ECE 418 Lab 5

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In this lab we use Halftoning algorithm to simulate the printer printing process. The printer produces the appearance of intermediate shades of grey by changing the intensities of neighboring pixels. We examine halftoning using dithering matrix and error diffusion and compare the results obtained.

Image A1:

Image A2:

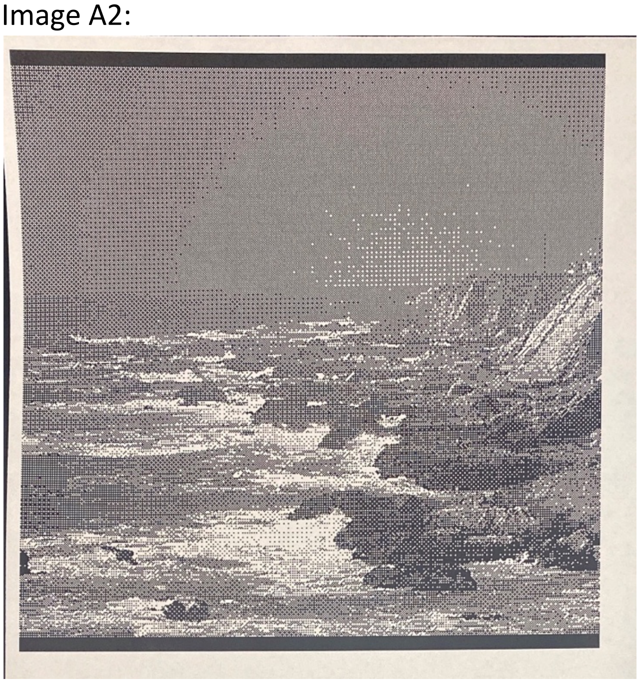


Image B:

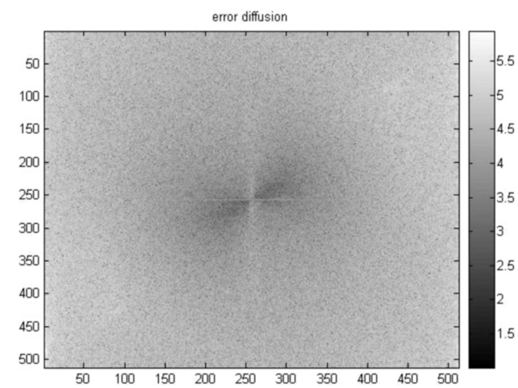
Using dithering matrix, we found both the images A1 and A2 look like the original image. However, image A1 produced by dithering matrix with 1x1 sub-block appears to have only black and white pixels and no grey pixels in it which is to be expected from a 1x1 sub block because since we use only 1 pixel sub block, the pixel colors do not blend into each other to produce grey color. Therefore, there are large areas of black and white in the image. Compared to A1, A2 produced by the 4x4 sub-block was much more similar in the color to the original image since it also seemed to have grey color areas. However, A2 still has many visible black pixel dots appearing on the grey background and the slight change between pixel intensity is more obvious compared to the original image. A2 also has some patters in the background that can be detected when looking closely into the image.

A2 seems to be more similar to the original image because of the created dithering image has more high frequency areas, like the black dots and patters which our eye filters out especially if the eyes at a large distance. A2 also has more variety of possible apparent bit depths compared to A1. Instead of having extreme bright and extreme dark pixels as in A1, A2 has intermediate brightness display as grey color which is much more similar to the original image.

Using error diffusion we get image B that seems to be the closest to the original image. It seems to be better the A1 and A2 since it doesn't have the random black spots and patters and seems more like an image with some noise in it.

It is not desirable to display low frequency errors while using error diffusion because we can see from the error diffusion image in frequency domain that error appears to be higher in the lower frequencies (edges of the image) than at higher frequency (centre of the image). Which could be seen from the image being brighter in the corners of the image than the centre which is basically black meaning almost zero error.

Error Diffusion, Frequency domain



MSE of the images are:

MSE of 1x1 dithering matrix = 9048.77
MSE of 4x4 dithering matrix = 13259.2
MSE of Error Diffusion = 12874.5

Comparing the images, the image processed by 1x1 dithering appears to have the least visual quality but it has the least mean square error. Error diffusion has the second most MSE and then 4x4 dithering matrix produces the highest MSE. 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. More importantly since viewers cannot distinguish errors at high frequency, if the error is in high frequency it will still look better like in error diffusion. Therefore, MSE is not an indication of good visual quality as MSE of 1x1 dithering matrix is lowest but it looks the worst of all three images.

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 127 which is much lower than the difference between other methods. The lowest attainable MSE for the image is 9048.77.

In this lab we compare two halftoning algorithms, namely dithering matrix and error diffusion method, and compare the results based on the MSE and visual perception. 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.