Image Quality Improvement by Rescaling of Color Saturation

Takashi WATANABE, Yuji AKIMOTO and Yasushi HOSHINO
Nippon Institute of Technology
Miyashiro, Saitama, JAPAN

Abstract

In general, the image reproduced by imaging system is different from the original one because of the differences of gamut and dynamic range. Tone rescaling is known to be effective in improving image quality. The rescaling of color saturation is also considered to be effective in image quality improvement.

The rescaling of color saturation by linear extension in *L*a*b** space is carried out. The rescaled images are evaluated subjectively. The effect for the rescaling of color saturation is confirmed and the effect is discussed from the feature of chroma histogram of image.

Introduction

As the progresses of digital processing technologies, various processings become possible and are used widely in many imaging systems. In the imaging system, the image quality improvement and image impression enhancement are important. To realize these improvement and enhancement, tone rescaling, edge enhancement and so on are known. In this report, image quality improvement by rescaling of color saturation is studied.

Experiment

Digital images were prepared by digital still camera (DSC) and the image data were processed, then the processed images were printed by ink-jet printer. The following devices are used in this experiment:

DSC: NIKON COOLPIX 5700,
Ink-jet Printer : EPSON PM-2200C,
ColorChecker : GretagMacbeth ColorChecker,
Spectrum colorimeter : MINOLTA CM2022.

The following softwares are used:

Image Viewer : ADOBE Photoshop 7.0,
Program : MICROSOFT Visual C++ 6.0.

Experimental procedure is as follows:
1) The digital images are prepared by DSC. Conditions are shown in Table 1.

Table 1. Conditions of capturing images.

	Location	Illumination
Image 1 (Fruits)	Indoor	Solar light from window
Image 2 (Human)	Outdoor	Solar light (Shade)
Image 3 (Tree)	Outdoor	Solar light (Sunshine)

The images used in this study are shown in Fig. 1(a), 2(a) and 3(a). Figure 1(b), 2(b) and 3(b) are their chroma histogram of the images respectively.

2) The uniform color space *L*a*b** is used for the rescaling. Chroma *S* is defined with Eq. 1.

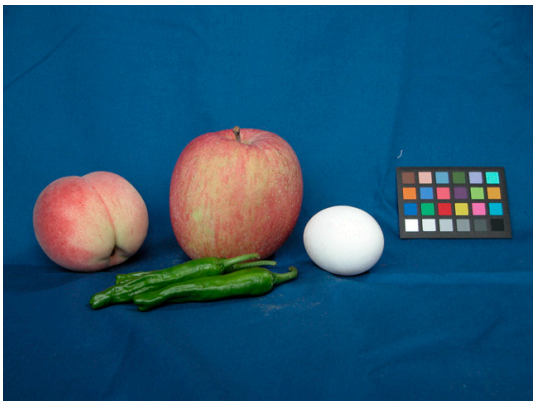
$$S = \sqrt{x^2 + y^2}, \qquad (1)$$

where *x*, *y* mean the values of *a**, *b**. Rescaling of color saturation is carried out as Eq. 2.

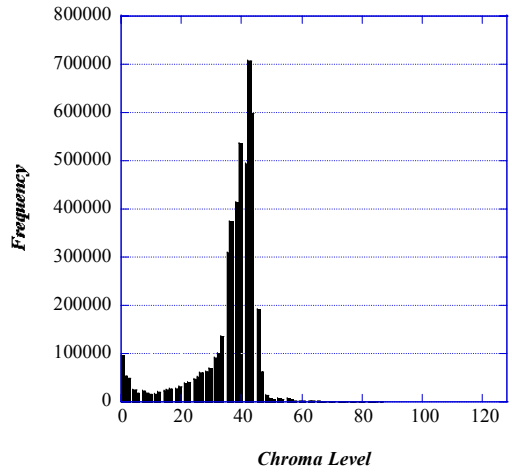
$$\begin{aligned} x' &= \alpha x, \\ y' &= \alpha y, \\ S' &= \alpha\sqrt{x^2 + y^2}, \end{aligned} \qquad (2)$$

where α is the rescaling factor. The rescaling is carried out on the α by 0.2 units from 0.2 to 1.8.

3) The rescaled images are printed by the printer. Subjective evaluation of the image is carried out on the vividness of the color chart. The evaluation was carried out by the measure of Table 2. This checks subjectively change of the color by rescaling of color saturation.

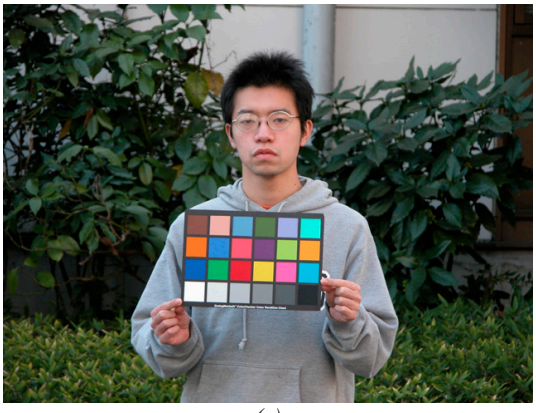


(a)

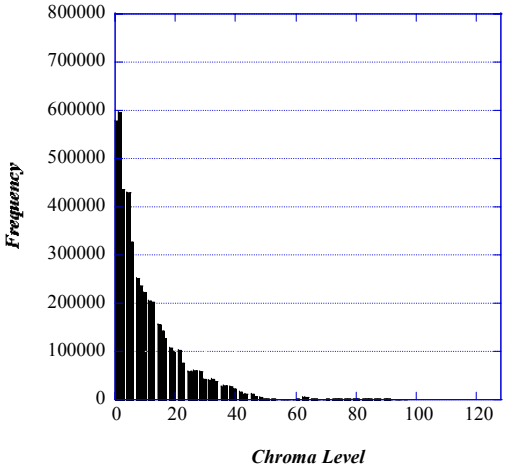


(b)

Figure 1.(a) Original image (Fruits) and (b) chroma histogram of the image.



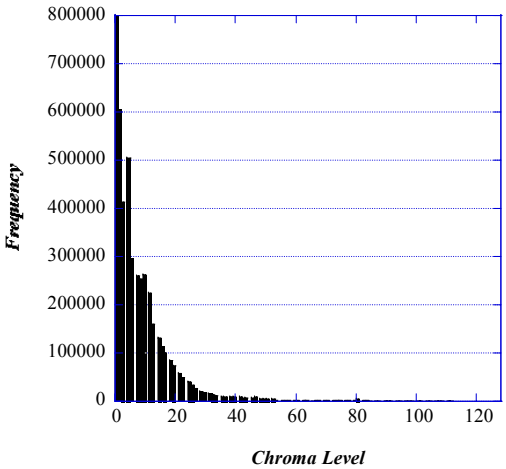
(a)



(b)

Figure 2.(a) Original Image (Human) and (b) chroma histogram of the image.

(a)



(b)

Figure 3. (a) Original Image (Tree) and (b) chroma histogram of the image.

Table 2. Subjectivity measure for evaluation.

Measure	Comparison with the color chart
5	More vivid
4	A little bit more vivid
3	Nearly same vividness
2	A little bit less vivid
1	Less vivid

Subjective evaluation on the image quality is performed with the measure in Table 3. The evaluation is carried out by ten persons.

Table 3. Subjectivity measure for evaluation.

Measure	Comparison with unprocessed image
5	Better
4	A little bit better
3	Same level
2	A little bit inferior
1	Inferior

The result image is evaluated by the paired comparisons.

Results and Discussions

The change of vividness by rescaling is evaluated subjectively by comparing with the original color chart. The result is shown in Fig.4. When the rescaled factor is around 1, it is found that the chroma is felt as same as the original color chart.

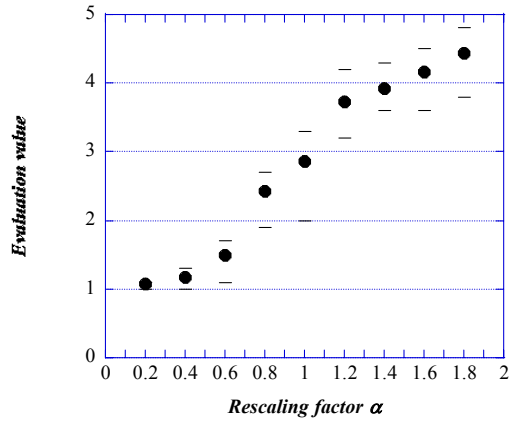


Figure 4. Dependence of chroma of 5 measure category evaluation on rescaling factor.

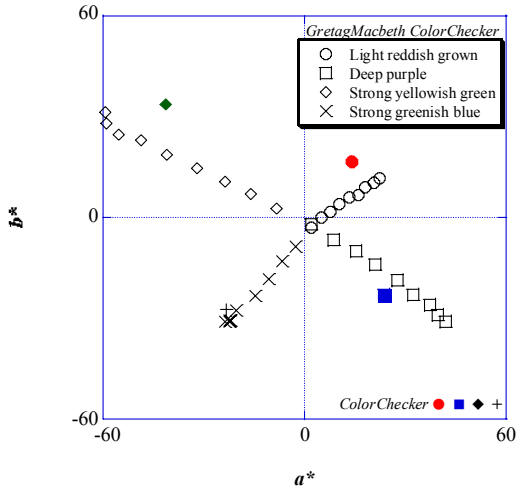


*Figure 5. Chromaticity diagram of a*b*.*

Figure 5 shows the measured result of the color chart part of the rescaled image. Bold type signs indicate the value of the original color chart. It is understood that the chroma has extended from the center to outside by changing the parameter from 0.2 to 1.8. It is found that the rescaled chroma is roughly same around α=1 from Fig.5. So, it is considered that chroma is felt subjectively same level at the rescaling factor α=1.

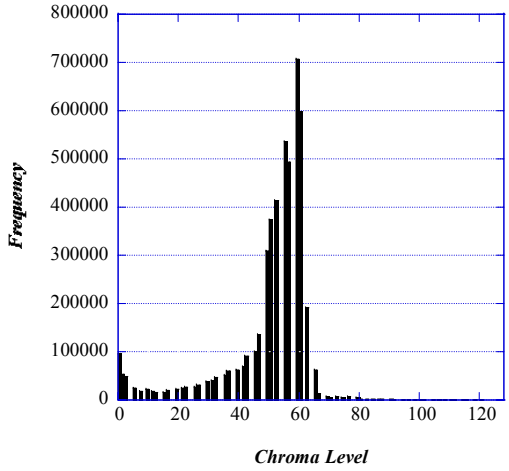


Figure 6. Histogram of Image 1 (α =1.4).

Figure 6 shows the chroma histogram of image 1 rescaled by the factor 1.4. The extension of the chroma was confirmed from the histogram of Fig.6.

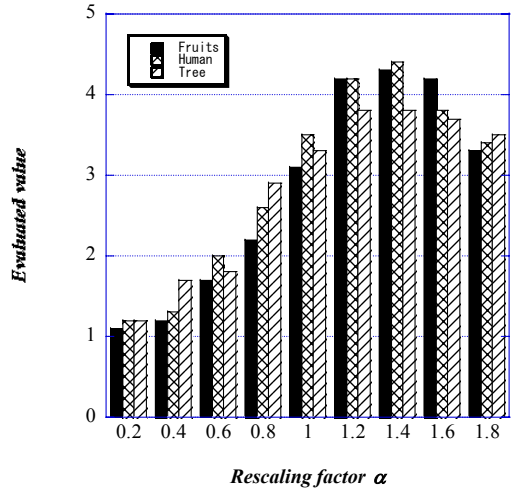


Figure 7. Dependence of evaluated value of 5 measure category evaluation on rescaling factor.

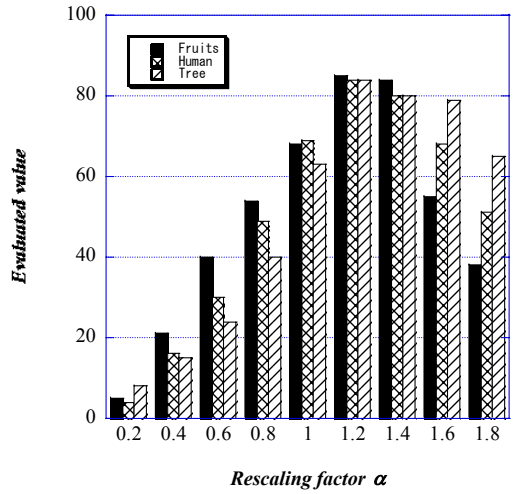


Figure 8. Dependence of evaluated value by a paired comparisons on rescaling factor.

Figure 7 shows the evaluated value of 5 measure category evaluation and Fig.8 shows the evaluated value by a paired comparison. Both results show that image quality shows peak at the α value around 1.2 - 1.4. From the Fig.4, when the rescaling factor is 1, the chroma of color chart of rescaled image is felt same as original color chart, so it is suggested that image quality is improved by the extension of rescaling the chroma 20 - 40 % on a^* and b^* axis.

The evaluated values of the image quality show decrease more than a=1.6 in both Figs. 7 and 8. It is considered that the decrease arises from the loss of balance of color or naturalness. It is found that the decrease is most abrupt in the image "Fruit" in Fig. 8. The image has high level components compared with other images in chroma histogram, so the loss of balance of color or naturalness is considered to have tendency to arise.

Conclusions

The effect of the rescaling of color saturation was studied by subjective evaluation. Concerning the three types of image, the saturation value was linearly expanded and the expanded images were evaluated. When the saturation value is extended around 20 - 40 % in chroma axis, the subjective evaluation shows peak value.

References

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Biographies

Watanabe Takashi is director of Teleconference division of NETWORLD Co.. He gained Bs., Ms. and Dr. degrees from Nippon Institute of Technology in 1996, 1998 and 2001 respectively. He joined KDDIS Co. in 2001 and developed telephone conferencing system. He moved to NETWORLD Co. in 2003. He is now studying color reproduction technology in Hoshino Laboratory of Nippon Institute of Technology.
E-mail:watanabe@networld.ne.jp

Akimoto Yuji is graduate course student of Nippon Institute of Technology. He gained Bs. Degree from Nippon Institute of Technology and now studying image processing in Hoshino laboratory of Nippon Institute of Technology.
E-mail:blue_blood_1124@yahoo.co.jp

Hoshino Yasushi is Professor of Nippon Institute of Technology. He gained Bs., Ms. and Dr. degrees from University of Tokyo, 1970, 1972, and 1984 respectively.

After he gained Ms. degree, he joined Electrical Communication Laboratories of NTT and developed first LED printer, high speed laser printer (process speed 89 cm/s), color laser printer by using ultra elliptical laser beam scanning, photo-induced toning technology and ion flow printing.

He moved to Nippon Institute of Technology on 1994. He published more than 20 papers and several papers also in IS&T's Journal. He attended almost NIP congresses.
E-mail:hoshino@nit.ac.jp