A GPU-Based Algorithm for Building Stochastic Clustered-Dot Screens

Meng Qi, Chenglei Yang, Changhe Tu, Xiangxu Meng, and Yuqing Sun

School of Computer Science and Technology, Shandong University, Jinan 250100
7777vivian@sohu.com, {chl_yang,chtu,mxx,yuqing_sun}@sdu.edu.cn

Abstract. In industrial pattern reproduction, clustered-dot screens are usually created to transform continuous tone image into halftone image for batch printing. But the algorithms generating clustered-dot screens are usually difficult to process large image because they are very slowly and need lot of memory. In addition, the generated halftone image often have periodic patterns, leading to poor tone reproduction. In this paper, a GPU-based algorithm for building stochastic clustered-dot screens is proposed. In the algorithm, after stochastically laying screen dot centers within a large dither matrix, Voronoi diagram is constructed to obtain the region of each screen dot, which is implemented with GPU. Then, each screen dot's region is filled to get the stochastic clustered-dot screens, where a better gray density filling method that can be implemented easily on GPU is used. Experiments show the method can generate screens faster and with less memory than traditional algorithms. Moreover, in a halftone image generated by our method, the details and highlight part can be better expressed.

Keywords: digital halftoning, GPU, stochastic clustered-dot screen, Voronoi Diagram.

1 Introduction

For many years, in printing and dyeing, chinaware, weave, silk, washrag, carpet, brand and other industries, how to reproduce continuous tone image with hundreds of gray levels and millions of colors using only one or limit colors is really a difficult but basically problem. The process of transforming continuous tone into binary image is called halftoning. Continuous tone image need to be transformed into halftone image before batch printing.

Digital halftoning is developed from the traditional halftoning. Error-diffusion algorithm is one kind of method for generating halftone images. General error-diffusion algorithms [1-3] are to compensate the quantization errors by distributing them on to the neighboring pixels of the input image. The problems has two main shortcomings: one is that invariable error-diffusion model can lead to periodically pattern especially in where the grayscale is changing smoothness or in the grayscale wedges; the other is that it is not easy to be parallelized. Another kind of methods that can generate halftone image utilizes Wang tiles to generate large point sets possessing a blue noise

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Fourier spectrum and high visual quality [4]. But they and Error-diffusion algorithms are both not easy to be parallelized and batch printed.

In industrial pattern reproduction, clustered-dot screens are usually created to transform continuous tone image into halftone image for batch printing [5-6]. In this kind of method, for each output pixel, we can find its corresponding locations both in the dither array and in the input image, compare these pixel's intensity values, then write the pixel to the output image. The whole process is very efficient, only one comparison is needed, and each output device pixels can be computed independently, which enables the process to be parallelized and pipelined easily. But the algorithms generating clustered-dot screens are usually difficult to process large image because they are very slowly and need lot of memory, and are not easy to be implemented with GPU. In addition, the generated halftone image often have periodic patterns, leading to poor tone reproduction.

In this paper, a GPU-based algorithm for building stochastic clustered-dot screens is proposed. In the algorithm, after stochastically laying screen dot centers within a large dither matrix, Voronoi diagram is constructed to obtain the region of each screen dot, which is implemented with GPU. Then, each screen dot's region is filled with sets of different intensity levels to get the stochastic clustered-dot screens, where a better gray density filling method that can be implemented easily on GPU is used. Experiments show the method can generate screens faster and with less memory than traditional algorithms. Moreover, in a halftone image generated by our method, the details and highlight part can be better expressed.

2 Previous Relative Works

Stochastic screens can offer finer grain compared to traditional screen, and advance the quality of presswork. It also permits to superimpose more than three layers without moirés and can reproduce more colors, gray grades and finer images details. Recent years, multiple authors have proposed some excellent stochastic clustered-dot screens algorithm such as [5-6].

In [5], a large dither matrix comprising thousands of stochastically laid out screen dots is constructed by first laying out the screen dot centers. After Delaunay triangulation of the screen dot centers, the maximal region of each screen dot is computed and iso-intensity regions are created, and then fill each region with different intensity levels. The algorithm in [6] adopts similar method to generate the screens. They introduces a Delaunay triangulation algorithm using a uniformly grid, which exhibits linear time complexity to improve the speed. Then it fills the cluster (maximal region of each screen dot) according to area proportion and divides each cluster into several triangles and quadrangles, and deal with them one by one to generate screens.

Based on these work [5-6], we propose a GPU-based algorithm for building stochastic clustered-dot screens, which can generate screens faster and with less memory, and the details and highlight part in a halftone image generated by our method can be better expressed.