Dependence of optimum edge enhancement condition on object histogram

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Abstract

Edge enhancement is effective to improve image quality. The optimum condition of edge enhancement has been studied on the histogram of objects of the image. When the edge of object is enhanced, our visual system becomes easy to recognize the shape and have sharp feeling. But if the edge is enhanced too much, we feel the image unnatural. It has been studied that the optimum edge enhancement depends on the histogram of image. In this study, the optimum conditions dependence on the factors of edge strength and color effect is investigated. The optimum edge enhancement condition will be varied by the sharpness of the edge of object. The image objects of various levels of edge sharpness are processed by edge enhancement and the processed images are estimated by subjective evaluation. The optimum edge enhancement condition is obtained.

Introduction

Digital imaging system has been highlighted as the essential component of digital technology according to the growth of digital medias. The edge enhancement is necessary processing for getting high-quality image in digital image system. The edge enhancement is effective because that suitable for making the image to feel sharp. The edge enhancement is effective to improve the subjective evaluation of the image quality. However, when the edge of image is emphasized too much, the image looks unnatural.

The edge of photographic image is not so sharp, and a little blur. Therefore, it is necessary to emphasize the outline, and it is known that the effect depends on the observation distance.

The image qualities of the natural objects captured by digital camera are examined by subjective evaluation under various conditions of tone rescaling and edge enhancement and the optimization conditions of edge enhancement is investigated. The results of subjective estimation are discussed from the viewpoint of HVS (Human Visual System).

Experimental

A sample image is shown in Fig.1 and it is the photographic image of building. The photographic images are taken by digital camera (OLYMPUS E-500) with resolution 400ppi and output with resolution 3264×2448 pixels.

Sigmoid function

A sigmoid function is a mathematical function that produces a sigmoid curve - a curve having an "S" shape. Often, sigmoid function refers to the special case of the logistic function shown at right and defined by the formula. The expression of sigmoid function is Eq.(1).The sigmoid function is shown in Fig.2.

Sigmoid function is used, and it processes it to the brightness of the image. The density difference of the image is changed by processing. Image that processes sigmoid function is shown in Fig.3.

Figure 1. *Sample image.*

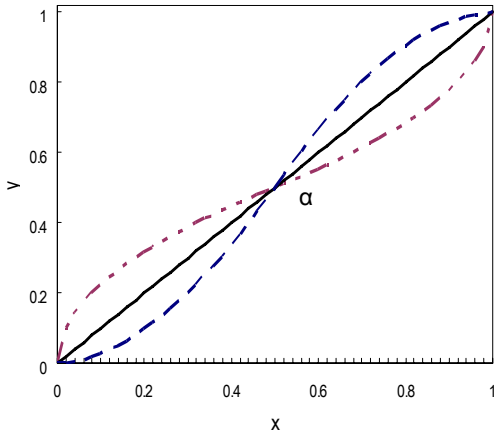


Figure 2. Sigmoid Function.

$$\left.\begin{aligned} y &= \alpha^{1-\gamma} x^{\gamma}, (0 \le x \le \alpha) \\ y &= 1-(1-\alpha)^{1-\gamma}(1-x)^{\gamma}, (\alpha < x \le 1) \end{aligned}\right\} \quad (1)$$

Operator of edge enhancement

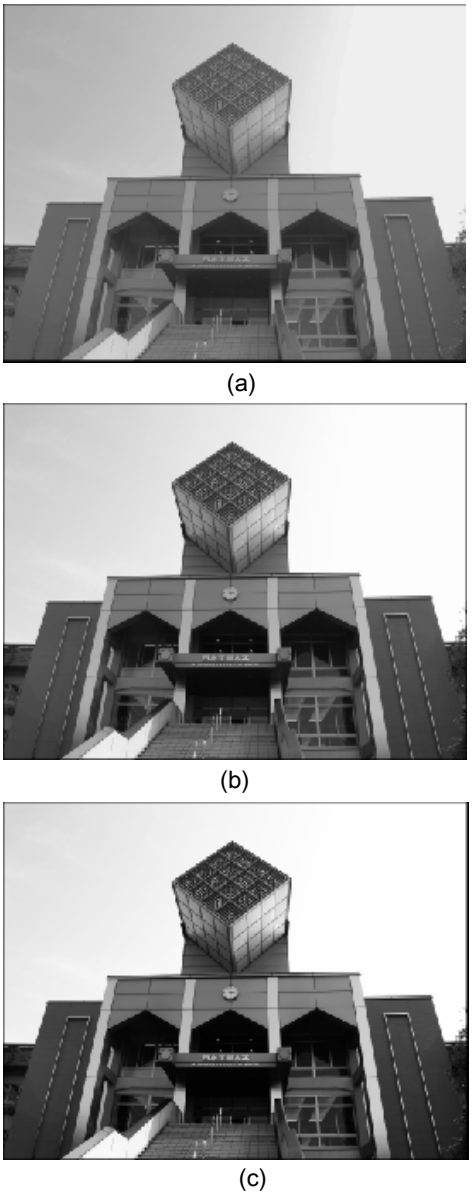
Laplacian filters are derivative filters used to find areas of rapid change (edges) in images. Since derivative filters are very sensitive to noise, it is common to smooth the image (e.g., using a

Gaussian filter) before applying the Laplacian. This two-step process is call the Laplacian of Gaussian (LoG) operation[1][2].

$$L(x,y)=\nabla^2 f(x,y)=\frac{\partial^2 f(x,y)}{\partial x^2}+\frac{\partial^2 f(x,y)}{\partial y^2} \qquad (2)$$

There are different ways to find an approximate discrete convolution kernal that approximates the effect of the Laplacian. A kernel is

$$\begin{pmatrix} 1 & 1 & 1 \\ 1 & -8 & 1 \\ 1 & 1 & 1 \end{pmatrix} . \qquad (3)$$



(a)

(b)

(c)

Figure 3. Images processed by sigmoid function (a)γ=0.5, (b) γ=1.0, (c)γ=1.5.

This is called a negative Laplacian because the central peak is negative. It is just as appropriate to reverse the signs of the elements, using -1s and a +8, to get a positive Laplacian. It doesn't matter.

The edge enhancement is generated as Eq. (4),

$$f'(x,y)=f(x,y)-\alpha\nabla^2 G(x,y)f(x,y) \qquad (4)$$

We adopt the edge enhancement technique to the experimental images. The center of the matrix contains the value as 8, which is the general number used in edge enhancement technique[2][3].

We separate the study in the case, α is determined to 1, 2, 3 and 4.

The Experimental Methodology

The experiment is carried out by subjective evaluation with the free observation distance. The subjectivity evaluation is paired comparison. The images are evaluated subjectively with 10 students by a pair comparison under the office level fluorescent lamp illumination.

Results and Discussions

Color and Gray

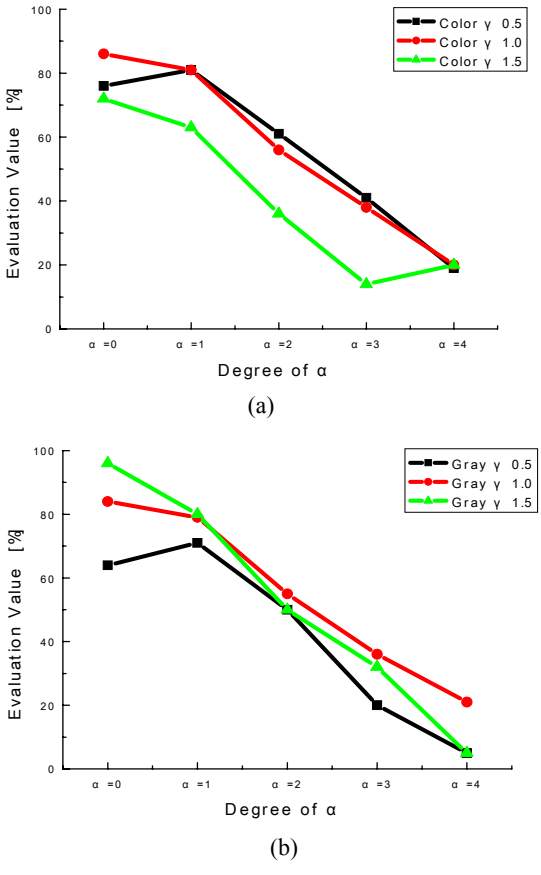
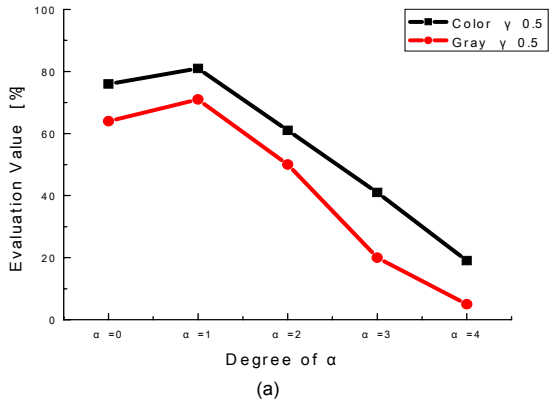
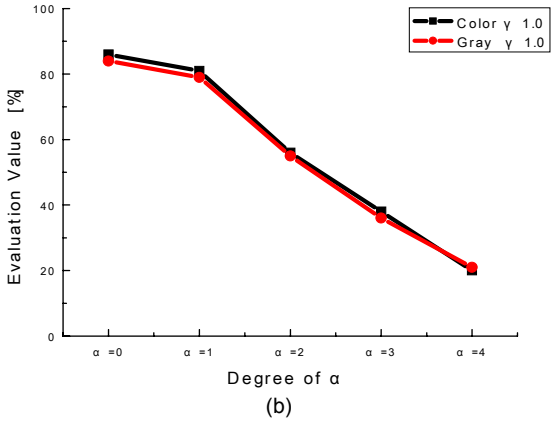


Figure 4. Result of subjective evaluation (a) Color image , (b) Gray image.





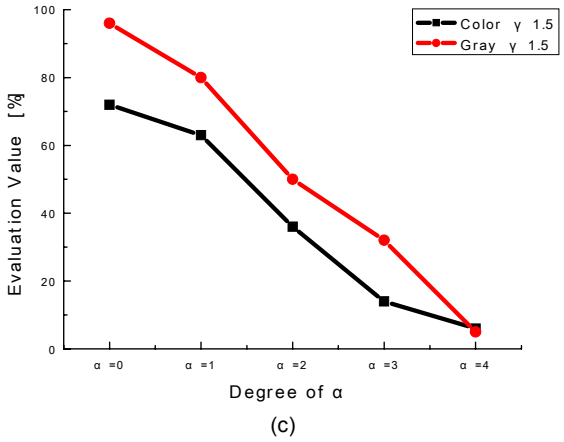
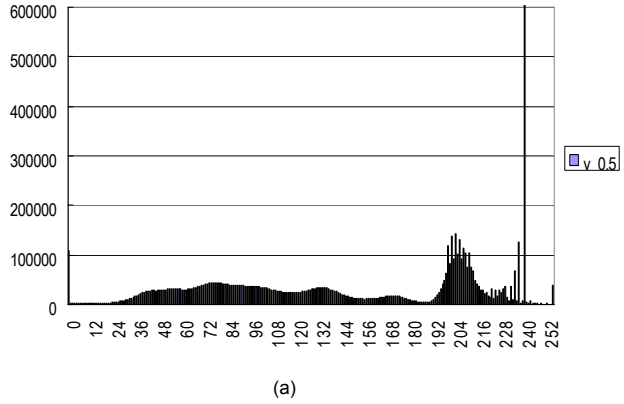
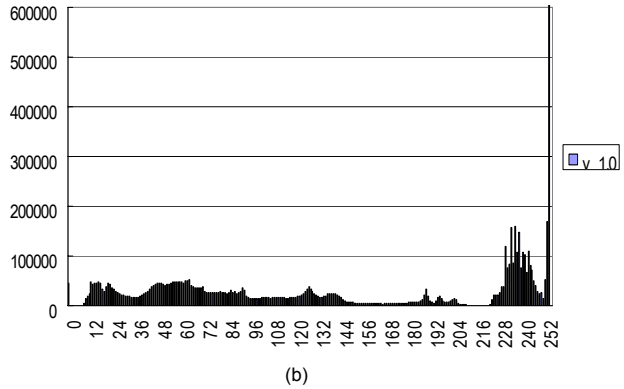


Figure 5. Result of subjective evaluation (a) γ =0.5, (b)γ =1, (c)γ =1.5.





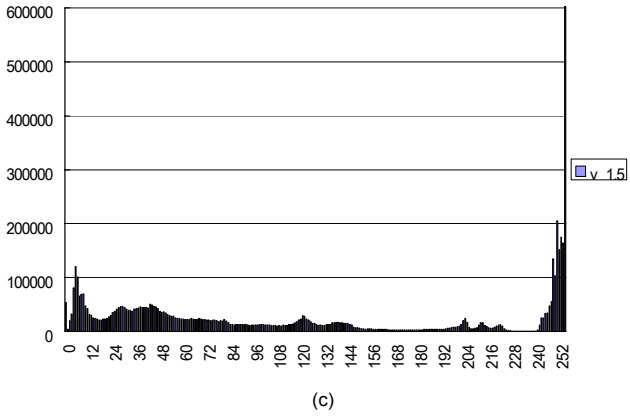


Figure 6. Histogram of brightness (a) γ =0.5, (b)γ =1, (c)γ =1.5.

Fig.4 shows the result of the subjective evaluation. It shows the results of color image and gray image.

On the result of the color image, the evaluation value decreases as the α increases. In the gray image, the evaluation shows high value when γ is large at α is 0.

Fig.5 shows results when the γ of sigmoid function is 0.5, 1, and 1.5.

In the Fig.5, when γ is 0.5, the evaluation value of the color image is higher than value of the gray images the evaluations. When γ is 1.0, the evaluation value of the color image and the gray image is almost the same. When γ is 1.5, the evaluation value of the gray image is higher than the color image.

Fig.6 shows the histogram of brightness when the γ of sigmoid function is 0.5, 1, and 1.5.

It is understood that the distribution of the histogram of brightness is different depending on the value of γ in Fig.6. The distribution of the histogram of the brightness of γ of the color image and the gray image is the same.

It is possible to convert it into a clearer image by correcting the histogram of the brightness of the image. It is known that the improvement of the color image can be carried out by choosing the method of correcting the histogram[4]. As for the color and the gray images of the same histogram, it is found that the effect of the edge enhancement is different. It cause that the images controls color information or not.

Conclusion

To obtain the optimal condition of edge enhancement for the photographic images, subjective evaluations are carried out on various edge enhancement conditions. The Laplacian filter was used in this experiment. It has been understood that tone rescaling factor γ influences the edge enhancement since it has it the conversion of the histogram of the brightness of the image by using sigmoid function.

References

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Author Biography

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