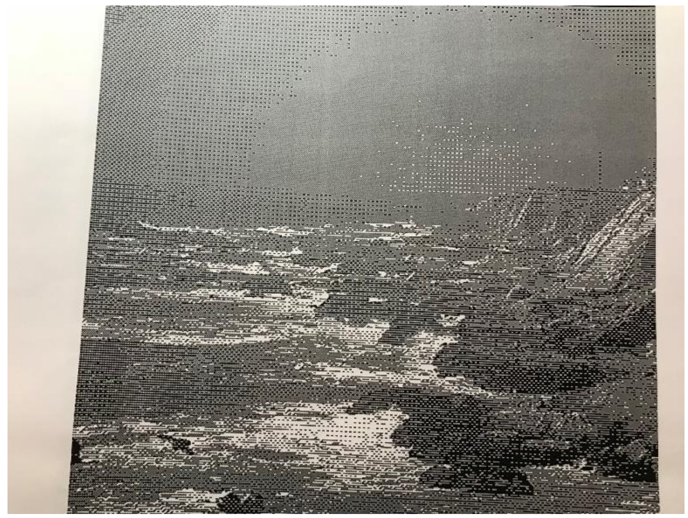
LAB5 Report Shuchen Zhang

Introduction:

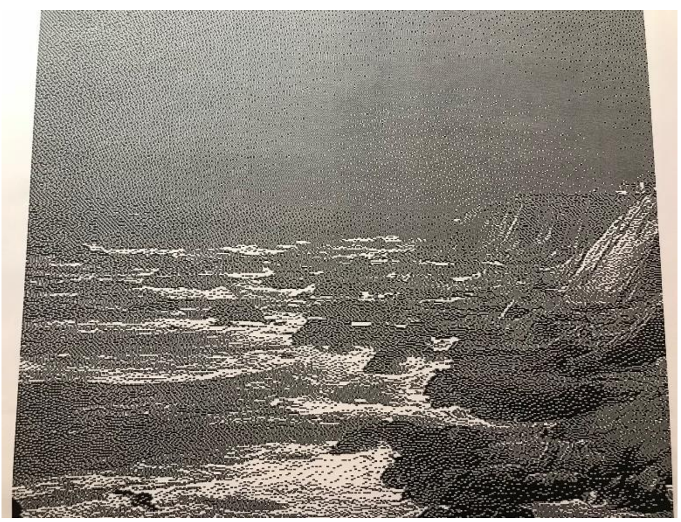
This lab we use the image operation algorithm Halftoning to simulate printer printing process. The printer produce the appearance of intermediate shades of grey in a local neighborhood of several pixels. Two methods were examined: dither matrix and error diffusion.

Printed output images:

1x1 Dithering Image



4x4 Dithering Image



Error diffusion Image

The error diffusion one looks more similar to the images in the local newspaper, but both images generated by halftoning methods are of lower quality than the local newspaper one. There are visible black dots which make the image color less smooth than the original image.

In part one, we examine the Dithering Matrix method. By halftoning an 8-bit grayscale image, we quantize the image into only 1 bit for each pixel. Dithering matrix replace each sub-block of pixels with a set of binary-valued intensities by comparing with the given matrix of threshold. The darker the original sub-block, there are more zeros assigned in the corresponding binary sub-block, vice versa.

Image A1 produced by dithering matrix with 1x1 sub-block (lonely pixel) appeared to have almost no grey color. There are large regions of straight black and white. Comparing to A1, A2 produced by dithering matrix with 4x4 sub-block has more similar color with the original image including many gray color. However, A2 still have many visible tiny black pixel dots appeared on the grey background and the slight change between pixel intensity is more obvious compared to the original image.

A2 is perceptually more similar to the original image. Because the created dithering image has more high-frequency (those individual dots structure). Our visual system will filter out these high-frequency components and especially for people observe from longer distance, they will be more likely to perceive the average local intensity. A2 has more variety of possible apparent bit depths compared to A1. Instead of having extreme bright and extreme dark as A1, A2 has intermediate brightness display as grey color which is much more similar to the original image.

It is not desirable to display low frequency error when using error diffusion because from the output low frequency energy image of the error image we could see that the error appears to be higher in the low frequency region with the fact that the low frequency terms are near the four corners of Fourier domain “image” and higher frequency terms are near the center.

Mean Square Error for 1x1 dithering is 9048.77

Mean Square Error for 4x4 dithering is 13259.2

Mean Square Error for error diffusion is 12892.1

By using only one threshold value, the image processed by 1x1 dithering appears to have the least visual quality but it has the least mean square error. Mean square error has the highest mean square error and closer to the mean square error of error diffusion. Image viewers are sensitive to certain types of visual artifacts, so the low mean square error doesn’t necessarily mean it will be visually good.

In terms of minimizing MSE, the best halftoning algorithm for image should be 1x1 dithering method. For 1x1 dithering, for each pixel value the difference between input image and the output image is no bigger than ½ x 255. The lowest attainable MSE for the image is 9048.77.

Conclusion:

In this lab, we examine the two halftoning methods used for the printer: dithering matrix method and error diffusion method. Error diffusion method appear to visually better than the dithering matrix method. Also dithering matrix method with 1x1 sub-block has much lower quality than the 4x4 one though it could minimize the Mean Square Error.