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Improvement of digital halftoning

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Abstract: When the image is displayed in the device that there is a limitation in the number of colors and the density value, the half tone processing is a needless technology. Several techniques like the dither method and the error diffusion method[1], etc. are proposed as a well known halftoning. The image evaluation of the processing image by the error diffusion method is superior compared with dither methods. Though, the processing image by the error diffusion method has visual problem. The blur is generated in the edge area. The noise of the striped pattern is generated in area that is low level value change of pixel. This paper, consider improvement the processing image by applying error diffusion algorithm with edge enhancement to using error coefficient corresponding to step edge. It is found that proposed technique process high quality halftoning image compared with error diffusion algorithm with edge enhancement.

Keywords: hlftoning, error diffusion, edge enhancement,

1 Introduction

Error diffusion algorithm with edge enhancement[2] is effect edge enhancement by determined threshold level for each pixel. Though, only this process, it is persisted that the noise of the striped pattern is generated in area that is low level value change of pixel. It is needed to solve this problem taking advantage of the Error diffusion algorithm with edge enhancement. In this paper, we consider the effectiveness that applying error diffusion algorithm with edge enhancement to using error coefficient corresponding to step edge.

2 Error diffusion algorithm with edge enhancement

In this section, describe error diffusion algorithm with edge enhancement briefly. Position of pixel being processed is put with (x, y), the pixel's value is g(x, y), the value that pixel processed is g'(x, y). Then g'(x, y) is as below.

$$g'(x,y)=\begin{cases}1 & g(x,y)\geq t(x,y)\\ 0 & g(x,y)<t(x,y)\end{cases} \tag{1}$$

t(x, y) is threshold level for each pixel. Enhancement coefficient is put with k, Standard threshold level is put with t', then t(x, y) is as below.

$$t(x,y)=(1-k)g(x,y)+kt' \tag{2}$$

Quantization error by processed is as below. This quantization error is diffused to neighborhood pixels as below.

$$error(x,y)=g(x,y)-g'(x,y) \tag{3}$$

$$(x',y')=(x',y')+W(x,y)\times error(x,y) \tag{4}$$

W(x, y) is diffusion coefficient that's range is 1 from 0. When k=1, threshold level for each pixel t(x, y) are same as standard threshold level t', it result in several algorithm error diffusion.

3 Reducing stripe noise using proper error coefficient

It is effective to solve the generated noise of the striped pattern that using large size error coefficient in area that is low level value change of pixel[3]. Though, in area pixel's value change high, the distance between the area generate quantization error and the area diffused quantization error is free. This causes the blur is generated in the edge area. Though, it is need to take the following measures.

1) In low level value change of pixel area, large size error coefficient is used.
2) In high level value change of pixel area, near the edge area, small size error coefficient is used.

Next section, describe the algorithm to search high level value change of pixel area to use above method.

4 Detection edge using differential filter

This study, we detect the edge using differential filter to search high level value change of pixel area. Differential filter outputs value change level of pixel as value of pixel, this is effective to search high level value change of pixel area. Differential filter are Fig.1, Fig.2. The value calculated by the differential filter is outputted as value of pixel, the image edge enhanced is displayed. (Fig.3). Value of edge is put with L(x, y), then L(x, y) is as below.

0	0	0
0	1	-1
0	0	0

Fig.1.
Horizontal differential filter $\triangle X$

0	0	0
0	1	-1
0	0	0

Fig.2.
Vertical differential filter $\triangle Y$

$$L(x,y)=\sqrt{\triangle X(x,y)^2+\triangle Y(x,y)^2} \quad (5)$$

Fig.3.
The image edge enhanced

5 Proposed method

It is summarized as follows : the proposed method.

1) The original image is detected the edge in advance.
2) Error diffusion algorithm with edge enhancement applied to the original image.
3) In near the edge area, small size error coefficient (Fig.4) is used. In low level value change of pixel area, large size error coefficient (Fig.5) is used.

It is used as small size error coefficient that is Floyd and Steinberg error coefficient(Fig.4). It is used as large size error coefficient that is original error coefficient(Fig.5). And also, near the edge area is defined as pixel that is detected the edge, and defined as 8 pixels surrounding the edge pixel is detected.

In the case, the quantization error by processed in low level value change of pixel area is diffused to near the edge by large size error coefficient, it is used small error diffusion the pixel.

	x	7/16
1/16	5/16	3/16

Fig.4.
Floyd and Steinberg error coefficient
(x : processed pixel)

				x	128	64	32	16
8	16	32	64	128	64	32	16	8
4	8	16	32	64	32	16	8	4
2	4	8	16	32	16	8	4	2
1	2	4	8	16	8	4	2	1

$\times \left(\frac{1}{930}\right)$

Fig.5.
Original error coefficient
(x : processed pixel)

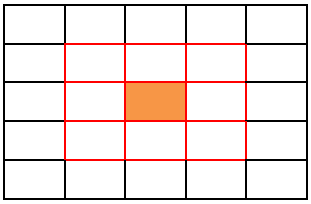

Fig.6.
The areas near the edge.

The pixel edge is detected.

The areas near the edge.

g'(x, y) processed above method is displayed binary as blue, green, red. Error diffusion with edge enhancement algorithm and using error coefficient corresponding to step edge is complete.

6 Result

The original image is Fig.7. This size is 256×256. Value of pixel is 256gradations. It is difficult to judge visual problems like the noise of the striped pattern by numerical evaluation level [4]. There for, these problems are judged by visual. And level deterioration by binary is judged tone reproduction evaluation (MSE) [4], [5]. Standard threshold level is determined by discriminative analysis method [6], [7]. Discriminative analysis method is determiner considering background and object. There for, it is expected superior process in the vicinity monotonic area and edge area. Fig.8 is error diffusion algorithm with edge enhancement. Fig.9 is proposed method.

$$MSE = \frac{1}{MN}\sum (g(x,y) - g'(x,y))^2 \qquad (6)$$

Fig.7. Original image

Fig.8. Error diffusion algorithm with edge enhancement
MSE=22.5074846939085

Fig.9. Proposed method
MSE=22.1088512291146

Fig.9 is superior process in low level value change of pixel area than Fig.7. MSE is superior than Fig.8 of Fig.9 is more. From this, it is effective for tone reproduction evaluation that applying error diffusion algorithm with edge enhancement to using error coefficient corresponding to step edge.

7 Closing

It is effective for decrease the noise of the striped pattern and tone reproduction evaluation, taking advantage of the error diffusion algorithm with edge enhancement that applying error diffusion algorithm with edge enhancement to using error coefficient corresponding to step edge. In addition, it is found evaluation level (MSE) is depended on threshold level from this study. Future study, it is needed to consider that another determination threshold level.

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