an image can influence pixels throughout the image. To avoid the problem, creating an appropriate mask is required.

Traditionally, this disadvantage has been avoided by using the Six Hues Method, in which pixels of 6 specified hues (R,G,B,C,M,Y) can be corrected separately without the need for any masking[2]. While this method is very useful, it is severely limited by the fact that only those 6 specific hues can be selected for correction.

In this paper, the authors propose two new selective color correction methods which eliminate this limitation, and perform effectively.

2 Conventional Six Hues Method

The conventional Six Hues Method is performed in the following steps. First, users indicate which of the six hues (R,G,B,C,M,Y) requires pixel correction. Next, chromatic contribution value (dR,dG,dB,dC,dM,dY) for each pixel with respect to the indicated hue is calculated (see Table 1). Figure 1 shows the distribution of chromatic contribution values for Red hue (dR) over RGB color space projected on a plane vertical to the Black-White axis.

Finally, each pixel value is corrected with Eq.(1). (R,G,B) are original pixel values, (R',G',B') are output pixel values, (a1,a2,a3) are arbitrary enhancement factors, and dH is the chromatic contribution value obtained from Table 1 for selected hue H.

$$(R', G', B') = (R, G, B) + dH \times (a1, a2, a3) \qquad (1)$$

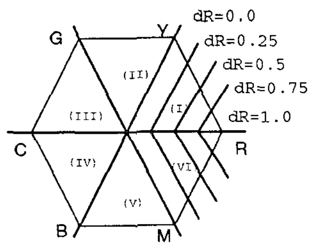


Figure 1: Distribution of chromatic contribution values for Red hue

3 Proposed Methods

While the Six Hues method is very useful, it is severely limited by the fact that only six hues (R,G,B,C,M,Y) are available for selection, and that users cannot select hue range or saturation range for correcting pixels in the target image. This makes effective correction of arbitrary hue pixels impossible.

In response to this situation, we have developed two new selective color correction methods, the HSV method and the RGB subtractive method, both of which can be applied to arbitrary hues. To do this, we first extended the concept of the chromatic contribution value to conceive of it as a distance in color space.

3.1 HSV Method

The first method we developed was the HSV method, which uses Smith's HSV color coordinate system [3]. Taking advantage of the fact that RGB color space projected on a plane vertical to the Black-White axis is equivalant to the HS (Hue-Saturation) plane in the HSV system, we developed an algorithm for calculating the chromatic contribution values for an arbitrary hue. In the HSV method, a pixel's chromatic contribution value "hx" is calculated with Eq.(2). "$(h1, s1, v1)$" is HSV values of the pixel. "Hue" is the hue selected for color correction, and "m" is the hue range. An hx value is calculated for each pixel, and the color correction process is performed using this value.

$$hx = \frac{pos(m - |Hue - h1|)}{m} \times s1 \times v1 \qquad (2)$$

$$where, pos(x) = \begin{cases} x, & \text{for } x \geq 0 \\ 0, & \text{for } x < 0 \end{cases}$$

Table 1: Calculation of chromatic contribution value

Area	Condition	dR	dG	dB	dC	dM	dY
I	$R > G > B$	R-G	0	0	0	0	G-B
II	$G > R > B$	0	G-R	0	0	0	R-B
III	$G > B > R$	0	G-B	0	B-R	0	0
IV	$B > G > R$	0	0	B-G	G-R	0	0
V	$B > R > G$	0	0	B-R	0	R-G	0
VI	$R > B > G$	R-B	0	0	0	B-G	0

The main advantage of the HSV method is that both "*Hue*" and hue range "*m*" can be freely selected.

3.2 Compatibility of the HSV Method with the Six Hues Method

Now suppose that Hue is 0(deg.) and m is 60(deg.), and $h1$, $s1$, $v1$ are HSV values of pixels for which $(R > G > B)$ and that are in area I as indicated Fig.1 and Table 1. In such a case,

$$h1 = \frac{G-B}{R-B} \times 60(deg.) \quad (3)$$

$$s1 = \frac{R-B}{R} \quad (4)$$

$$v1 = R, \quad (5)$$

and the HSV chromatic contribution value hx_r will be

$$hx_r = R - G. \quad (6)$$

This result is that calculated for dR in area I by the Six Hues method (see Table 1). With appropriate parameters, then the HSV method can perform the same correction as the Six Hues method for the other 5 hues, too. The fact shows that the HSV method is obviously compatible with the Six Hues method.

3.3 RGB Subtractive Method

The RGB subtractive method uses the difference between each pixel's RGB value and a reference RGB value "X". This reference RGB value X = $(r0, g0, b0)$ is a color selected by the user for a target correction color. In the method, the chromatic contribution value "$hx2$" to an RGB pixel (r, g, b) is calculated as follows. First, (dr, dg, db) is obtained through the following equations:

$$\begin{aligned} (r0', g0', b0') &= (r0, g0, b0) - min(r0, g0, b0) \\ (r', g', b') &= (r, g, b) - min(r, g, b) \\ (dr, dg, db) &= (r0' - r', g0' - g', b0' - b') \quad (7) \end{aligned}$$

Next, "$dmax1$" and "$dmax2$" are calculated using (dr, dg, db).

$$dmax1 = max(pos(dr), pos(dg), pos(db)) \quad (8)$$

$$dmax2 = max(neg(dr), neg(dg), neg(db)) \quad (9)$$

where,

$$pos(x) = \begin{cases} x, & \text{for } x \geq 0 \\ 0, & \text{for } x < 0 \end{cases}, neg(x) = \begin{cases} 0, & \text{for } x \geq 0 \\ -x, & \text{for } x < 0 \end{cases}$$

$hx2$ is obtained through the following equations, where W is a weighting value. An $hx2$ value is calculated in each pixel, and the color correction process is performed using this value.

$$D = dmax1 + dmax2 \quad (10)$$

$$hx2 = 1.0 - W \times D \quad (11)$$

The advantage of the RGB subtractive method is that correcting color can be selected by RGB values (not hue). Therefore, only pixels of high saturation or low saturation can be corrected.

3.4 Compatibility of the RGB Subtractive Method with the Six Hues Method

It is shown bellow that the RGB subtractive method is compatibile with Six Hues method. Suppose that reference RGB values X is (r0,g0,b0) = (1,0,0), and W is 1.0. The RGB chromatic contribution $hx2_r$ in pixels where $R > G > B$ is calculated as follows.

$$\begin{aligned} (r', g', b') &= (R - B. G - B. 0) \quad (12) \\ D &= 1.0 - R + G \\ hx2_r &= R - G \end{aligned}$$

This value is equal to dR in area I (Table 1) for the Six Hues method. Using appropriate parameters, the RGB subtractive method can also perform the same correction as the Six Hues method for the other 5 hues. In other words, the RGB subtractive method is also compatible with the Six Hues method.

3.5 Distribution of the Chromatic Contribution Values

Figure 2 compares chromatic contribution value distributions for the conventional method with those of the proposed methods, and also shows contours of chromatic contribution values. The results for (b),(c1) and (d1) show that the proposed methods can be expected to perform with the same effectiveness as the Six Hues method when the six pre-determined hues (R,G,B,C,M,Y) are selected. On the other hand, the results for (c2),(c3),(d2) and (d3) show that the proposed methods can be applied to arbitrary hues, over an arbitrary range by parameter adjustment.

4 Experiment

The two proposed methods were applied to several photograph images. Figure 3 shows results for the

RGB subtractive method, in which the red hat color in the original image (a) has been altered to green. As can be seen in the middle photo (b), which shows correction performed with the conventional method, the skin color was altered along with that of the hat. However, in the photo on the right (c), which shows the correction performed with the proposed RGB subtractive method, this problem did not occur.

Figure 4 shows results for the HSV method, that is an image processing example in which the color of the rubber raft in the original image (a) is altered to orange. As can be seen, in the upper right photo (b), which shows correction performed with the conventional method, the color of the water was altered along with that of the raft. However, in the lower photo (c), which shows correction performed with the proposed HSV method, this problem did not occur. The hue of the original raft is about 48 degree, and that of the water is about 62 degree. Because both of the hues place around Yellow hue (60 degree), it is impossible to correct only the raft using the conventional method.

5 Conclusions

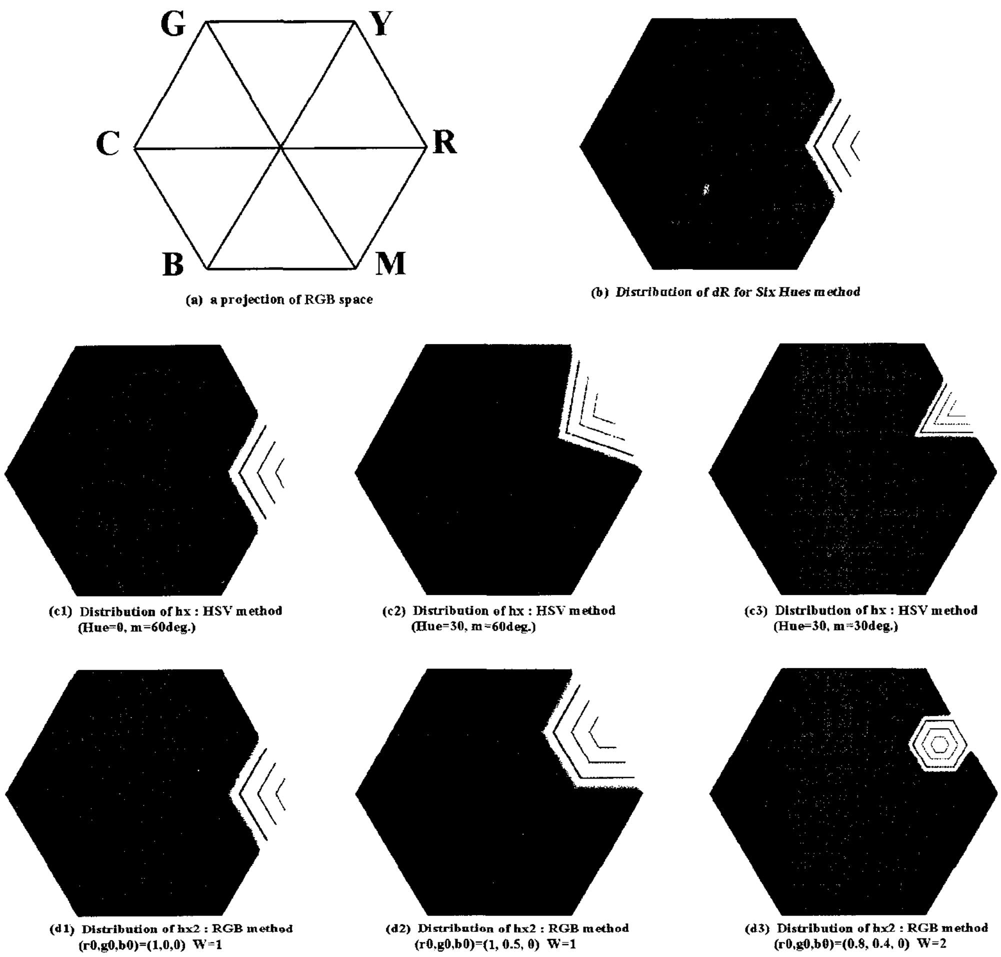
The proposed methods do not require masking of the area to be corrected, and this makes it easy to retouch photograph images. The experimental results obtained from several photograph images are excellent. Color alteration quality is smooth and natural. Moreover, the proposed methods have the important advantages that, unlike the conventional method, arbitrary hues can be corrected over an arbitrary range. The proposed selective color correction methods appear to be extremely promising for use in various imaging systems.

References

[1] J.A.C.Yule, "Principles of Color Reproduction", John Wiley & Sons, (1967)

[2] J.Tajima, "Principles of Color Image Reproduction", Maruzen(in Japanese),pp.71-74 (1996)

[3] A.R.Smith, "Color Gamut Transformation Pairs", Computer Graphics, vol.12, pp.12-19 (1978)



(a) a projection of RGB space

(b) Distribution of dR for Six Hues method

(c1) Distribution of hx : HSV method (Hue=0, m=60deg.)

(c2) Distribution of hx : HSV method (Hue=30, m=60deg.)

(c3) Distribution of hx : HSV method (Hue=30, m=30deg.)

(d1) Distribution of hx2 : RGB method (r0,g0,b0)=(1,0,0) W=1

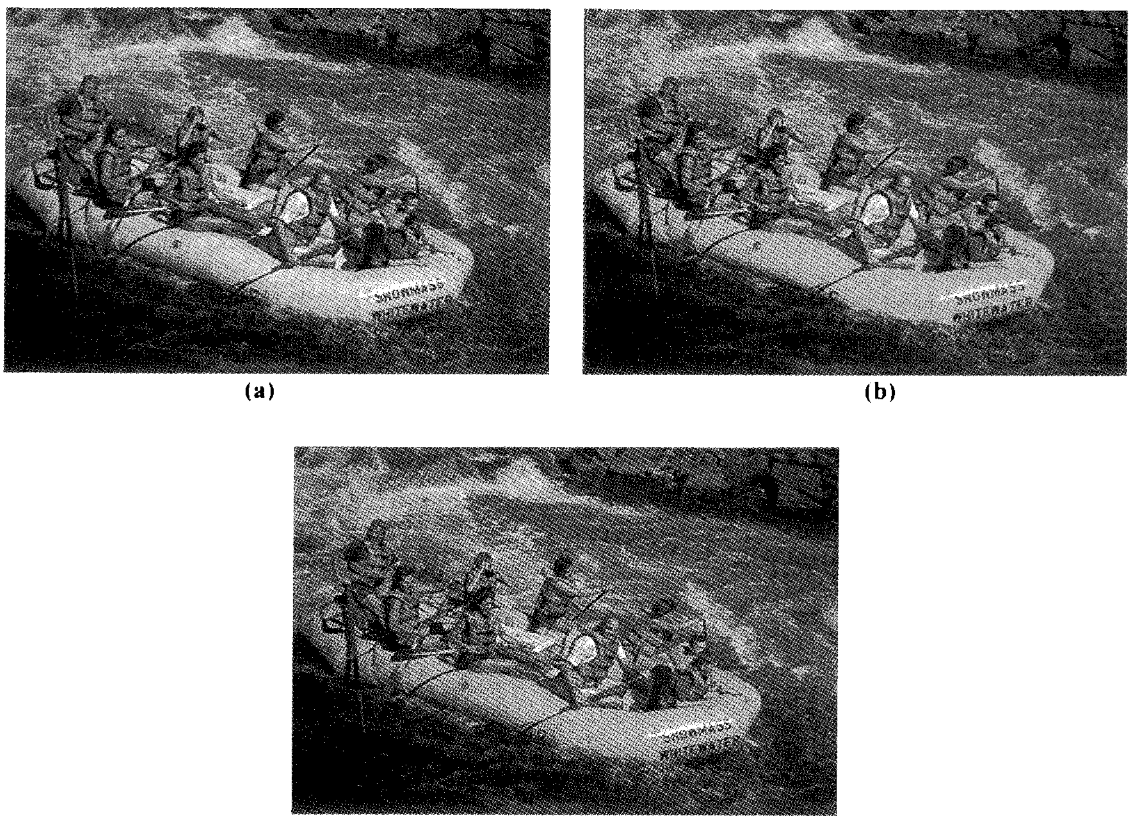
(d2) Distribution of hx2 : RGB method (r0,g0,b0)=(1, 0.5, 0) W=1

(d3) Distribution of hx2 : RGB method (r0,g0,b0)=(0.8, 0.4, 0) W=2

Figure 2: Distribution of the chromatic contribution values

(a) (b) (c)

Figure 3: Results of color correction using RGB subtractive method



(a) (b)

(c)

Figure 4: Results of color correction using HSV method