Color Image Arrangement Using Histogram Matching

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Abstract

For the arrangement processing of image using its histogram, we previously have presented a Histogram Matching method based on Gaussian Distribution (HMGD). However, in the case where the brightness histogram of input image has multiple peaks, the HMGD processing does not always bring good results. In this paper, we present an improved histogram matching method using the reference histogram that is made by appropriate moving average (HMMA) processing over the histogram of input image. Also in this paper, we show the experimental results.

Keywords: Image processing, Histogram matching (HM), Moving average, Kansei impression

1. Introduction

Recently, automated image arrangement processing such as enhancement of images that we have already reported is usually used in the various imaging devices, for example, Digital Camera, Smart Phone and so on [1], [2], [3].

In our previous papers, we have presented a Histogram Matching based on Gaussian Distribution (HMGD) processing for the image arrangement [4], [5], [6], [7]. And we illustrated that HMGD processing can improve feeling (or Kansei) impression of the original image [4], [5], [6], [7].

In this paper, we propose an improved Histogram Matching method using the reference histogram that is made by appropriate Moving Average (HMMA) processing over the histogram of input image [8]. Also, in this paper, we provide the experimental results for some color images and show its effectiveness of the proposed method.

2. Principle

2.1. Histogram Matching as Example of Gaussian Distribution [9]

In the section, we describe the principle of histogram matching method as an example of Histogram Matching based on Gaussian Distribution (HMGD).

Fig. 1 shows the conceptual image of HMGD. Let $f(x)$ and $h(y)$ be two probabilistic density functions (PDF) on real variables x and y, respectively. The PDF is corresponding to histogram of image brightness level which is discretely defined.

In addition, let $y=\phi(x)$ be a continuous and monotonic increase function corresponding to cumulative histogram of image brightness level between variables x and y. And let $y=\phi(x)$ be defined by Eq. (1).

$$y = \phi(x) + L\int_0^x f(x)\,dx \quad \text{..... (1)}$$

At first, we have to expand brightness level of original image histogram and convert into uniform distribution histogram, because we aim to match Gaussian distribution. From Eq. (1) and Fig. 1, we can derive Eq. (2) and (3).

$$f(x) = h(y)\varphi'(x) = h(y)Lf(x) \quad \text{..... (2)}$$

$$h(y) = \frac{1}{L} \quad \text{..... (3)}$$

We understand the histogram of original image $f(x)$ becomes uniform distribution $h(y)$ by Eq. (3). This means that brightness level of original image $f(x)$ is expanded to $h(y)$.

Then, let $g(z)$ and $\gamma(z)$ be the function that is defined by Eq. (4) and Eq. (5), respectively.

$$g(z)=\frac{1}{\sqrt{2\pi\sigma^2}}\exp\left(-\frac{(z-\mu)^2}{2\sigma^2}\right) \quad \text{..... (4)}$$

$$y=\gamma(z)=L\int_0^z g(z)\,dz$$

$$=\frac{1}{\sqrt{2\pi\sigma^2}}\int_0^z \exp\left(-\frac{(z-\mu)^2}{2\sigma^2}\right)dz \quad \text{..... (5)}$$

Here, Fig. 1 shows the relationship between $y=\phi(x)$ and $y=\gamma(z)$. So we can be obtained following Eq. (6) and Eq. (7).

$$L\int_0^x f(x)\,dx=\frac{L}{\sqrt{2\pi\sigma^2}}\int_0^z \exp\left(-\frac{(z-\mu)^2}{2\sigma^2}\right)dz \quad \text{.... (6)}$$

$$\frac{d}{dx}L\int_0^x f(x)\,dx=\frac{d}{dz}\frac{L}{\sqrt{2\pi\sigma^2}}\int_0^z \exp\left(-\frac{(z-\mu)^2}{2\sigma^2}\right)dz. \quad \text{.. (7)}$$

If we perform Eq. (7),

$$L\varphi'(x)=L\gamma'(z),\quad f(x)\Rightarrow g(z) \quad \text{..... (8)}$$

That is, we understand that $f(x)$ becomes Gaussian distribution $g(z)$ when we take the transform function as Eq. (1) and Eq. (5).

Thus, histogram matching processing is the function which defined by cumulative histogram transformation the original histogram into arbitrary histogram.

3. Experimentation

Fig. 2 and Fig. 3 show the example of results and the corresponding histogram respectively. In this case, we understand that HMGD image is very enhancing brightness and contrast than original image.

However, the touch of brush detail transforms unnatural in this image. Also we understand that HMMA image is enhancing contrast than original image and the color tone keeps and slightly brighter than original image.

Fig. 4 and Fig. 5 show another example of results and the corresponding histogram, respectively. In this case, we understand that the simple application of HMGD processing gives poor perspective impression. And HMMA image is enhancing its perspective and detail of rocks in this image than original.

From the experimental results, we consider that HMMA processing enhances the effect of the Kansei impression effect more than HMGD processing.

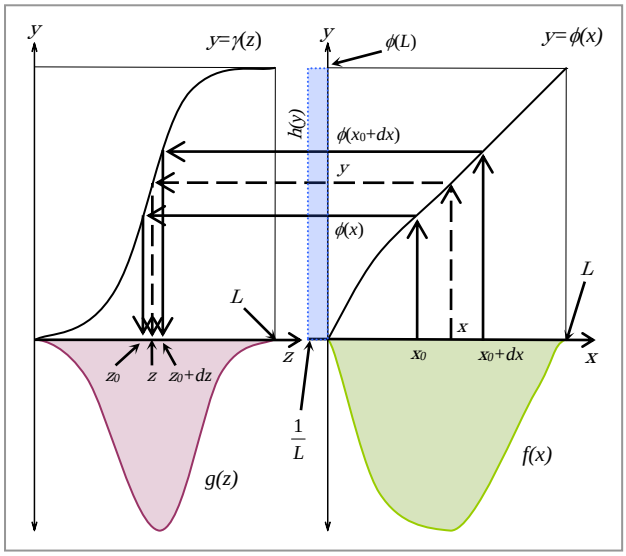


Fig.1 Conceptual image of histogram matching (example of HMGD).

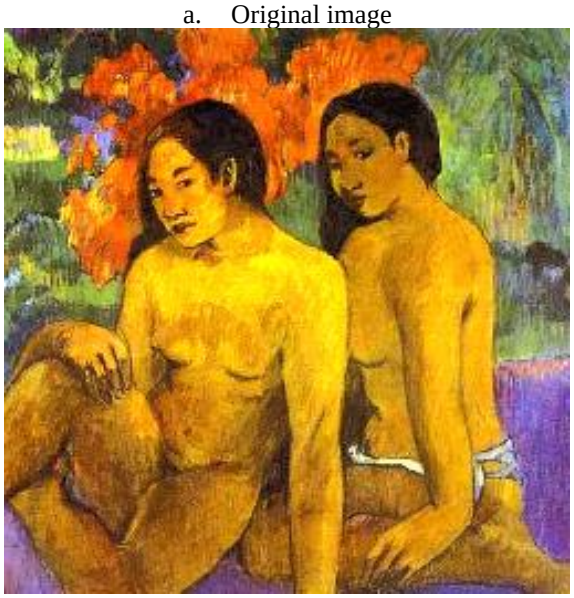
4. Conclusion

In this paper, for the color image arrangement processing, we have described two histogram matching based methods: Histogram Matching based on Gaussian Distribution (HMGD) and Histogram Matching based on Moving Averaged histogram (HMMA).

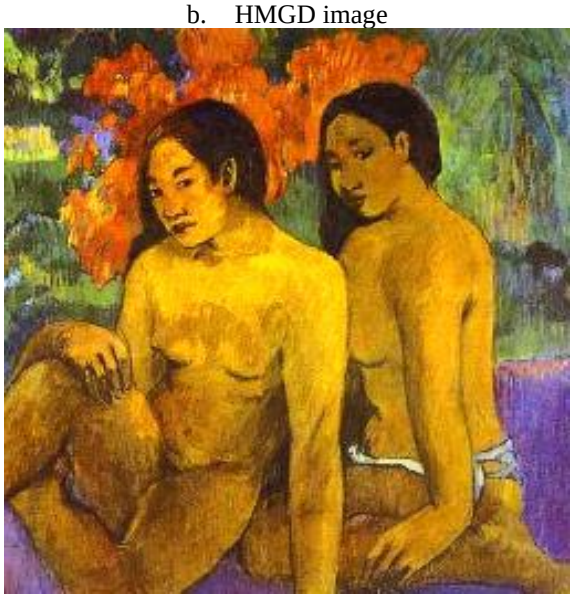
And we have compared the two methods as to how each processing brings about the Kansei impression effect. Although the number of experimented images that we have shown in this paper is limited, from the results, we can find that the processing by HMMA more enhances the contrast, brightness, and detail of original image than by HMGD. That is, we consider that HMMA processing can improve the Kansei impression.

Since these evaluation of impression effects are subjective at this point, so we will objectively investigate the improvement of Kansei impression through questionnaire surveys and characteristics quantity in image, for future study.

a. Original image

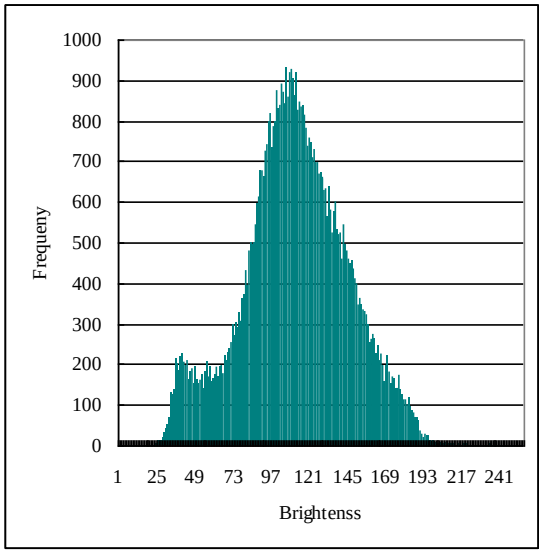


b. HMGD image

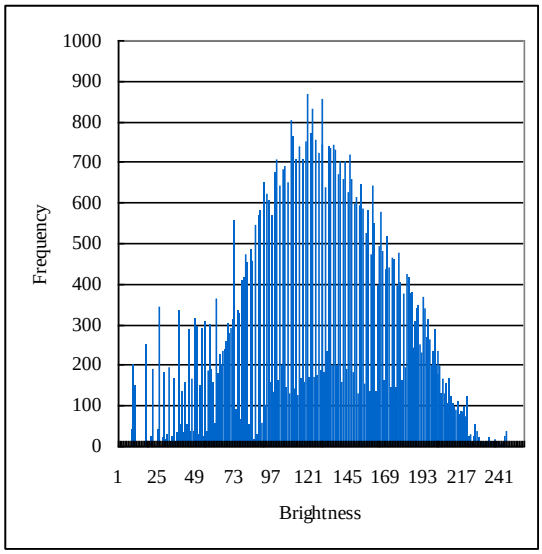


c. HMMA image

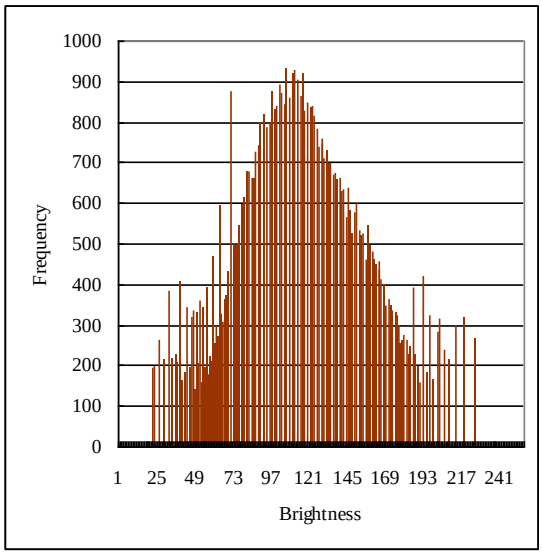
Fig. 2. Experimental results of original image, HMGD image, and HMMA image



a. Original image histogram



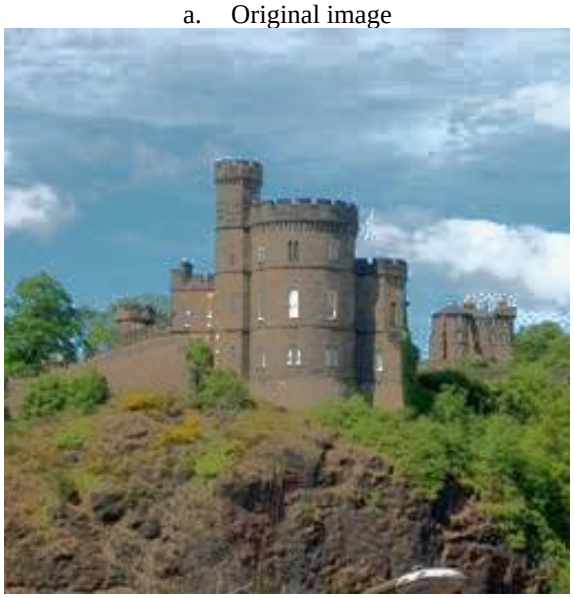
b. HMGD image histogram



c. HMMA image histogram

Fig. 3. Corresponding histogram of Fig. 2

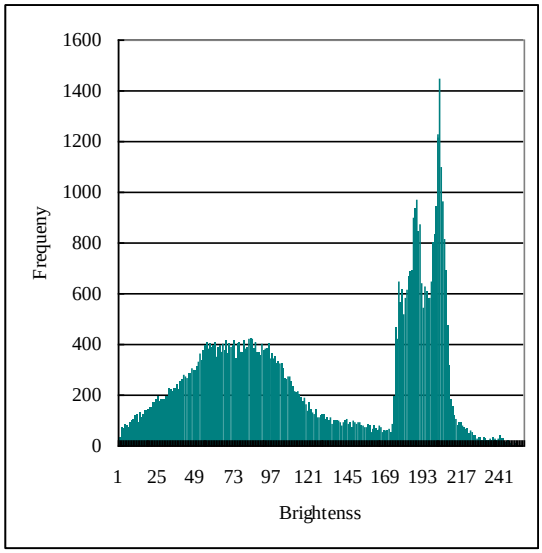
a. Original image



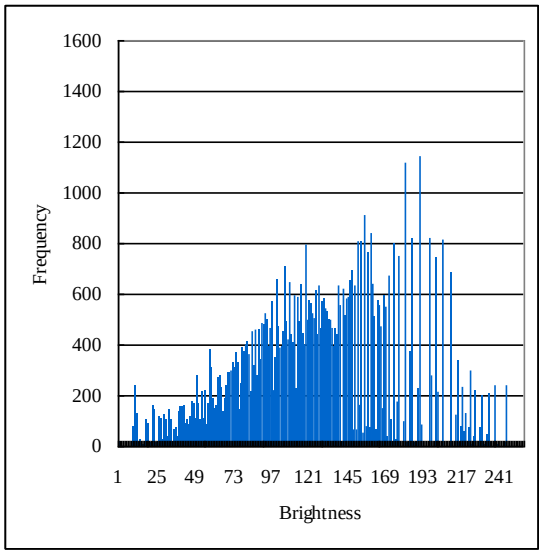
b. HMGD image

c. HMMA image

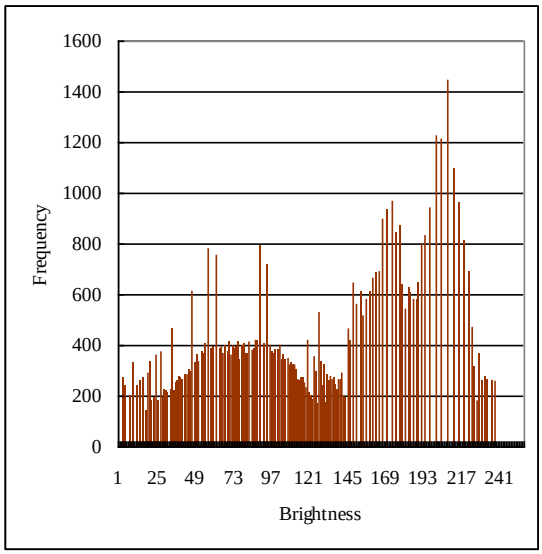
Fig. 4. Experimental results of original image, HMGD image, and HMMA image



a. Original image histogram



b. HMGD image histogram



c. HMMA image histogram

Fig. 5. Corresponding histogram of Fig. 4

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