Adaptive Visibility Improvement Method for Color Digital Image

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Abstract

In recent year, the great amounts of digital images are in common use for variety output ways, such as in CRT display or hard copy with printers. However, it is very difficult to picturize and read out as images all of the objects or information contained in the scene that actually is sensed with the human eye. In the human eye, the range on which the eye focuses fits well in a field of vision. With this adjustment mechanism, we can sense details to a certain extent even when the differences in brightness object or scene are large. However, it is difficult to express the information about such subjects or scenery in an image when only a constant exposure can be established like photographs. For example, taking a picture against the sun cause those darker sections in the scene blacken and a brighter section blench. In this regard, a method is proposed in which we don't lose the information sensed with the eyes when producing an output of an image. This is a method for expressing more information in an image by collapsing the balance of brightness intentionally an expanding local dynamic ranges. In this method, we deal with the brightness of color image (monochrome image), which is created from the color image represented as RGB value. This method is an automatic image-processing algorithm that minimizes loss of information and sense of incongruity by collapsing the coloration balance in an output image as a whole on a minimum level.

1.Introduction

In recent year, we have seen remarkable progress in the production technology for inexpensive digital cameras and printers for personal use. Using such instruments, it is now possible for us to print very high quality photo image. But unlike the human eye, unique value for exposing condition is given in printed images.

As the result, there are cases that the information sensed with the human eye is lost because of insufficiency of dynamic range. Therefore, we propose a method that applies AHE (Adaptive Histogram Equalization) , that is one of the algorithms for enhancing local contrast, to improve the local dynamic range. It is named Adaptive Dynamic Range Improvement Algorithm (ADRIA). In this paper, a description of the proposed method is given, and application results of the method are showcased for color Images with a digital camera for the consuming public.

2.Flow Chart of Proposed Method

Figure 1 shows the flow chart of proposed method.

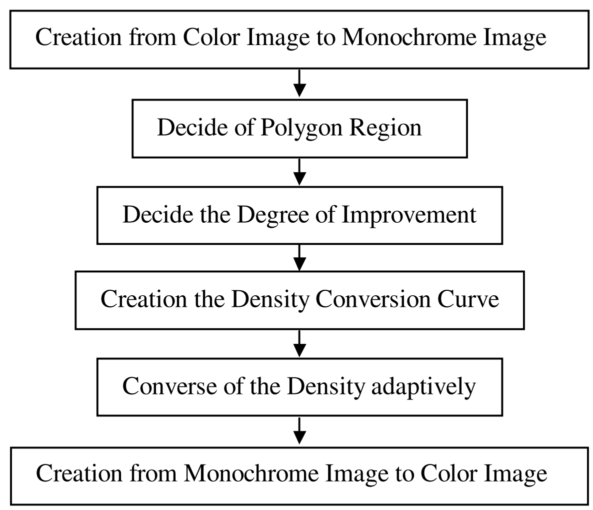


Figure 1. Flow chart of proposed method

3.Creation from Color Image to Monochrome Image

In this method, we deal with the brightness of color image, which is created from the image represented as RGB value. We can calculate that brightness value *I* by calculating the next equation.

$$I = \left(Min\{R, G, B\} + Max\{R, G, B\}\right)/2 \qquad (1)$$

The brightness image (monochrome image) is created by using results of (1) at all pixels. This monochrome image is improved at the following processes, 4- to 5.And, after processing of the adaptive improvement algorithm to this brightness image; we need to recreate the color image. In order to get a better deal of the final result, color image, the equation (2) is used.

$$\left(r, g, b\right) = \left(R/I, G/I, B/I\right) \quad (2)$$

This value set *r, g, and b* show like a kind of color of each pixel.

4.Automatic Decide of Polygon Region

In the method we propose to improve the local dynamic range by dividing the whole image into some regions, and adopting the most suitable parameter that determines the degree of dynamic range improvement in each region.

First, we divide the whole image into a small square block and integrate a block of the same region by using the LOG filter.And we make histograms in each region, and improve the local dynamic range by using them.

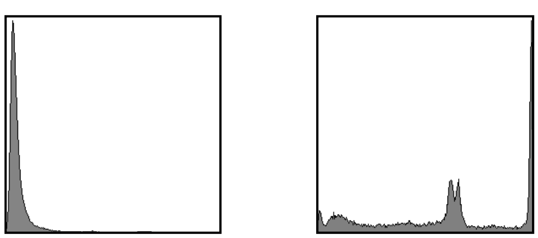
5.Automatic Decide of the Degree of Improvement

For each block, we need to decide the degree of improvement. For example, the degree of a darker region should be set to high. Conversely, the degree of a brighter region where we can sense details should be set to low. In order to determine this degree, two parameters, the mean entropy of histogram and the complexity of texture are used.

5.1 Parameter1: The Entropy of Histogram

Some histograms of each region show this relation. In the regions in which we lose the information sensed with the eyes, for example, darker sections, the dynamic ranges are narrow. Conversely, in the regions in which we can sense details, brighter sections, the dynamic ranges are wide. In other word, we can find the degree of improvement by quantifying the width of the dynamic range.

The width of the dynamic range is represented as the entropy of histogram. (Two illustrations, Figure 2-(a)(b)) Then the degree of improvement *D* is determined by fixing the proportionality relation is given in Figure 3.



(a) Dynamic range is narrow The entropy is small

(b) Dynamic range is wide The entropy is big

Figure 2. Two illustrations of histograms

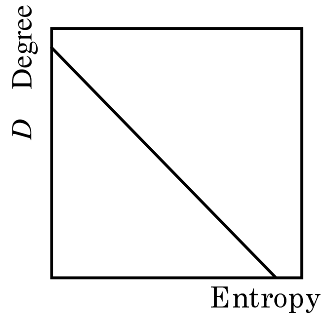


Figure 3. Entropy toDegree Relation

5.2 Parameter2: The Complexity of Texture

In the above method, decided of the degree by the mean entropy, however, a following problem occurs. In the region, which includes the self-colored object, for example, a white-walled building, the mean entropy (**5.1**) is small and the degree of improvement is big. However, in this case, it is not like that dynamic range is small but number of color is small. So this area should not be improved as far as possible. In order to clear up this problem, the complexity of texture of each region that is computed automatically is used. Specifically, we count the number of edge pixel *N* that is abstracted by using the LOG filter. And then, the degree of improvement is changed for the better (*D'*) by multiplying *N* to *D*.

6.Creation the Density Conversion Curve

For each block, we create a suitable the density conversion curve by using *D,* the degree of improvement. This method is the algorithm to which HE (Histogram Equalization) as a general contrast enhancement algorithm is applied.

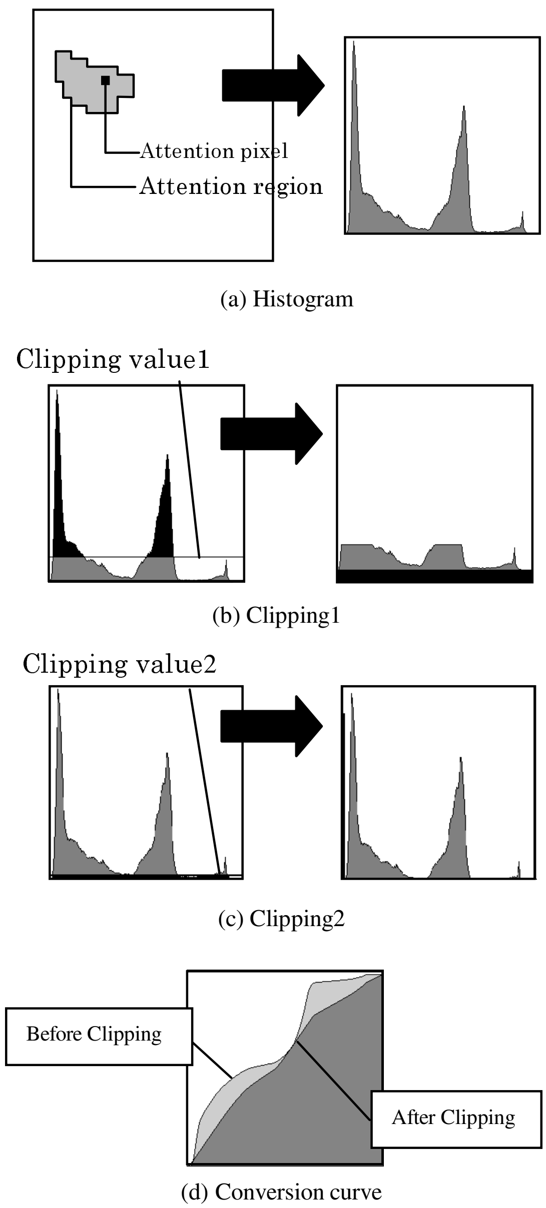
HE (The Histogram Equalization) is a contrast enhancement algorithm. We make a density histogram from a region. Then, we make an accumulation histogram from the density histogram. By using the density conversion curve, it is possible to enhance image contrast of the region. In this method, we set up two thresholds or clipping values and clipping off pixel value. Then for each block, we can get a suitable the density conversion curve for improving contrast and brightness.

[1] Clipping 1: The control of the enhancement of contrast

We set up clipping value1 at the upper part of a density histogram and clip off pixel values exceeding the value, which are distributed equally to every density. (Figure4 (b)) When the clipping value1 is small, the accumulation histogram, conversion curve is smooth and the enhancement of contrast is small. For the suitable enhancement of contrast, we determine clip value1 by proportionate to *D*, the degree of improvement.

[2] Clipping2: The control of the brightness

Next, we set up clipping value2 at the lower part of a density histogram and clip off pixel values not-exceeding value, in this case, clipping value2, which are laded at minimum value, zero. (Figure4 (c)) As the result, when we make an accumulation histogram, the conversion curve is moved to upper part. For the suitable brightness, we determine clip value2 by proportionate to *D*, the degree of improvement.



(a) Histogram

(b) Clipping1

(c) Clipping2

(d) Conversion curve

Figure 4. Histogram Equalization and Clipping

Clipping 1,2 are ran at the same time. By this process, the most suitable curve is computed automatically for each region.

7.Converse of the Density Adaptively

In the above, however, enormous processing time is needed because we need to generate a density histogram for all pixels in the image. As a result, we generally divide the image into square regions, and we use the same conversion curve in the same region. As a result, the processing time is shorter. Occasionally, however, the density at the boundary between regions is broken up, and block-noise occurs. In order to prevent block noise, a proportional distribution of the four blocks around the attention pixel is used (Figure 4). The output value using the proportional distribution explains the next equation.

$$g(x,y) = \{(J-j)/J\}\{(I-i)/I * g1 + I/I * g2\} + (j/J)\{(I-i)/I * g3 + I/I * g4\} \quad (3)$$

Where g1, g2, g3 and g4, are the converted values using the density conversion curve made from circumference 4 blocks.

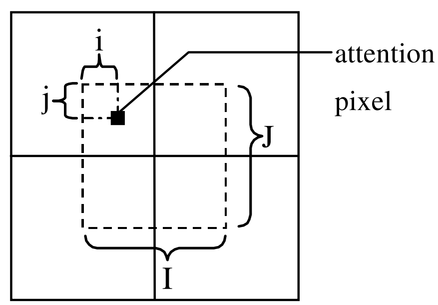


Figure5. Proportional Distribution

8. Creation from Monochrome Image to Color Image

At last, we calculate the color image from *I'*, which is output value of the conversion curve, and the value set (*r, g, b*), ((2)). The equation (4) is used.

$$(R,G,B) = (r \times I', g \times I', b \times I') \quad (4)$$

By using those equation (2),(3) for creation the brightness of color image, the vibrancy of final result color image can be reflected in improvement of the brightness image.

9.Result

The following are processed images.

Figure 6 is the original image. Figure 7 is an output image after our processing.

Figure 6. Original image

Figure 7. Putput image

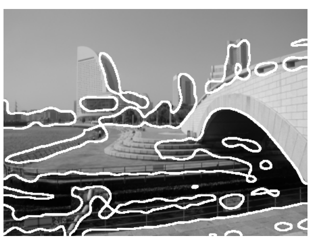


Figure 8. LOG filter

Figure 9. Image of region

Figure 8 is an image representing the regions as result of LOG filter, and Figure 9 is an image representing the block regions. In Figure 8 and 9, the boundaries of the regions are represented as a white line.

The size of the original full-color image was 2048 x 1536 pixels, and the time needed for processing was about 20 second (using a Pentium Ⅲ running at 1 GHz).

Conclusion

A method doesn't lose information sensed with the eyes when producing the output of an full-color image, even when the original image covers a wide dynamic range. We applied HE, one of the algorithms for emphasizing contrast, to improvement dynamic range of a region. In this instance, we create the monochrome image form color image, divide the image into several polygon regions on the basis of information provided the LOG filter and used proportional distribution in order to shorten processing time. The results of devoid block-noise at the boundaries of regions. It was possible to obtain output image by the suitable density conversion curve for each region, which is decided by measuring entropy and the number of edge.

References

1. Kosei Takahashi, Masato Nakajima: "Adaptive Dynamic Range Improvement Method for Personal Printer Devise ", *Final Program and Proceedings of International Conference on Digital Printing Thecnologies*, pp342-345,(1999)
2. Debargha Mukhejee and B.N. Chatterj, "Adaptive Neighborhood Extended Contrast Enhancement and Its Modifications, *Graphical Models and Image Processing*. Vol.57, No.3, May, pp254-265 (1995)

Biography

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