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Some Novel Methods of Ordered Dither

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Abstract:

Various authors have contributed their original works in the field of digital halftoning during past two to three decades. Still this field has not lost its glory. The goal of the study was to investigate novel methods in digital halftoning specially, in ordered dithering.
This paper is concerned with two novel methods of ordered dither. In the first method dithering is done first by pre-embedding a pattern image generated from a matrix pattern with the original image. In the second method dithering is done by thresholding the original image with respect to a threshold matrix pattern constructed using a character writing pattern.
The two methods may be applied in digital halftone reproduction and as special effect imaging.

Keywords:

dithering, thresholding, pattern, maskmatrix, imaging

1. Introduction

The various innovative methods of digital halftoning of grayscale images have enriched the field of digital halftoning [15 4 1 11 5 6]. There are two major categories of halftoning, those that operate on only the pixels themselves (point operations) and those that additionally work on the neighborhood around a pixel (neighborhood operations). Neighborhood techniques generally produce better-looking halftone images at the cost of more computation and storage [17]. Examples of such techniques are 2-D pulse density modulation [3] and various approaches to error diffusion [4 13 14 16]. Here the author has presented two novel methods of ordered dither. Halftoning by the point operation of ordered dither is an established area. There are different methods for dithering an image but ordered dither is the easiest to implement, as it does not require processing or storage of neighboring pixels. Ordered dither can be divided into two types by the nature of dots produced, clustered and dispersed. The most popular method, printer's screen is generated using clustered-dot ordered dither by following the optical process used in printing industry for over 100 years. In offset printing, clustered-dots are needed where the area of each pixel is too small to hold the ink on the printing plate. For many electronic displays dispersed dot ordered dither is preferred where single-pixel constraints are not an issue. Bayer popularized the most widely used patterns for dispersed dot ordered dither [2]. Among the modifications of ordered dither, a prominent place belongs to Ulichney's void and cluster method [18], which is also dispersed dot ordered dither. After proper investigation in the field of ordered dither the author found two new methods which might be useful.

2. Experimental Procedures

The two novel ordered dithering methods that are attempted here are as follows

Dithering by pre-embedding the pattern.

Dithering by simulating character writing pattern

2.1 Dithering by Pre-Embedding the Pattern

In normal ordered dithering to get a halftone image, threshold operation is done on an image by using a pattern of threshold matrix. Pattern is not embedded with the image but here in this case pattern is pre-embedded before processing for halftone.

7	8	9	10
6	1	2	11
5	4	3	12
16	15	14	13

Figure: 1 Mask matrix (Spiral)

112	128	144	160
96	16	32	176
80	64	48	192
256	240	224	208

Figure: 2 Threshold matrix

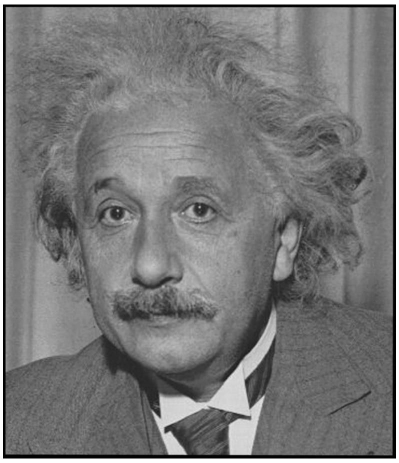


Figure 3: Sample Image

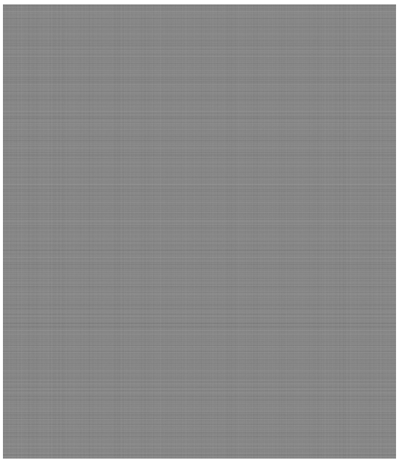


Figure 4 (a) Pattern to be embedded

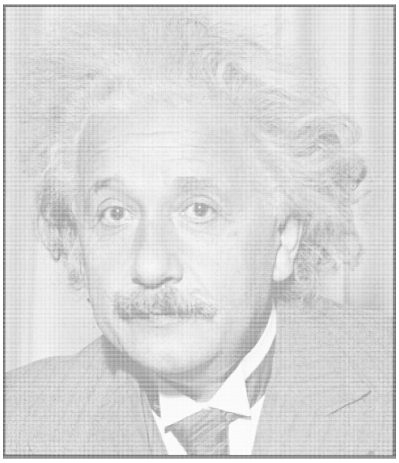


Figure 4 (b) Pattern embedded sample

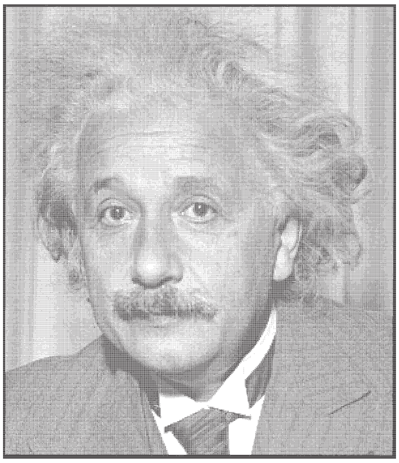


Figure 4 (c) Pattern embedded sample after halftoning

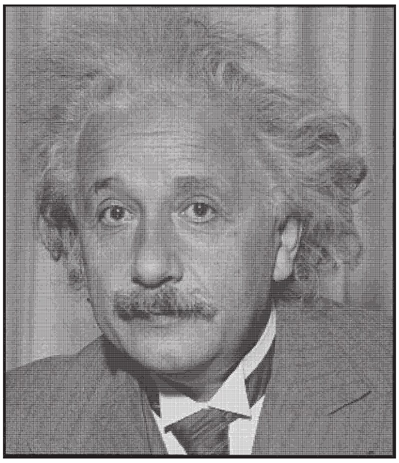


Figure 4 (d) Sample image of figure 3 is halftoned using pattern

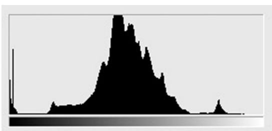


Figure 5(a)

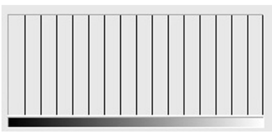


Figure 5(b)

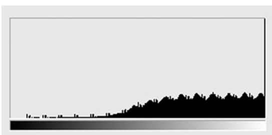


Figure 5(c)

Figure 5. (a) Histogram of the sample image of 'figure 3'. (b) Histogram of the embedded pattern (c) Histogram of the embedded image

2.1.1 Algorithm (Method 1):

1. A pattern image corresponding to an order dither matrix (figure 1) is created and then by adding the pattern column wise and row wise, a final pattern image (figure 4(a)) is obtained which is of same size as that of the gray sample image (figure 3).
2. Then gray sample image is embedded with the above final pattern image to get the pattern embedded sample (figure 4(b)).
3. After embedding the required pattern in the image then the threshold operation is done to get the final halftone (figure 4(c)).

2.2 Dithering by Simulating Character-Writing Pattern

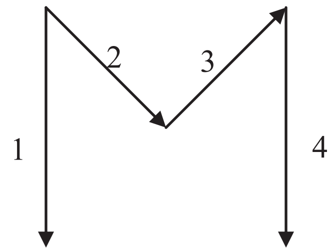


Figure: 6. Writing pattern of M

0	0	0	0	0	0	0	0
0	1	7	0	0	14	15	0
0	2	8	0	0	13	16	0
0	3	0	9	12	0	17	0
0	4	0	10	11	0	18	0
0	5	0	0	0	0	19	0
0	6	0	0	0	0	20	0
0	0	0	0	0	0	0	0

Figure: 7 Mask matrix

255	255	255	255	255	255	255	255
255	4	28	255	255	56	60	255
255	8	32	255	255	52	64	255
255	12	255	36	48	255	68	255
255	16	255	40	44	255	72	255
255	20	255	255	255	255	76	255
255	24	255	255	255	255	80	255
255	255	255	255	255	255	255	255

Figure: 8 Threshold matrix with background of the character white

Figure 9. Sample Image grayscale

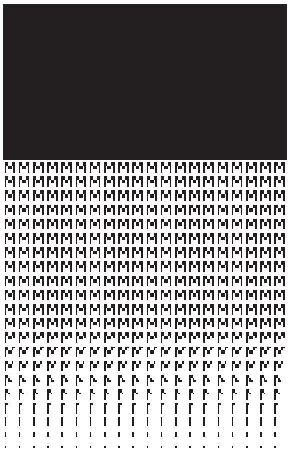


Figure 10. Sample image of figure 9 is halftoned using the matrix of figure 8

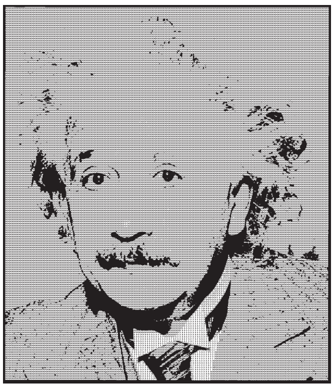
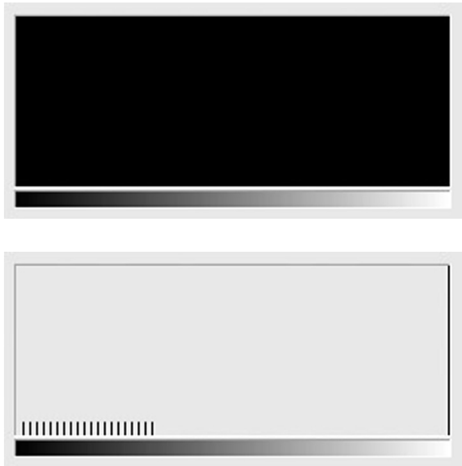


Figure 11. Sample image of figure 3 is halftoned using the matrix of figure 8



(a)

(b)

Figure 12. (a) Histogram of the grayscale (0-255) image of 'figure 9'. (b) Histogram of the image corresponding to matrix of figure 8.

2.2.1 Algorithm (Method 2)

1. A mask matrix (8 x 8) (figure: 7) containing all the pixel positions is generated corresponding to the writing path of the character. Where as all other pixels which are beyond the writing path (but within the matrix) are assigned zero value.
2. Then a threshold matrix (figure: 8) is generated from the mask matrix. The pixel positions beyond the writing path but within the matrix are assigned a value of 255.
3. A pattern image is generated from the threshold matrix.
4. Final halftones (figure 10 and figure 11) are generated by thresholding the original sample image of figure 3 or grayscale sample of figure 9, using the pattern image.

3. Results and Discussions

3.1 For Method 1:

The image after embedding the pattern become lighter (as evident in the histogram Figure 5(c)) due to adding of gray values of the pattern with the gray values of the image.

Halftone Image (figure 4(c)) is obtained as a result of processing, is containing lesser image details (image appears to be lighter) than the halftone produced in normal way (figure 4(d)) i.e. without pre-embedding the pattern.

3.2 For Method 2:

In the halftone image 'figure 10', it is seen that the character writing pattern of '**M**' tends to be completed when we approach from lighter tone to darker tone.

Another image 'figure 3' is also halftoned using the character writing pattern to produce the image 'figure 11', generating fewer image details.

4. Conclusions

Here the author has presented two novel digital halftoning methods based on ordered dither.

The method 1 has produced halftone by pre embedding the pattern image. The sample image embedded with pattern may be used in special effect imaging. This method has produced halftone, which is of considerable good quality.

The method 2 has produced halftone by using a character-writing pattern. This process may be used to simulate the writing pattern of any character of alphabets.

In future further investigations based on this two methods of ordered dither may lead to new avenues of halftone research.

5. References

1. Analoui , M. and Allebach , J. P., 1992 "Model-based Halftoning using Direct Binary Search", Proceedings of the 1992 SPIE/IS&T Symposium on Electronic Imaging Science and Technology, Vol. 1666, San Jose, CA, pp. 96-108
2. Bayer, B.E., 1973 "An optimum method for two level rendition of continuous-tone pictures", Proc. IEEE Int. Conf. Commun., Conference Record, pp.(26-11)-(26-15).
3. Eschbach, R. and R. Hauck, 1987 "Binarization using a two dimentional pulse-density modulation", J.Opt. Soc. Of Am., vol. 4, no.10, pp.1873-1878.
4. Floyd, R. W. and Steinberg, L, 1976 "Adaptive algorithm for spatial grey scale", Proc. SID, Vol. 17/2, pp. 36-37
5. Gooran, S., Österberg, M., and Kruse, B., 1996 "Hybrid halftoning –A Novel Algorithm for Using Multiple Halftoning Technologies", Proc. IS&T Int. Conf. On Digital Printing Technologies (NIP12), pp. 79-86
6. Gooran, S., and Kruse, B., 1998 "Near-optimal model-based halftoning technique with dot gain", SPIE, Human Vision and Digital Display III, San Jose.
7. Gusev, D. A., 1999 "Anti-Correlation Digital Halftoning by Generalized Russian Roulette", IS&T's PICS Conference.
8. Hearn D., and Baker M.P., 2005 "Computer Graphics, C Version", (Pearson Education (Singapore) Pte. Ltd., Delhi 110 092, India).
9. Kundu, P., and Pal, Arun Kiran, 2009 "Some Methods of Digital Halftoning", Taga Conference 2009, March 15-18.
10. Lau, D.L., Arce G.R., 2001 "Modern Digital Halftoning" Marcel Dekker, Inc, New York.
11. Nilsson, F., 1996 "Pre-computed frequency modulated halftoning maps that meet the continuity criterion", Proceedings of the IS&T International Conference on Digital Printing Technologies (NIP12), pp. 72-77
12. Otsu, N., 1979 "A Threshold Selection Method from Gray-Level Histograms" IEEE Transactions on Systems, Man, and Cybernetics., 9(1): 62-66

13. Stevenson, R.L. and G.R.Arce, 1985 "Binary display of hexagonally sampled continuous-tone images", J.Opt. Soc. Am A, vol.2, no.7, pp.1009-1013.
14. Stucki, P., 1981 "MECCA –a multiple-error correcting computation algorithm for bilevel image hardcopy reproduction", Research Report RZ1060, IBM Research Laboratory, Zurich, Switzerland.
15. Ulichney, R., 1987 "Digital Halftoning", MIT Press.
16. Ulichney, R., 1988 "Dithering with Blue Noise", Proc. IEEE, vol.76, no.1.
17. Ulichney, R., 1989 "Frequency Analysis of Ordered dither", Proc. SPIE, Hardcopy Output, Vol.1079, pp.361-373
18. Ulichney, R., 1993 "The Void-and-Cluster Method for Generating Dither Arrays", IS&T/SPIE Symposium on Electronic Imaging Science & Technology, San Jose, CA, vol. 1913, Feb. 1-5, pp. 332-343