

Gamma Transformation by Sigmoid Function in Digital Camera System

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Abstract

In a imaging system such as digital still camera, gamma transformation is important, because of the difference of dynamic range between natural scene and printer. We propose gamma transformation by sigmoid function adjusted by the peak position of histogram of lightness level. It is confirmed that the sigmoid transformation increases the clearness of image.

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. 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 gamma have been carried out. Recently, the application of sigmoid function is proposed and verified the effectiveness of its use.[2)] Rescaling to convention photography tone that is a kind of γ transformation is studied.[4)]

Various image processing is possible for digitized image. Several tone rescaling methods are considered. Tone rescaling depended on image or ROI is considered effective. We study tone rescaling by using sigmoid function and the histogram of the image.

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,

$0 \le x \le a$,

$$y = a^{1-\gamma} x^{\gamma},$$

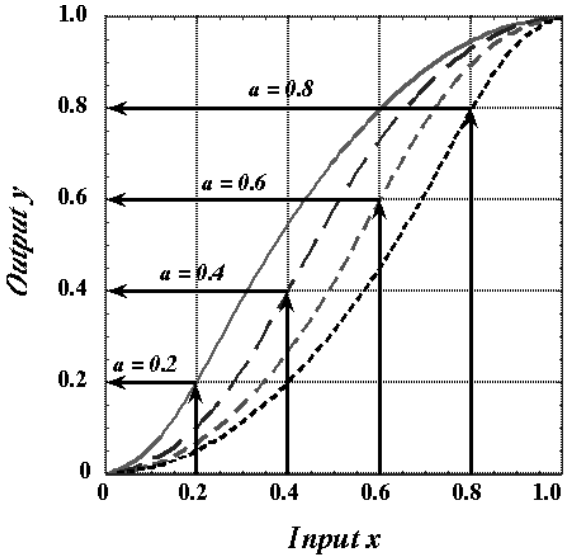
$a < x \le 1$,

$$y = 1 - (1-a)^{1-\gamma}(1-x)^{\gamma}.$$

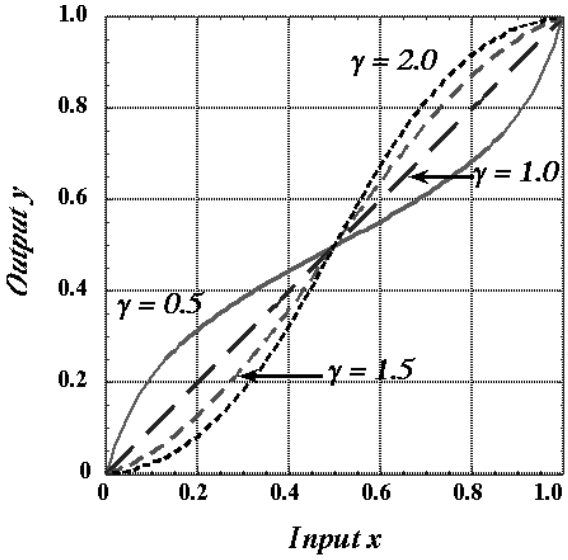
The function has two parameters,

γ: power of x,

a : range of γth power of x.



(a)



(b)

Figure 1 Dependence of sigmoid function on parameters: (a) a= 0.2, 0.4, 0.6, 0.8 at γ=2.0; (b) γ=0.5, 1.0, 1.5, 2.0 at a=0.5.

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.

Experiment

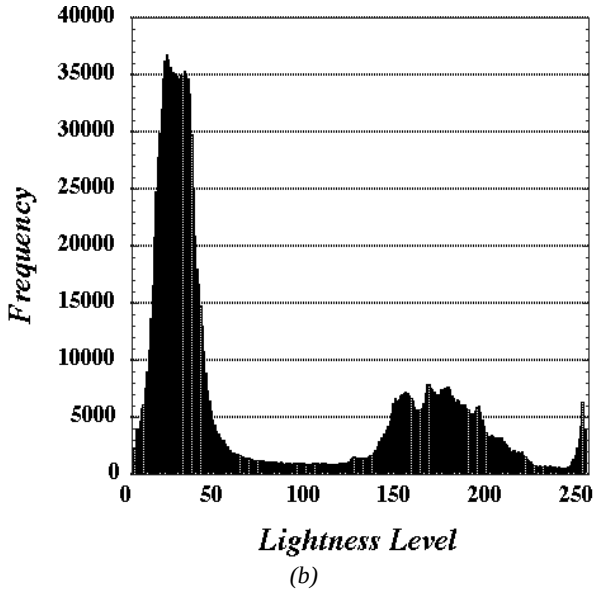
The following devices are used in this experiment:

Digital Input : Digital Camera (KODAK DC260Zoom)
Printing System : Inkjet Color Printer (EPSON PM2000C)
Computer : APPLE PowerMacintosh7300/180
CRT (APPLE AppleVision 1710 Display)

The following softwares are used:

Image Viewer : Photoshop 5.0,
Program : METROWERKS CodeWarrior PR3 C++.

(a)



(b)

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

Sigmoid transformation is programmed by using C++. Several images are captured by DSC. The images are rescaled by the following methods:

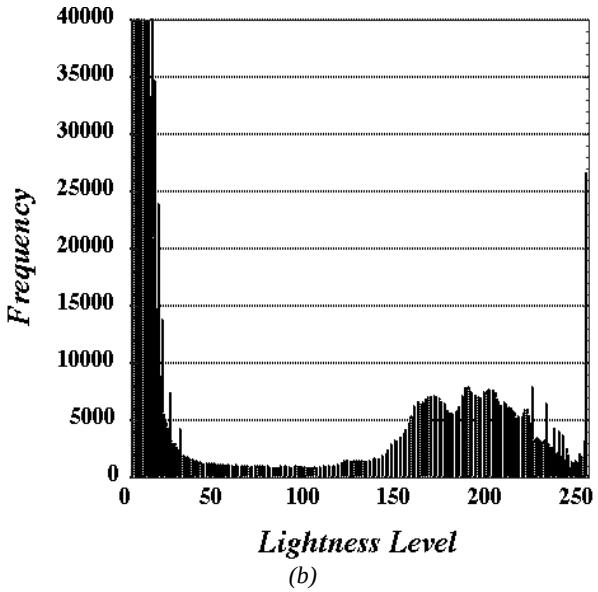
1) The parameter a is the center of lightness range and gamma is varied from 1.2 to 2.2,
2) The parameter a is the peak of histogram and gamma is varied from 1.2 to 2.2,
3) The parameter a is the peak of histogram of ROI and gamma is varied from 1.2 to 2.2

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 two peaks: one corresponds to dark area and another corresponds to bright area.

1) a = the center of lightness range

(a)



(b)

Figure 3 (a) Image processed by method 1 and (b) histogram of the image.

When a=1/2, that means middle lightness level, the transformed image is shown in Fig. 3. In this case, dark area becomes darker and the object in the dark area becomes hard to be distinguished. From the histogram, the frequency peaks move to both sides and the widths of peaks are shrunk. In general, when *a* is the center of lightness range, the image becomes clear by increasing γ to some extent.

Although image quality depends on the region of interest, when the histogram splits, the image becomes unclear by increasing γ.

2) *a* = the center of the histogram peak

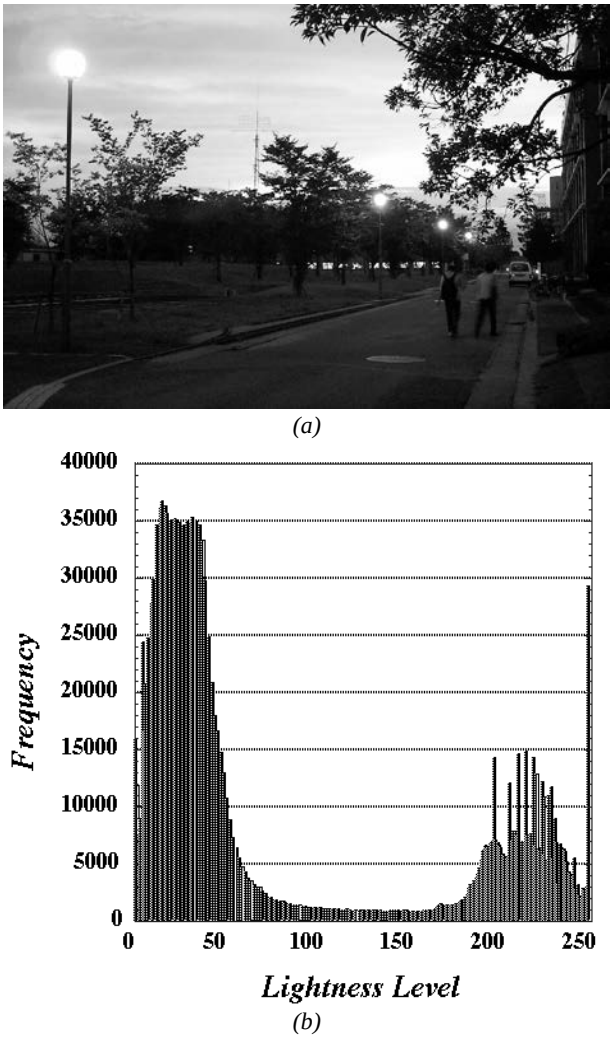


Figure 4 (a) Image processed by method 2 and (b) Histogram of the image.

In the case that images have narrow peak of histogram, the gradation levels of the peak are difficult to be distinguished. To widen the gradation levels is a kind of image enhancement. It is carried out the process that the histogram of the peak is widened with keeping the center of the peak. The processed image is shown in Fig. 4. From the Fig. 4, we can see the image contrast of the dark area is enhanced. The enhanced image is felt to keep natural feeling. This is thought due to keeping the center of the peak.

3) a = the center of the histogram peak of ROI

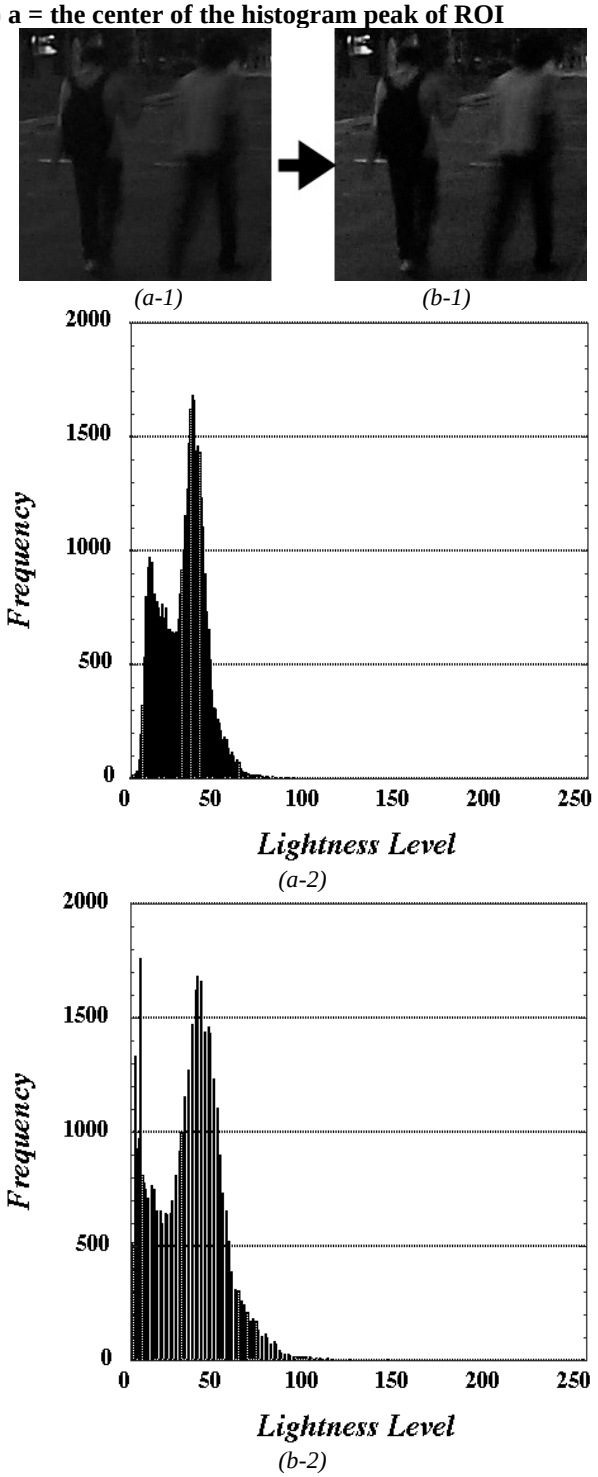
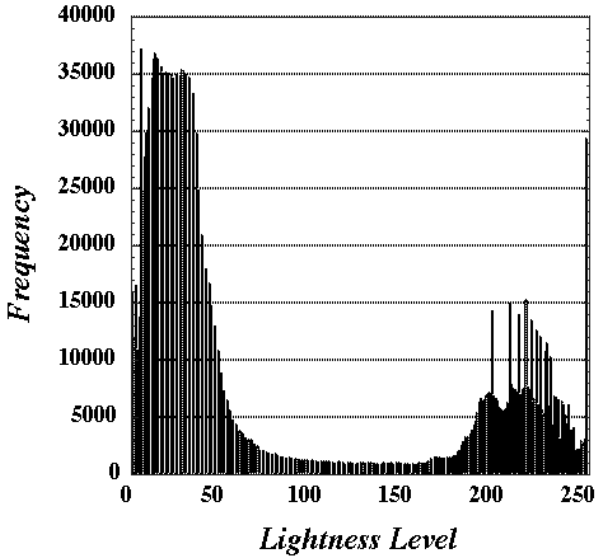


Figure 5 Image processing by method 3, (a-1) ROI, (b-1) processed image of ROI, (a-2) histogram of ROI, (b-2) histogram of processed ROI.

The impression of image is greatly influenced by the image quality or clearness of ROI. So we studied the processing that the histogram of the peak of ROI is widened with keeping the center of the peak. The processed image is shown in Fig.5. Figure 5 shows that the figure of person becomes to easy to be distinguished and shows that the peaks of the histogram of the ROI is widen by the processing. The image processed by the method is shown in Fig. 6. The ROI part of the image become clear and the whole image is also felt to be improved.

(a)



(b)

Figure 6 (a) Image processed by method 3 and (b) histogram of the image.

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 - 2.2 at the peak of histogram of ROI. It is expected that the method is useful to improve image in many cases.

References

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Biography

Watanabe Takashi is graduate course student of Nippon Institute of Technology. He gained Bs. and Ms. degrees from Nippon Institute of Technology and is now studying color reproduction technology in Hoshino laboratory of Nippon Institute of Technology.
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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