Title	食い違い度理論に基づいたデジタルハーフトーニングにおける点配置問題に関する研究
Author(s)	大島，穣
Citation	
Issue Date	2004-03
Type	Thesis or Dissertation
Text version	author
URL	http://hdl.handle.net/10119/1784
Rights	
Description	Supervisor:浅野 哲夫，情報科学研究科，修士

The Point Placement Problem in Digital Halftoning Based on Discrepancy Theory

Minoru Ohshima (210011)

School of Information Science,
Japan Advanced Institute of Science and Technology

February 13, 2004

Keywords: point placement problem, discrepancy theory, digital halftoning, randomized rounding, space filling curve.

In this study, we report digital halftoning techniques based on discrepancy theory which is one of the point placement problem. Also, we develop new digital halftoning methods based on this theory and compare these methods with existing techniques.

Recently, the digital cameras have been becoming popular rapidly. At the same time, it also has been becoming particularly a high performance. Consequently, it is an important problem that the ink-jet printer prints a output image from a digital image so that quality of image may not be degraded as much as possible.

This high quality printing is mainly based on improvement in a hardware. Resolution is increased due to mechanical improvement to make it possible to place many small points, and printer can output a high quality image now. An ink-jet printer put dots of ink on a paper. In other words, it represents colors by combinations of ink-colors to be put. Therefore, it cannot output an image in full color because the number of ink colors in a printer is restricted. As a result, the problem (software-problem) is how to output a binary image (only black and white dots are allowed) that looks similar to a continuous-tone image (each pixel may have an arbitrary 'color' on the grey scale) as much as possible. This problem can be regarded as the problem that transforms a continuous-tone image into a binary image. Such binarization of an image is called digital halftoning. There are a number of algorithms for halftoning, such as typical ones like simple thresholding, orderd dither, and error diffusion. Each algorithm has both advantages and disadvantages. But, these algorithms have the common disadvantage that a output image has many particular patterns.

In this thesis, we consider digital halftoning problem as the point placement problem. We developed the algorithms that calculates a good point placement and applied these algorithms to digital halftoning techniques. To reduce many particular patterns generated by traditional methods, discrepancy theory that have been studied in computational geometry is very useful. B. Doerr et al. developed several algorithms based on randomized rounding, and analyzed these algorithms based on discrepancy theory. The Doerr's algorithms round randomly pixels in the processing region, so that the error of the whole pixels in the region doesn't exceed a fixed value. However, The discrepancy of these algorithms are increased in proportion to pixel size because the discrepancy is accumulated each rounding. Moreover, a output image has many patterns like granularity etc because a region of each rounding is very small. Therefore, we modify Doerr's algorithms in consideration of the following two points.

The first point is to diffuse the error of the whole processed pixels to the next region. By the diffusing error above, it is conceivable that the discrepancy of a output image is always small.

The second point is the rounding order. When the processing order is in constant direction like the raster order or the snake order is applied, a particular pattern appears in an output image. We use the space filling curve as the order. There are many typical space filling curve method, but the processing order of their methods is not random. Therefore, we introduce two methods generating an order of changing a direction randomly. One method is to transform the fundamental forms such as the snake order little by little at random. The other method is to use a spanning tree generated at random.

From these points, we implemented some algorithms. The estimation method of these algorithms are to compare these algorithms with traditional methods from sensuous appearance, and to estimate a discrepancy of these algorithms theoretically.

About estimation from sensuous appearance, we obtained some images without a particular pattern. However, the output image that applied these algorithm is rougher than the error diffusion method. To solve this problem, it is conceivable that we can obtain the clearer image by expanding the region where are processed at a time.

On the other hand, it is hard to estimate discrepancy theoretically because of diffusing error and randomized rounding order. Analyzing of this estimation is one of the important future works.