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Digital Halftoning with Single Pixel Error Diffusion using Random Space Filling Curve

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Abstract. In this paper, we address the problem of digital halftoning using random space filling curve when diffuse error into neighboring pixels. We can find excessive bright pixel segments that occur in the resulting halftone image occasionally. We analyzed the cause of this artifacts and proposed one-pixel only error diffusion method as an improvement. This proposed method removes the problem of multiple pixel error diffusion methods effectively. We show the experimental results of previous methods and proposed methods.

Keywords: Digital halftoning, Error diffusion, Space filling curves

1 Introduction

Digital halftoning is a relatively well-known image processing techniques that converts a continuous tone grayscale digital image into a binary image consisting of black and white pixels. Error diffusion method is one of digital halftoning techniques that transform a continuous gray scale image into a black and white image pixel by pixel and get a good result by diffusing the resulting errors into neighboring pixels. In this paper, we deals with problems related to digital half-toning algorithm proposed by Asano which uses random space filling curve(RSFC)[1, 2]. His algorithm distributes the resulting error to neighboring pixels along the RSFC. In this paper, we address the problem of excessive bright pixel segments that occur in the resulting halftone image and the cause of this artifact. And we also proposed one pixel only error diffusion method as an improvement.

2 Previous Works

The most popular technique in the error diffusion methods is developed by Floyd and Steinberg[3]. Using a left-to-right scan, resulting quantization error diffused to four neighboring pixels does not processed yet with fixed error weights. In [4] new

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approaches proposed based on space filling curve(SFC). And related improved methods also proposed in [5, 6, 7].

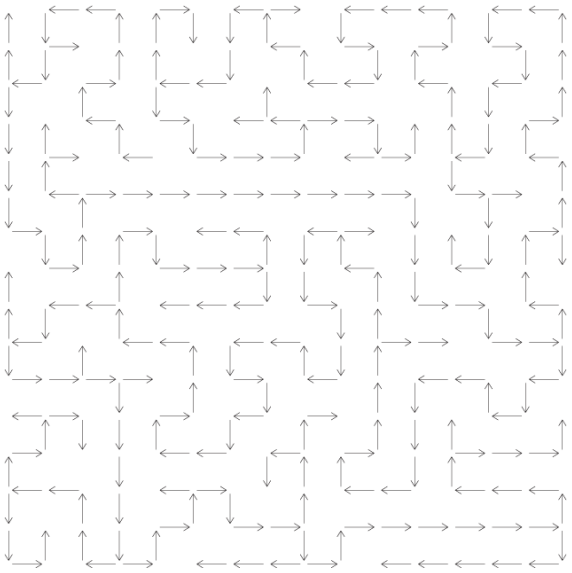

Fig. 1. The example structure of random spanning tree.

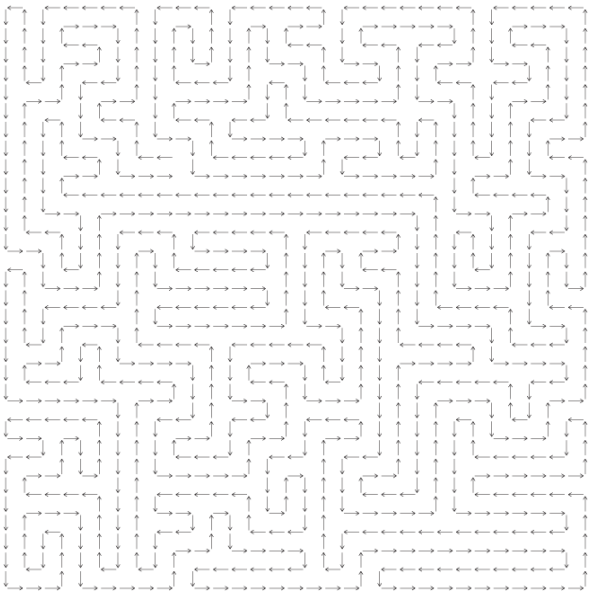

Fig. 2. The example structure of random space filling curve.

In addition, in order to reduce the repetitive patterns of SFC [1, 2] use a RSFC. In other to generate a RSFC like in Fig 2, we need to build a maze like random spanning tree first. And form a RSFC by tracing the wall of random spanning tree like in Figure 1 along both sides. The drawback of digital halftoning using RSFC is an extremely bright pixel segment can be occurred in the resulting image, experimental results are represented in Figure 3 and Figure 5. In the case of [2] to solve this problem, only about 76% of the error is diffused. This can prevent too long error propagation but resulting image also can be darkened too. In [1] adaptive method which distributes larger portion of the error to neighboring pixels which receive error from smaller number of pixels is used. These methods reduce the artifact somewhat, but basically the problem is difficult to remove.

3 Cause Analysis and Proposed Method

The actual cause of resulting artifact is folding shape of created scanning path. First scanned part of RSFC along spanning tree too much error is distributed to pixels of later scanning part. As a result halftoning image is darkened. While later scanning part of RSFC along spanning tree accumulate too many errors from pixels of first scanning part. As a result too bright halftoning image come out. In order to improve these results, pixels have the large differences in processing order between other pixels should limit error diffusion. Therefore, the proposed improvement is error diffusion to very next pixel along the scanning path. In this way, the results obtained by applying shown in Figure 4 and Figure 6. Similar method to the SFC was used in [8], but proposed method on the RSFC can solve problems of previous error diffusion effectively.

4 Conclusions

In this paper, the error along the RSFC to spread to the surrounding pixels in a digital halftoning method for problems that can occur and their causes were presented. To the author's best knowledge, these issues addressed at the first time. We also proposed new method to remove the problems occurring in previous halftoning method and the experimental results were showed.

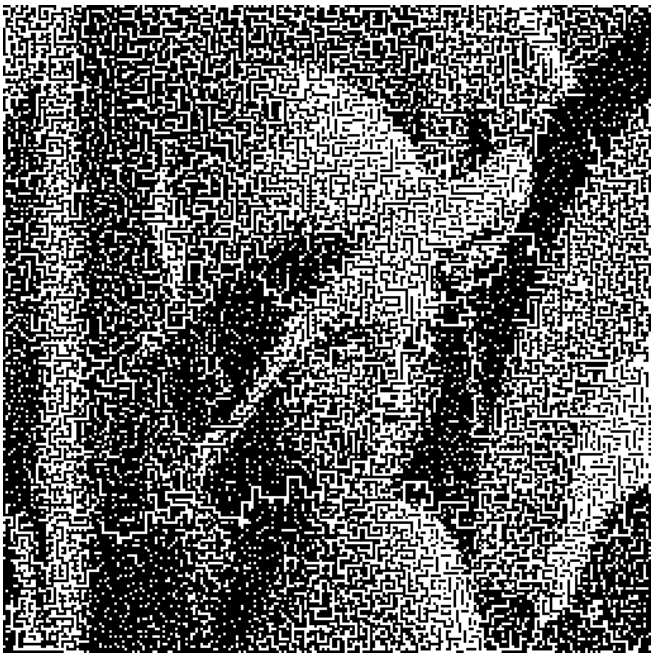

Fig. 3. The result of the Lena image that conventional method was applied.

Fig.4. The result of the Lena image that new method was applied to.

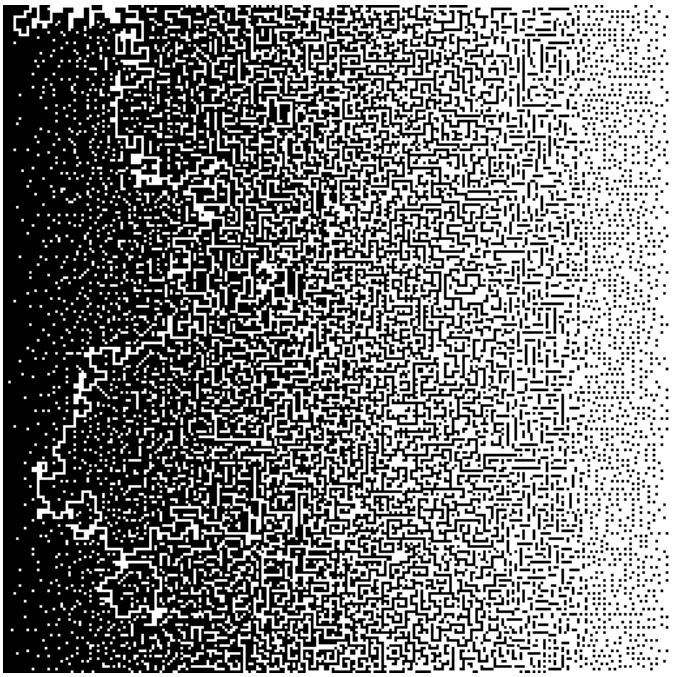

Fig. 5. The result of ramp image that prevous method was applied to.

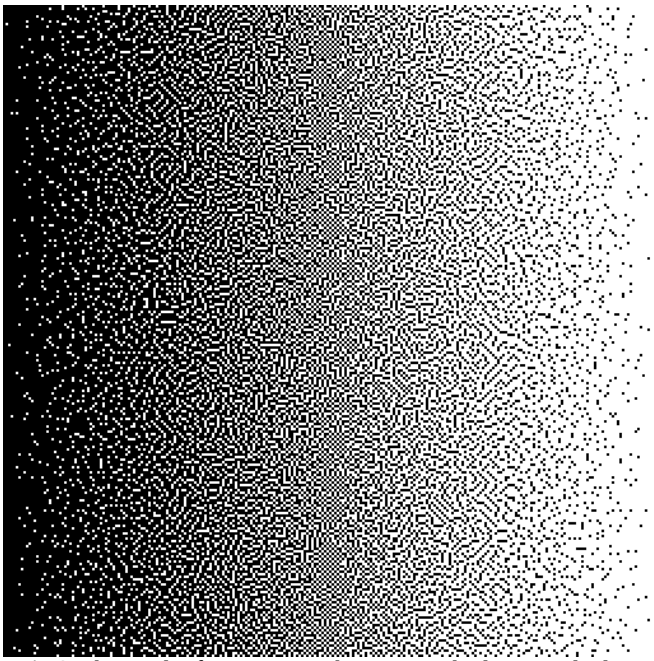

Fig.6. The result of ramp image that new method was applied to.

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