Digital Image Processing, Spring 2023

Assignment 4 - Report

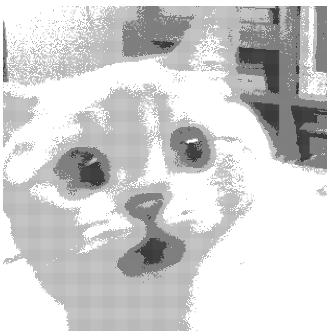
R11922133, 廖政華, 資工所碩一

Problem 1: DIGITAL HALFTONING

(a) Dithering I_2

(a) sample1.png

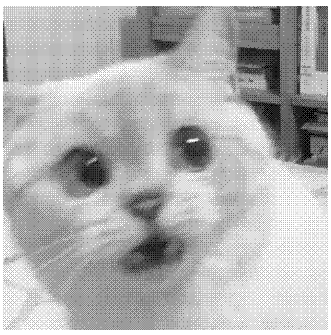
(b) result1.png



(c) result1.png (with noise)

(b) Dithering I_{256}

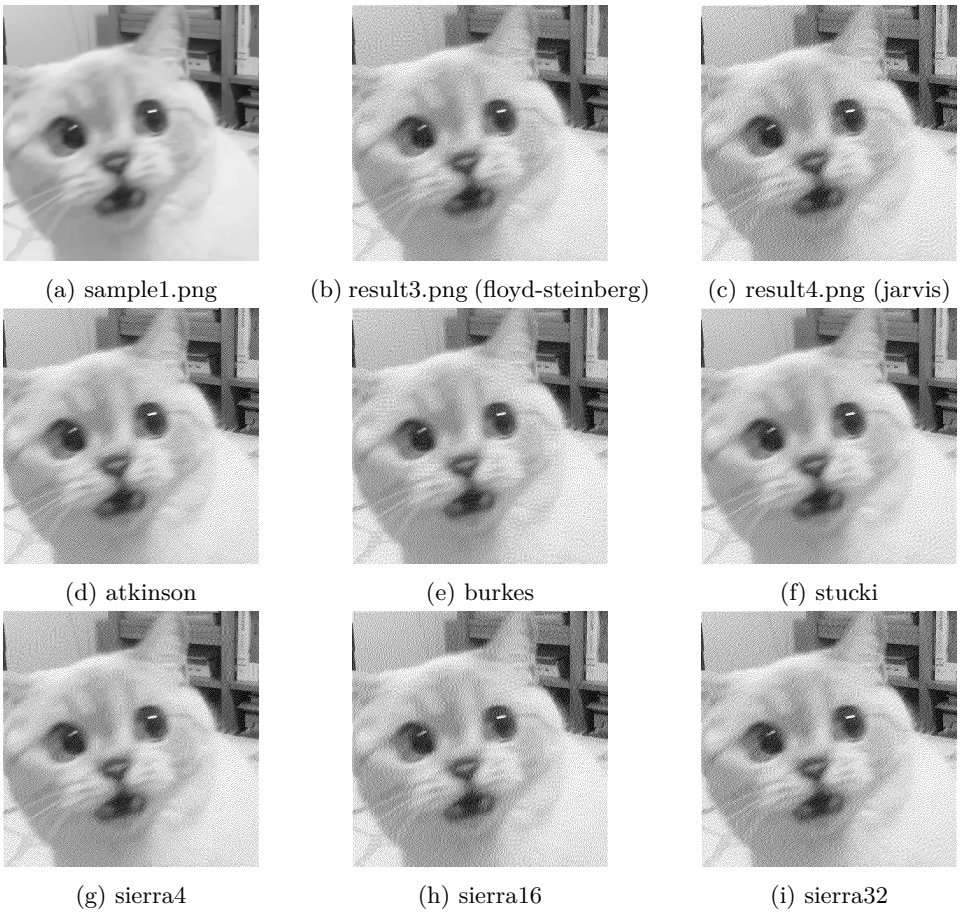
(a) sample1.png



(b) result2.png

Comparing `result1.png` and `result2.png`, the former exhibits large areas of smoothness and many details from the original image are lost. This is due to the fact that a smaller dithering matrix is associated with higher regularity, and produces rather non-smooth (staircase-like) thresholds, making it less sensitive to local features in the image. On the other hand, `result2.png` contains more fine-grained textures and details, owing to the larger dithering matrix used in the dithering process.

(c) Error diffusion



(a) sample1.png (b) result3.png (floyd-steinberg) (c) result4.png (jarvis)

(d) atkinson (e) burkes (f) stucki

(g) sierra4 (h) sierra16 (i) sierra32

Figure 3: Results of different masks.

The difference between the results is very subtle to the naked eye. However, with closer observation, it is possible to see that the Floyd-Steinberg's method produces smoother regions, whereas Jarvis's method yields results with higher contrast, as depicted in Figure 4.

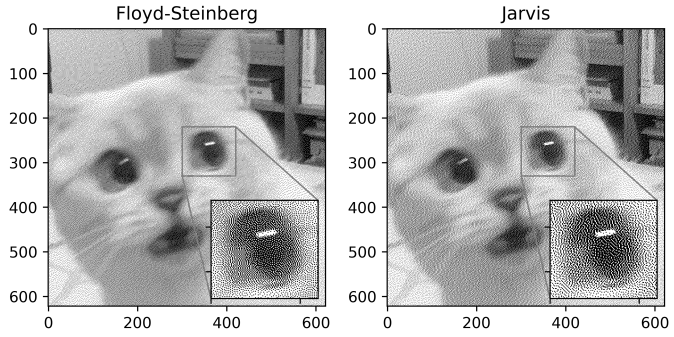


Figure 4: Zoomed in views of the results.

Problem 2: FREQUENCY DOMAIN

(a) Image sampling

The maximum frequency in the x-axis is 0.4996 and in the y-axis is 0.4995. To perform sampling that avoids aliasing, it is crucial to follow the Nyquist theorem, which states that the sampling frequency should be at least twice the maximum frequency present in the signal. In this case, to avoid aliasing, the sampling frequency should be greater than 0.9992 in the x-axis and 0.9990 in the y-axis.

(a) sample2.png (b) result5.png ($\Delta x = \Delta y = 25$)

(b) Gaussian high-pass filtering

The Gaussian high-pass filter K used here is defined by

$$H(u, v) = 1 - \exp\left(-D(u, v)^2/(2D_0^2)\right)$$

where

$$D(u, v) = \sqrt{(u - 1024)^2 + (v - 819)^2} \text{ and } D_0 = 30$$

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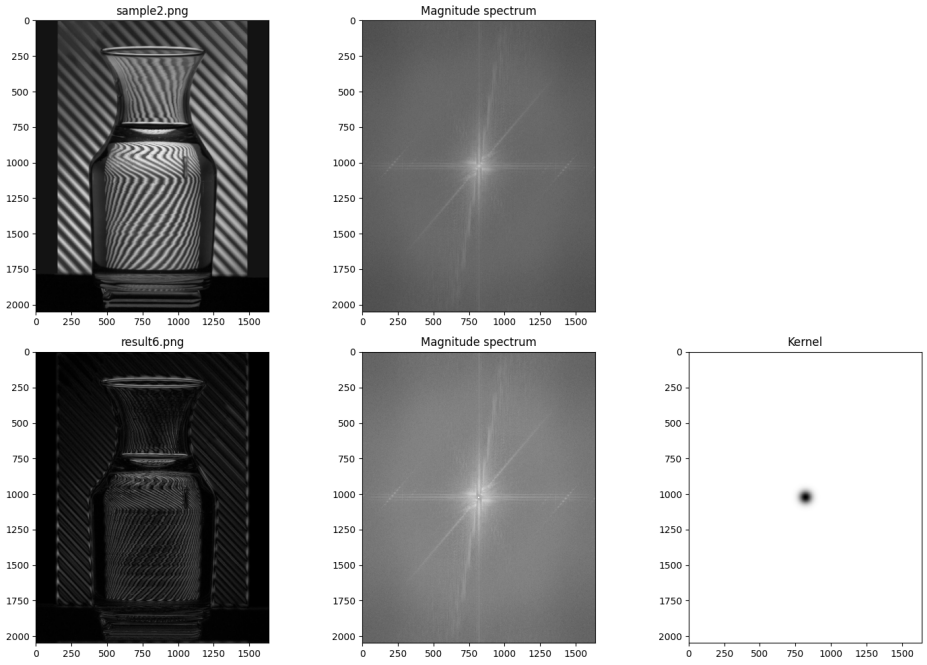

Figure 6: Images before and after high-pass filtering in frequency domain.

(c) Pattern removal

Given that the periodic noise present in the image exhibits high frequency along the vertical axis, it is feasible to apply a notch rectangle filter along the high frequencies area in that axis. The result is shown in Figure 7.

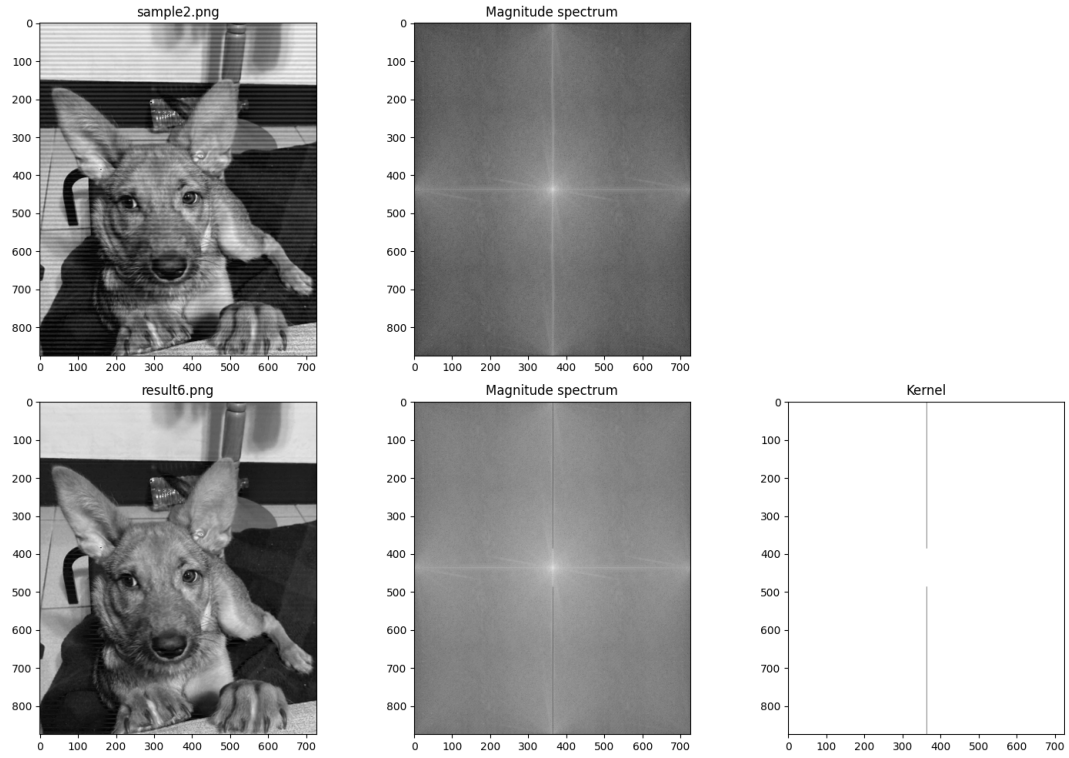

Figure 7: Images before and after notch-reject filtering in frequency domain

References