Gamma Transformation (Tone Rescaling)by Sigmoid Function (II):

Subjective Estimation by Paired Comparison

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Abstract

The digital technology is greatly developed in recent years. In the world of a photograph, the information of image is digitized and the digital image technology centering on a computer is progressing with the spread of the digital still cameras. In this research, tone rescaling of a digital image is performed using sigmoid function. It is found that the tone rescaling by sigmoid function improves the image quality when the peak position of the slope of sigmoid function is adjusted to the peak of histogram of region - of - interest. The improvement of the image quality is confirmed by subjective estimation.

Introduction

Recently the progress of digital still camera (DSC) is very rapid. The related imaging technologies such as computer, display, printer and image processing are also progressing. The digitization of photographic image is advancing rapidly. In imaging systems, because of the difference of dynamic range between natural scene and output device, dynamic range compression is important.[1-3] In general, the input signal is compressed at an equal ratio in digital system. When image is displayed or printed by using the signal, total dynamic range of the image is expressed as a whole. But the ROI (region-of-interest) is sometimes felt unsatisfied because of insufficient contrast. The various studies of optimization of tone rescaling have been carried out. Recently, the application of sigmoid function is proposed and verified the effectiveness of its use.[2;4]

Rescaling to conventional photography tone that is a kind of γ transformation is studied.[5]

Various image processing is possible for digitized image. Many tone rescaling methods are considered effective. The tone rescaled images by sigmoid function are estimated subjectively and the optimization condition is studied.

Sigmoid Function

Sigmoid function has characteristics that the function increases relatively abruptly in the low input range and it saturates in the high input range. Various types of the sigmoid function are considered. We use a simplified sigmoid function as,

$$0 \le x \le a$$
$$y = a^{1-\gamma} x^{\gamma} \quad (1)$$

$$a \le x \le 1$$
$$y = 1 - (1-a)^{1-\gamma} (1 - x)^{\gamma} \quad (2)$$

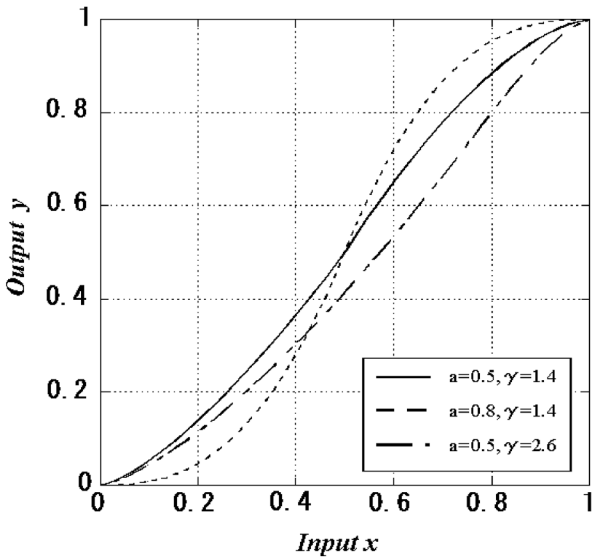


Figure 1. Sigmoid function

The function has two parameters,

γ: power of x in the range of 0 ~ *a*,
a: range of γ-th power of *x*.

The value γ controls the slope of curve. By changing a, we can shift the steepest place of the curve. At the point $x = a$, the output value is the same as the input value and the slope of curve becomes steepest. The example of sigmoid function is shown in Fig. 1.

Experiment

The following devices are used in this experiment:
Digital input: Digital Camera (KODAK DC260Zoom),
Printing system: Inkjet Color Printer (EPSON PM2000C).

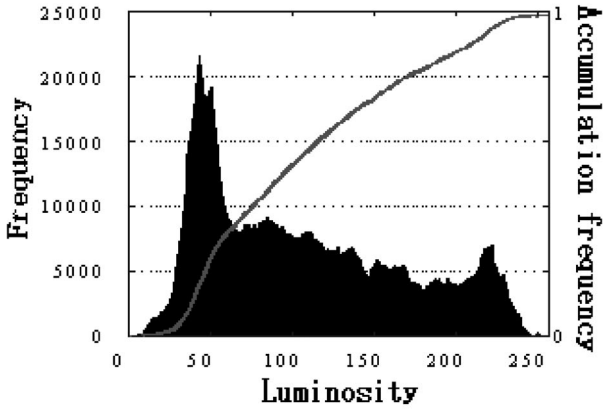
The following softwares are used:
Image Viewer: Photoshop 5.0,
Program: Microsoft Visual C++.

Sigmoid transformation is programmed by using C++. Several images are prepared by the following methods:

1. The parameter *a* is the center of lightness range and the gamma is varied from 1.2 to 1.8,
2. The parameter *a* is the peak of histogram and gamma is varied from 1.2 to 1.8.
3. The parameter *a* is the peak of histogram of ROI and gamma is varied from 1.2 to 1.8.

Subjective estimation of the tone rescaled imaged is carried out by 15 persons under the illumination of fluorescent lamp.

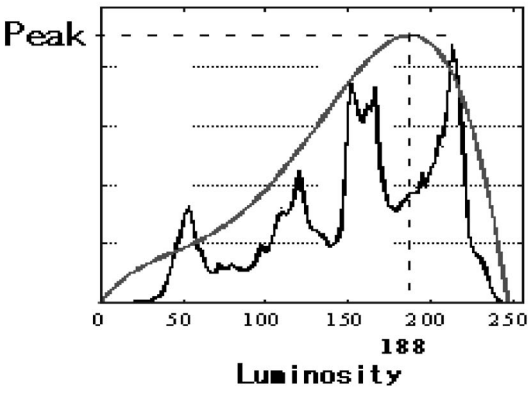
(a)



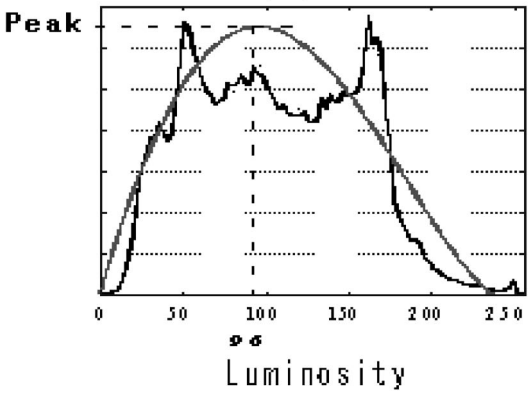
(b)

Figure 2. (a) Example of image, (b) Histogram of the image

(a-1) (a-2)



(b-1)



(b-2)

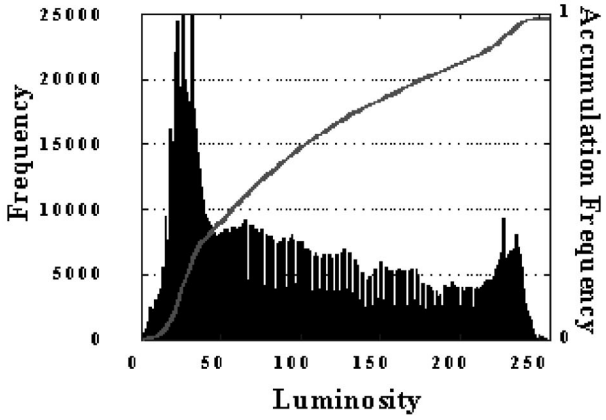
Figure 3. (a-1) ROI 1, (a-2) ROI2, (b-1) histogram of ROI 1, (b-2) histogram of ROI2

Results and Discussions

An example of image used in this study is shown in Fig. 2(a). Figure 2(b) is the lightness level histogram of the image. The histogram of the image has one peaks and the histogram is distributed relatively in wide range. The impression of image is greatly influenced by the image quality of ROI. So, we studied the processing method, of which the peak of the histogram of ROI is widened with keeping the position of the peak. The image processed by using Fig. 3 (a-1)as ROI is shown in Fig. 4. Figure 4 shows that the flower becomes enhanced and shows that the peaks of the histogram of the ROI is widened by the processing.

The ROI part of the image become clear and the whole image is also felt to be improved. Taking other ROI area of Fig. 3 (a-2),the image is processed. It is found that the ROI become clear.

(a)



(b)

Figure 4. (a) Processed Image, (b) Histogram of Processed Image

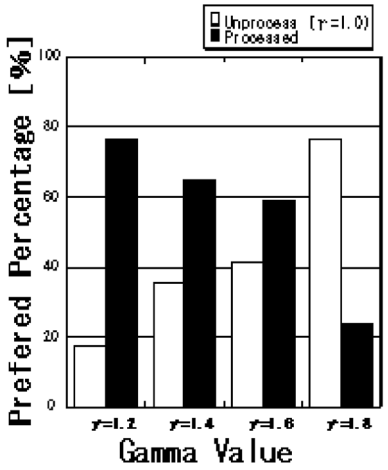


Figure 5. Result of Subjective Estimation: reproducibility of ROI

Paired Comparison

Subjective estimation of an unprocessed image and the processed image was carried out. The result is shown in Fig. 5. It is found that the processed image is preferred than unprocessed image in the gamma value 1.2 ~ 1.6. It is considered that ROI which dynamic range is compressed is decompressed in some extent by this processing. It is found that the image processed with gamma 1.8 is not preferred. It is considered that the image processed with the gamma value 1.8 is felt unnatural.

Conclusion

Tone rescaling by sigmoid function is studied. The sigmoid function has two parameters for controlling transformation characteristics. We studied the method of adjusting two parameters by the histogram of image pixel data. We got results that image become clear by changing the gamma value of tone rescaling 1.2 ~ 1.6 at the peak of histogram of ROI. It is expected that the method is useful to improve image in many cases. From the subjective estimation of reproducibility of ROI, it is found that the processed images gain higher score than the unprocessed image in the gamma of 1.2 ~ 1.6.

References

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Biography

Yoshitaka Iwasaki is graduate course student of Nippon Institute of Technology. He gained Bs. Degrees from Nippon Institute of Technology and is now studying color reproduction Technology in Hoshino laboratory of Nippon Institute of Technology.