IMPROVEMENT OF COLOR HALFTONING USING ERROR DIFFUSION METHOD

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ABSTRACT

In the printer and the facsimile communication, digital halftoning is extremely important technologies. Error diffusion method is applied easy for color image halftoning. But the problem in error diffusion method is that a quite unrelated color has been generated though it is necessary to express the area of the grayscale in the black and white when the image that there is an area of the grayscale on a part of the color image is processed. The halftoning was assumed to be a combinational optimization problem to solve this problem, and the method of using SA (Simulated Annealing) was proposed. However, new problem existed because the processing time was a great amount compared with error diffusion method. Then, we propose the new error diffusion method.

Keywords: color halftoning, error diffusion , grayscale, Simulated Annealing,

1. Introduction

In the printer and the facsimile communication, digital halftoning is extremely important technologies. There are many methods of digital halftoning of a monochrome image, for example, ordered dither[1], error diffusion[2], and application of combination optimization problem.[3,4] Error diffusion method is applied easy for color image halftoning, and has already been put to practical use. However, the problem in error diffusion method is that a quite unrelated color has been generated though it is necessary to express the area of the grayscale in the black and white when the image that there is an area of the grayscale on a part of the color image is processed. The halftoning was assumed to be a combinational optimization problem to solve this problem, and the method of using SA (Simulated Annealing)[5] was proposed. However, new problem existed because the processing time was a great amount compared with error diffusion method. Then, we propose the new error diffusion method. In quantization process, the level of red component of halftone image is selected the same level of green component of halftone image, when the level of red component of original image is equal to the level of green component of original image in the same pixel position. The processing time of this propose method is shorter than that of SA. Image quality of this proposed method is can high-speed process, and visually obtains an excellent result. Moreover, even if the grayscale area existed in the full color image, the area that contains black and white in halftone image is able to obtain the grayscale area in the original image.

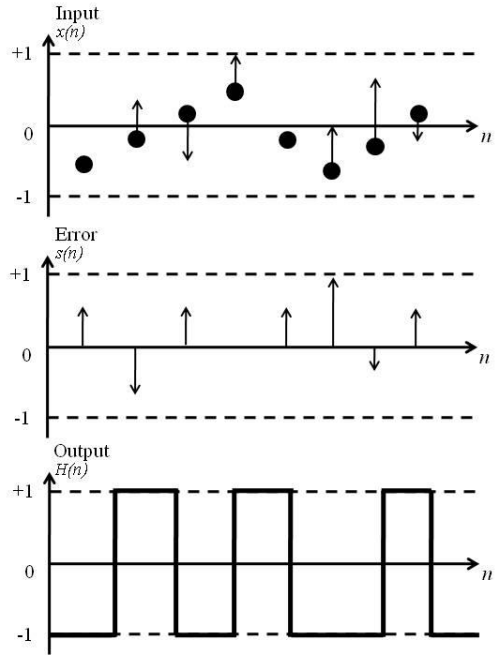


Fig.1 : Basic concept of error diffusion method

2. Previous method of error diffusion

2.1 Basic concept of error diffusion method

Fig.1 shows basic concept of the error diffusion method. Data $f(n)$ is assumed that the value within the range of -1～+1 is taken.

1. Data $f(k)$ in n=k is read.Value $g(k)$,which the quantization error is added, is given as follows.

$$g(k) = f(k) + e(k-1), \qquad (1)$$

where, if k is equal to zero, quantization error $e(k-1)$ is equal to zero. This is because that n is greater that zero.

2. The values $g(k)$ are compared with threshold (=0) and binary number $H(k)$ is obtained as follows.

$$H(k) = \begin{cases} +1 (g(k) \geq 0) \\ -1 (g(k) < 0) \end{cases} \qquad (2)$$

3. Quantization error $s(k)$ which generated between $g(k)$ and $H(k)$ is given as follows,

$$s(k) = g(k) - H(k) \qquad (3)$$

4. Value $g(k+1)$, which the quantization error $e(k)$ is added, given as follows.

$$g(k+1) = f(k+1) + e(k) \qquad (4)$$

5. Ass data $\{f(n)\}$ are quantized by a similar process that consisting of the procedure 2.～4., mentioned above. Output binary number $\{H(n)\}$ is obtained.

2.2 Extension to color image

The color image is composed by the combination of each Red, Green, and Blue (three primary colors). At the color image the case of Windows Bit Map, the three primary colors of R, G and B has density information of 0-255 respectively. Therefore, the color data is first divided into each primary color element. And, processing similar to the case of a monochrome image is done. Each primary color results are united at the end. Then, the color image can be treated. Figure 2 shows this process.

2.3 Experiment result and problem

In this experiment, the image of $256(H) \times 256(V)$ pixels, 24bit images specification was used. Fig.3 shows the processing image. In image B, the right side of an original image is a Grace kale. However, the colors other than white and the black mix at the right side of the processing image(B-ED). This is because it was processed in the direction from the left side of the image to the right side according to the raster scanning. Therefore, it is thought that the error margin in a color area of left side influenced the Grace kale area of right side. Consequently, like image C when the left side of the image is a Grace kale, unrelated colors other than white and the black did not mix with the area of the Grace kale.

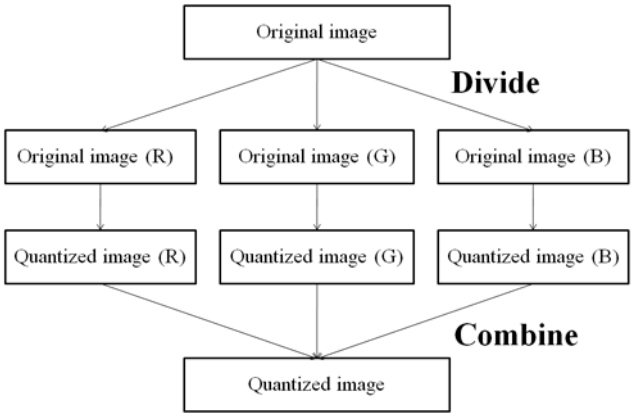


Fig. 2 : Procedure of the halftoning with dividing the three primary colors

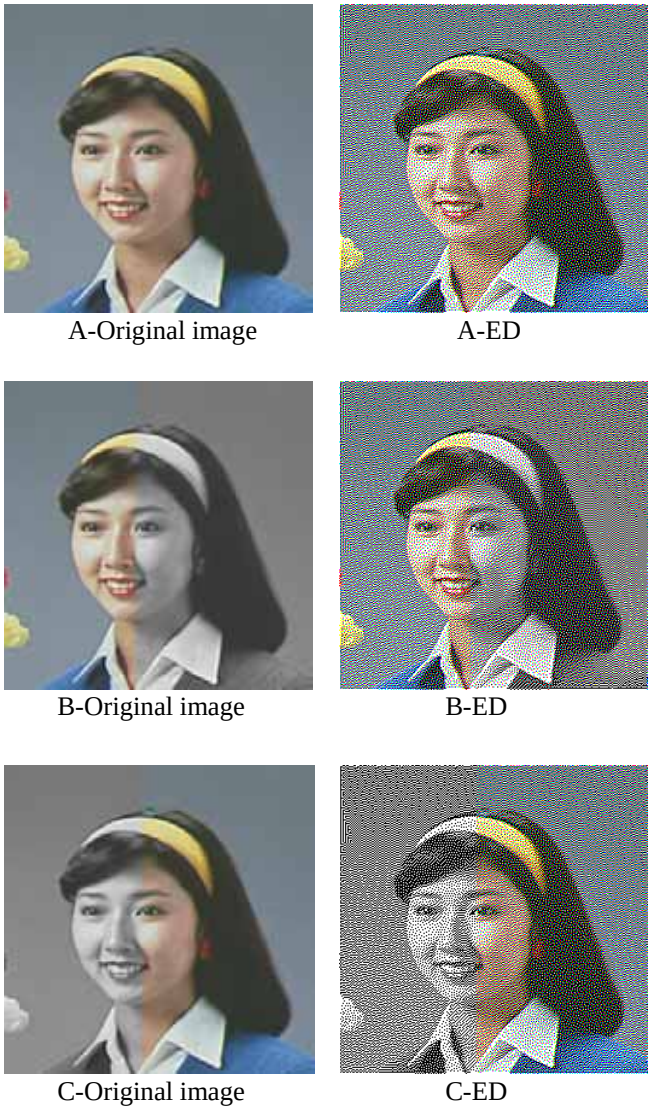


Fig.3 : Halftone images using Error Diffusion (Original images is full color image)

3. Introduction of a limitation condition in choice of a color

Fig.4 shows the relation between RGB(Red, Green, and Blue) and MCY(Magenta cyanogens and yellow). When the input is an image of 24 bit color, as for one pixel, each RGB is shown by the value of 0-255. Trouble like Chapter 2.3 occurs if it meets the requirement with RGB each element of the input. Then, the method of the proposal this time selects the color by specific conditions at Halftoning. Each condition is described as follows.

3.1 For R=G=B

When R=G=B is approved, the gradation that changes from the black into white as the value changes from 0 into 255. Therefore, the black and white are selected at Halftoning.

3.2 For R=G

It is in the diagonal that connects the black with yellow in

Fig.4 when the color is expressed by the vector. In addition, the influence of blue element is received. Therefore, it is necessary to select the black, yellow, blue, and white at Halftoning.

3.3 For R=B

There is a color vector in the diagonal that connects the black with the magenta when thinking as well as Chapter 3.2. In addition, the influence of green element is received. Therefore, it is necessary to select the black, the magenta, green, and white at Halftoning.

3.4 For G=B

There is a color vector in the diagonal that connects the black with cyanogens when similarly thinking. In addition, the influence of red element is received. Therefore, it is necessary to select the black, cyanogens, red, and white at Halftoning.

3.5 Experiment result

Fig.5(*-proposed) shows the processing image. In Fig.4 B-new, the problem like Chapter 2.3 cannot be confirmed.

4. Halftoning using Simulated Annealing

In this chapter, SA is used in the halftoning in the color image. SA is one of the methods of the combination optimization problem. In the halftoning of the color image, externals of this method are also effective. Moreover, the colors other than black and white do not mix with the processing image when the input is a grayscale.

4.1 Processing time

The processimg time of each method is compared. Table 1 shows the result. The method of using SA requires a great amount of processing time compared with other methods.

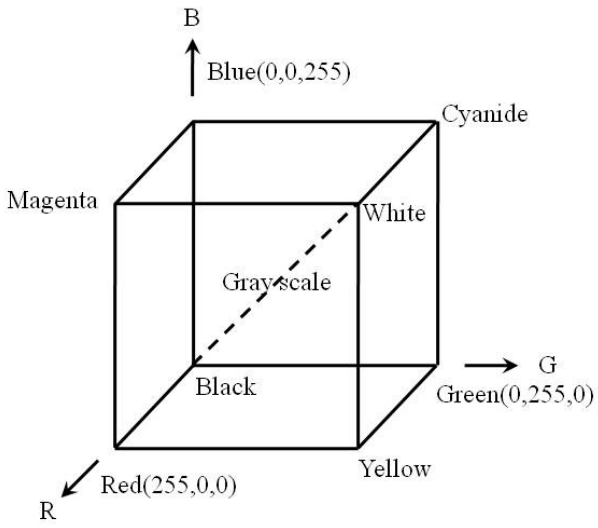
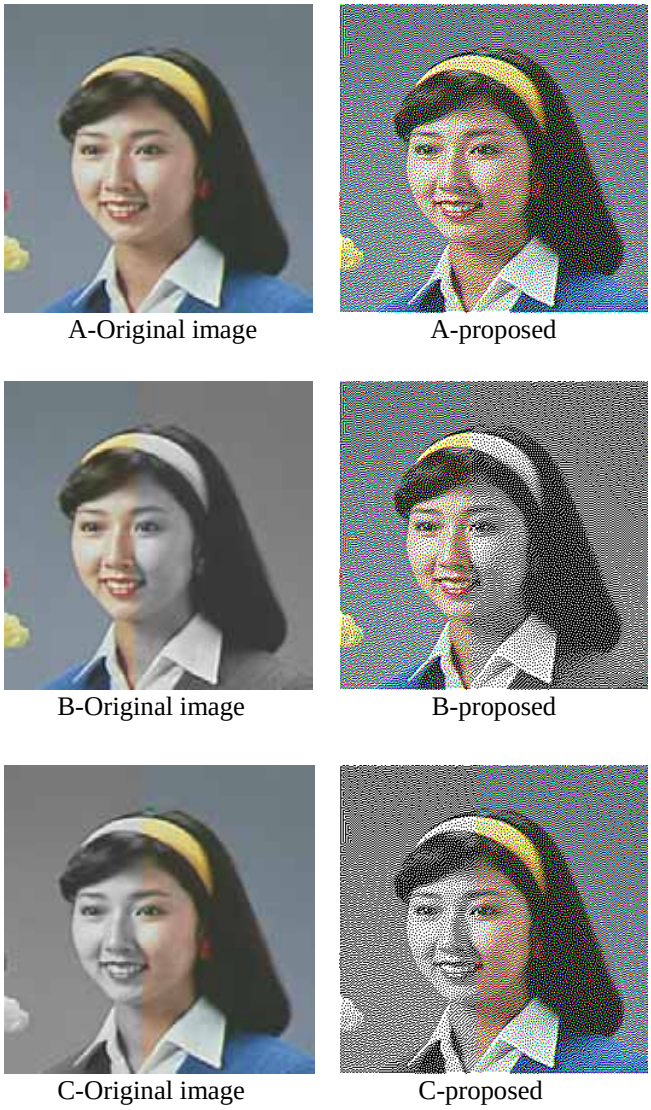


Fig.4 Relation between RGB and MCY



A-Original image　A-proposed

B-Original image　B-proposed

C-Original image　C-proposed

Fig.5 : Halftone images using proposed method (Original images is full color image)

5. Conclusions

In this thesis, error diffusion method was applied as Halftoning. The random dither has already been put to practical use. However, when the area of the color and the area of the Grace kale have divided on a certain condition, unrelated colors other than black and white mixed with the area of the Grace kale. Then, the author clarified that this problem was solved by devising the selection of the color at Halftoning. When R=G=B is approved, the output is composition in white and the black because it becomes a

Method	ED	Proposed	SA
Time	< 5sec.	< 5sec.	15min.

Table 1 : processing time of each method

Grace kale. Therefore, the method of specifying the color used when each condition was output was developed. As an another way, the processing time became huge and the practicality was lacked greatly though the method of using SA was proposed. The improvement of the error diffusion method was able to be proven to be the abovementioned and effective. The color reproducibility is improved as future tasks.

6. References

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