HOMEWORK ASSIGNMENT 4

Digital Halftoning, Frequency Domain

Due Date: 11:59 pm on May. 27, 2021
Please read the **submission guideline** carefully before getting started. All images in this homework are in PNG format and can be downloaded from our `NTU COOL` website. Details of all files offered are listed in the appendix. You are **NOT** allowed to use other functions except I/O, plotting and basic functions.

Problem 1: DIGITAL HALFTONING

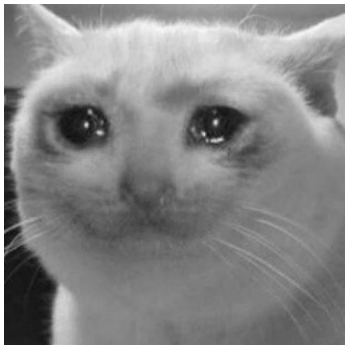
sample1.png is given in Figure 1.(a) Please apply several halftoning methods to the given image and provide discussions about the detail of the results.

(a) (`5 pt`) Perform dithering using the dither matrix I_2 in Figure 1.(b) and output the result as **result1.png**.

(b) (`10 pt`) Expand the dither matrix I_2 to I_{256} (256×256) and use it to perform dithering. Output the result as **result2.png**. Compare **result1.png** and **result2.png** along with some discussions.

(c) (`15 pt`) Perform error diffusion with two different filter masks. Output the results as **result3.png**, and **result4.png**, respectively. Discuss these two masks based on the results.
You can find some masks **here** (from lecture slide 06. p23)

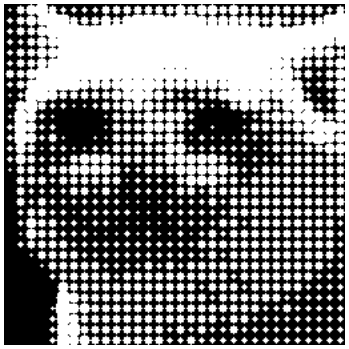
(d) (`10 pt`) Try to transfer **result1.png** to a dotted halftone / manga style binary image such as **sample1_dotted.png** in Figure 1.(c). Describe the steps in detail and show the result.
You may need to utilize a function like **cv2.circle** to draw a circle.



(a) sample1.png

1	2
3	0

(b) Dither Matrix I_2



(c) sample1_dotted.png

Figure 1: The image and dither matrix for digital halftoning.

Problem 2: FREQUENCY DOMAIN

In this problem, please perform Fourier transform and observe the relation between the spatial domain and the frequency spectrum. You may adopt tools for Fourier transform. The recommended tools are listed in the Appendix.

(a) (`10 pt`) Perform Fourier transform on **sample2.png** to obtain its frequency spectrum and output it as **result5.png**. (Please take the log magnitude of the absolute value and center the low frequency part at the origin for visualization.)

(b) (`15 pt`) Based on the result of part (a), design and apply a low-pass filter in the frequency domain and transform the result back to the pixel domain by inverse Fourier transform. The resultant image is saved as **result6.png**. Please also design a low-pass filter in the pixel domain which behaves similarly to the one you design in the frequency domain. Output the result as **result7.png** and provide some discussions.

(c) (`15 pt`) Based on the result of part (a), design and apply a high-pass filter in the frequency domain and transform the result back to the pixel domain by inverse Fourier transform. The resultant image is saved as **result8.png**. Please also design a high-pass filter in the pixel domain which behaves similarly to the one you design in the frequency domain. Output the result as **result9.png** and provide some discussions.

(d) (`10 pt`) Perform Fourier Transform on **sample3.png** and output it as **result10.png**. Please discuss what you observe in **sample3.png** and **result10.png**.

(e) (`10 pt`) Try to remove the undesired pattern on **sample3.png** and output it as **result11.png**.

(a) sample2.png

(b) sample3.png

Figure 2: Images for Fourier transform.

Appendix

Problem 1: DIGITAL HALFTONING

sample1.png:	256×256	gray-scale

Problem 2: FREQUENCY DOMAIN

sample2.png:	480×640	gray-scale
sample3.png:	480×640	gray-scale

Recommended tools for Fourier transform

scipy.fftpack.fft2
scipy.fftpack.ifft2
scipy.fftpack.fftshift
scipy.fftpack.ifftshift
numpy.fft.fft2
numpy.fft.ifft2
numpy.fft.fftshift
numpy.fft.ifftshift