Modified Error-Diffusion Methods and its Comparison with Halftone Method

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Abstract

Algorithms of converting a continuous-tone image into a binary, high quality image has been studied in non-impact printing field. In this research we show some experimental results on the relation between the magnification of halftone dots and the quality of output binary image.

Introduction

Resolutions of printers are getting higher rapidly these days. When we make a hardcopy of a digital image data, the resolution of a printer has close relation to the quality of output image. For example, when the resolution of the printer is lower than that of the image, the quality of output image would not be the best. Since the optimal resolution of the printer is known in general, it is desirable that we can get any size of output image with that resolution from one input digital image data. Thus it is important to study the method of magnifying or reducing the image size and the method of binarizing it. In this research we show some experimental results. We magnify an input image size by copying each dot and then binarize it by using the error-diffusion method or the halftone method. We use 256 gray-level images for input data and a 400dpi laser printer.

Error-Diffusion and Halftone Methods

We use a standard error-diffusion method. The set of coefficients[1] is expressed as the following:

$$\begin{bmatrix} - & * & a_{1,0} \\ a_{-1,1} & a_{0,1} & a_{1,1} \end{bmatrix} = \begin{bmatrix} - & * & 7 \\ a & 5 & 1 \end{bmatrix} = \qquad (1)$$

We use two types of halftone method. One has a 4 × 4 threshold matrix and the other 8 × 8. The threshold matrices are shown below:

$$\begin{bmatrix} 6 & 5 & 4 & 3 \\ 7 & 14 & 13 & 2 \\ 8 & 15 & 12 & 1 \\ 9 & 10 & 11 & 0 \end{bmatrix} \qquad (2)$$

and

$$\begin{bmatrix} 14 & 13 & 12 & 11 & 10 & 9 & 8 & 7 \\ 15 & 38 & 37 & 36 & 35 & 34 & 33 & 6 \\ 16 & 39 & 54 & 53 & 52 & 51 & 32 & 5 \\ 17 & 40 & 55 & 62 & 61 & 50 & 31 & 4 \\ 18 & 41 & 56 & 63 & 60 & 49 & 30 & 3 \\ 19 & 42 & 57 & 58 & 59 & 48 & 29 & 2 \\ 20 & 43 & 44 & 45 & 46 & 47 & 28 & 1 \\ 21 & 22 & 23 & 24 & 25 & 26 & 27 & 0 \end{bmatrix} \qquad (3)$$

Results

In this paper we use two sample images as in Figure 1 and 2. Both are 400 dots by 400 dots, 256 gray-level images, though we can not express their continuous tone by a laser printer.

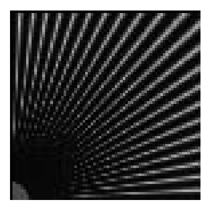

Figure 1.

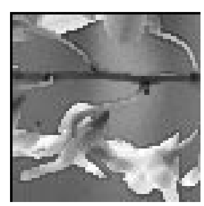

Figure 2.

Three double-sized, binarized images are shown in Figure 3. The error-diffusion method, the halftone method with a 4 × 4 threshold matrix, and the halftone method with an 8 × 8 threshold matrix are used to output Figure 3(a), (b), and (c), respectively. When output on the computer display, Figure 3(b) looks the best. When printed, Figure 3(a) looks better than the others.

Two printed binary images are shown in Figure 4. They are also twice as large as the original image. Both are good in some respect, that is, Figure 4(a) is good in the reproductivity of resolution and Figure 4(b) in the reproductivity of gradation.In case of electrophotographic printing like these, the error-diffusion method seems to be effective for lower magnification, and halftone method seems to be good especially for higher magnification (× 5 or more).

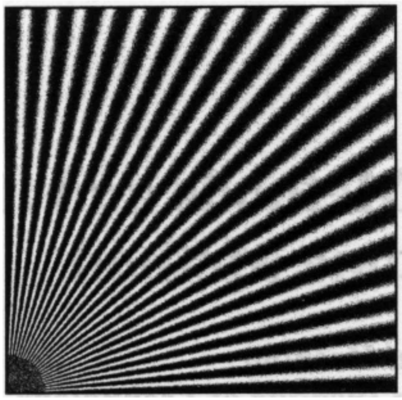

Figure 3(a). Error Diffusion

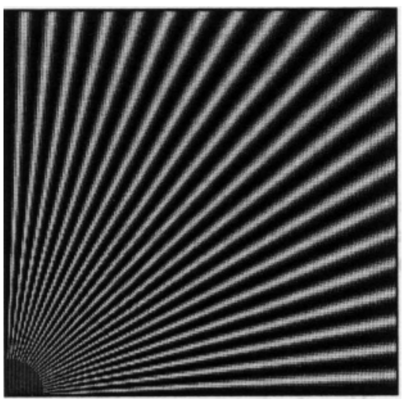

Figure 3(b). Halftone (4 × 4)

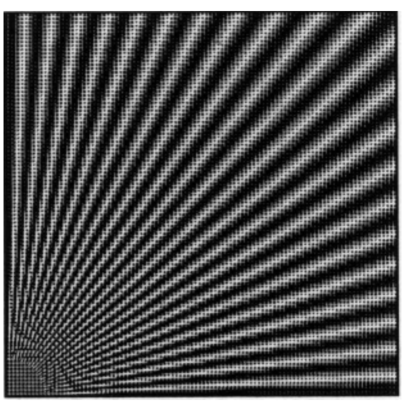

Figure 3(c). Halftone (8 × 8)

Figure 4(a). Error-Diffusion

Figure 4(b). Halftone (8 × 8)

Summary

We study the relationship between the number of dots and the resolution of output. This will be important when the printers with higher resolution are developed. Algorithms of magnification and binarization corresponding to the printing method should be studied more.

References

1. R. Floyd and L. Steinberg, An Adaptive Algorithm for Spatial Greyscale, *Proc. SID*, Vol **17**, No 2, pp. 75-77, 1976.

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