高等數位影像處理

作業#5

姓名：巫伯銘

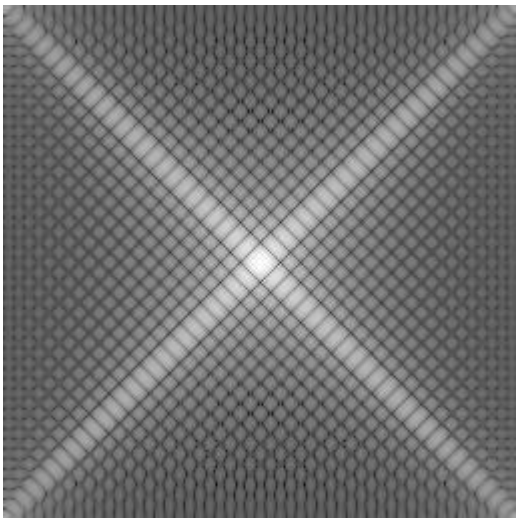
學號：111318096

指導老師：張陽郎 教授

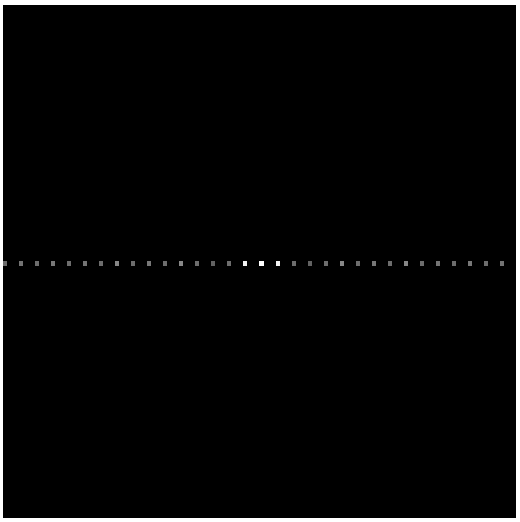
1.(1)

Figure

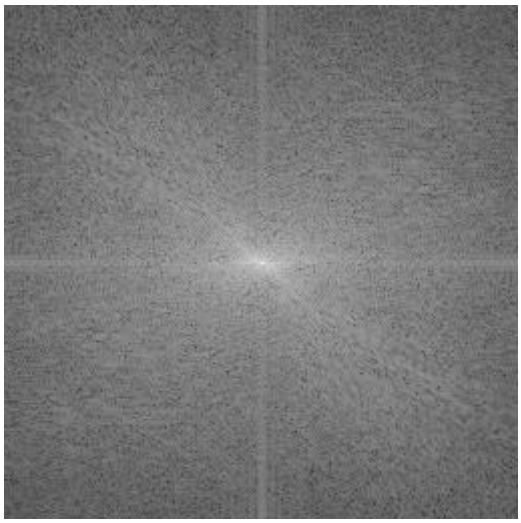
01_rhombus_magnitude_spectrum_DFT_C.png



02_sine_magnitude_spectrum_DFT_C.png



03_lena_magnitude_spectrum_DFT_C.png



Discussion

本題使用做兩次 1D 的 DFT 得到 2D DFT 的方式，結果如上所示。

因為空間域中越窄的訊號轉換至頻域，就會越寬；空間域中越寬的訊號轉換至頻域則反之。因此 rhombus 呈現 X 的形狀；sine 只有水平方向有變化，所以點都集中在中間水平線上。

1(2)

Discussion

以下表格為 C 以及 OpenCV 的 DFT 執行時間：

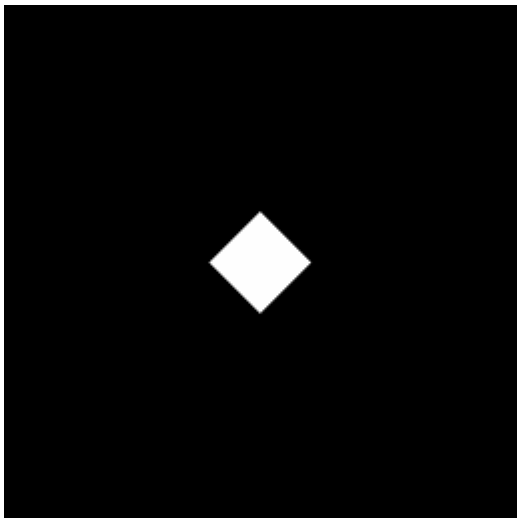
DFT	C execution time(sec.)	OpenCV execution time(sec.)
rhombus_256.raw	1.98982	0.0096883
sine_128.raw	0.230481	0.00009
lena_256.raw	2.0447	0.0002267

做出來的 DFT 結果基本上相同，但是在時間運算上差異非常大，原因是 OpenCV 內建是使用 FFT 運算。

1(3)

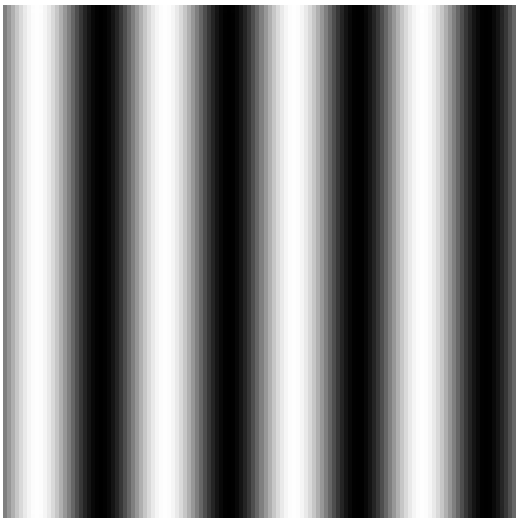
Figure

04_rhombus_IDFT_C.png



(MSE =0.020)

05_sine_IDFT_C.png



(MSE =0.919)

06_lena_IDFT_C.png

(MSE =30.361)

Discussion

拿 IDFT 與原圖做比較，其實用肉眼觀察不出來差異，但是使用 MSE 計算還是能發現些許誤差，推測可能是在將傅立葉級數轉換為 0~255 時有些小數點精度的問題導致的，因為使用 unsigned char 輸出必將捨去小數點。

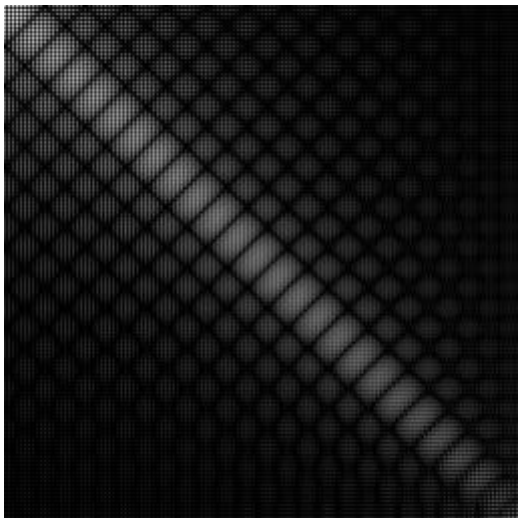
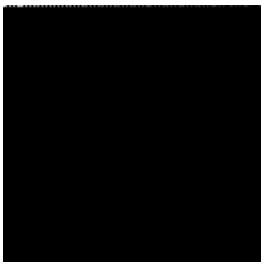
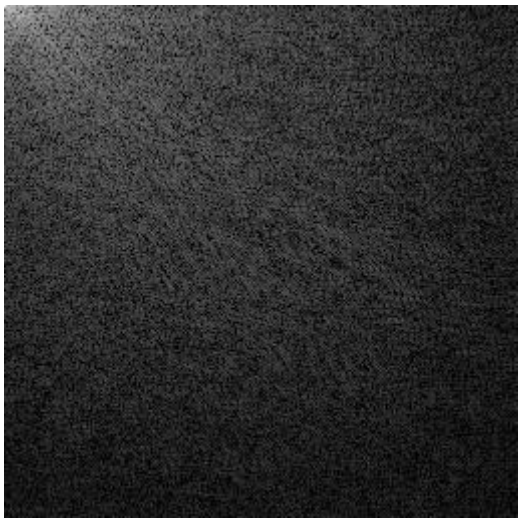
1(4)

Discussion

以下表格為 C 以及 OpenCV 的 IDFT 執行時間：

IDFT	C execution time(sec.)	OpenCV execution time(sec.)
rhombus_256.raw	1.7298	0.0038154
sine_128.raw	0.198424	0.0004802
lena_256.raw	1.72127	0.0004608

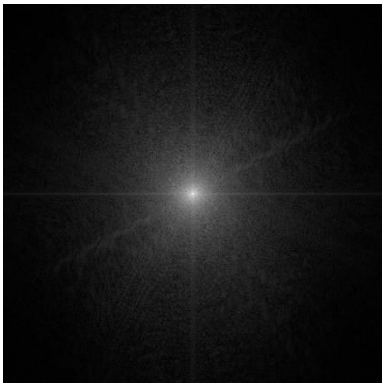
做出來的 DFT 結果基本上相同，但是在時間運算上差異非常大，原因是 OpenCV 內建是使用 FFT 運算。

1(5)
Figure
07_rhombus_magnitude_spectrum_DCT.png  08_sine_magnitude_spectrum_DCT.png  09_lena_magnitude_spectrum_DCT.png 
Discussion
在執行程式時可以明顯發現 DCT 的運算時間比 DFT 快了很多，因為少了複數的運算處理，過程簡化很多。

2(1)

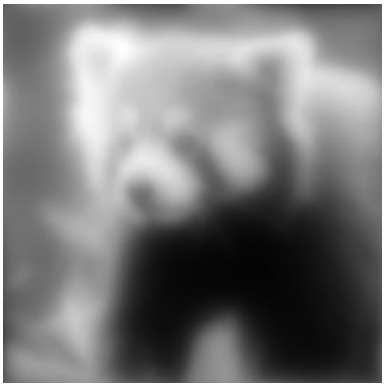
Figure

10_raccoon_BLPF_5_1_magnitude_spectrum.png



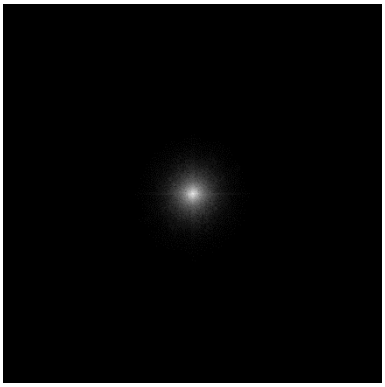
(Butterworth LPF, D0 = 5, n = 1)

11_raccoon_BLPF_5_1_idft.png



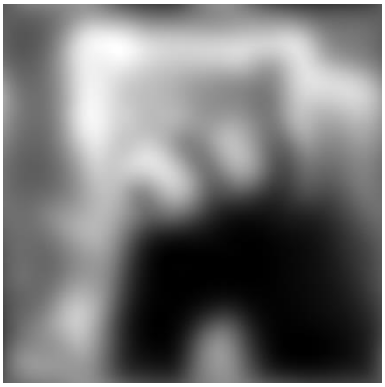
(Butterworth LPF, D0 = 5, n = 1)

12_raccoon_BLPF_5_2_magnitude_spectrum.png



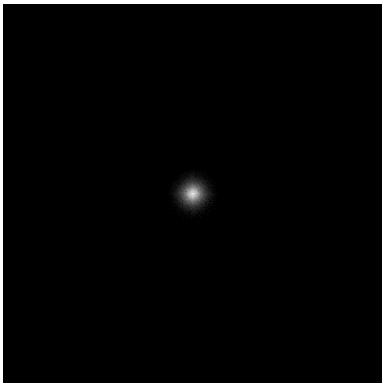
(Butterworth LPF, D0 = 5, n = 2)

13_raccoon_BLPF_5_2_idft.png



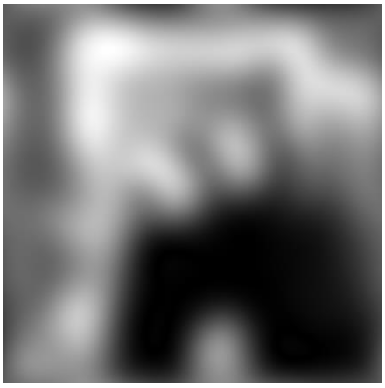
(Butterworth LPF, D0 = 5, n = 2)

14_raccoon_BLPF_5_3_magnitude_spectrum.png



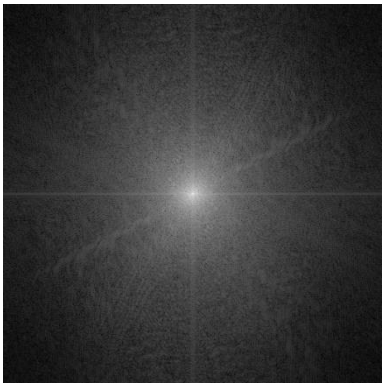
(Butterworth LPF, D0 = 5, n = 3)

15_raccoon_BLPF_5_3_idft.png



(Butterworth LPF, D0 = 5, n = 3)

16_raccoon_BLPF_20_1_magnitude_spectrum.png

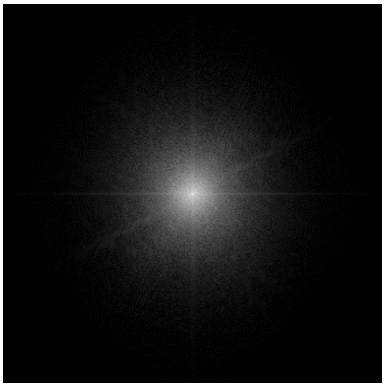


(Butterworth LPF, D0 = 20, n = 1)

17_raccoon_BLPF_20_1_idft.png

(Butterworth LPF, D0 = 20, n = 1)

18_raccoon_BLPF_20_2_magnitude_spectrum.png

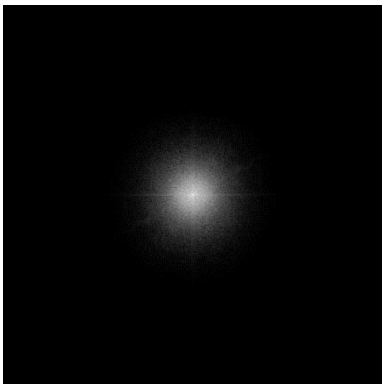


(Butterworth LPF, D0 = 20, n = 2)

19_raccoon_BLPF_20_2_idft.png

(Butterworth LPF, D0 = 20, n = 2)

20_raccoon_BLPF_20_3_magnitude_spectrum.png

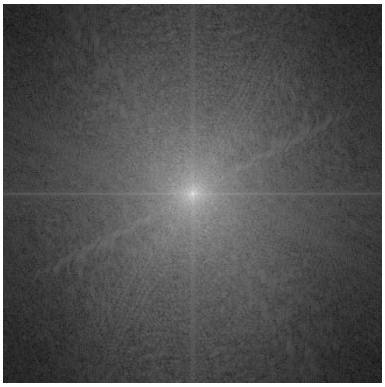


(Butterworth LPF, D0 = 20, n = 3)

21_raccoon_BLPF_20_3_idft.png

(Butterworth LPF, D0 = 20, n = 3)

22_raccoon_BLPF_50_1_magnitude_spectrum.png

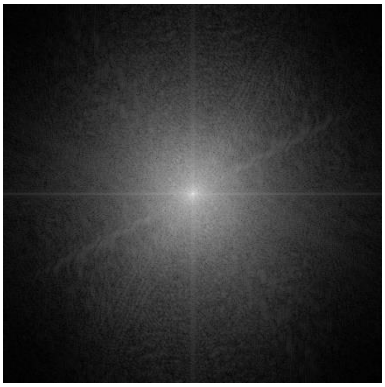


(Butterworth LPF, D0 = 50, n = 1)

23_raccoon_BLPF_50_1_idft.png

(Butterworth LPF, D0 = 50, n = 1)

24_raccoon_BLPF_50_2_magnitude_spectrum.png

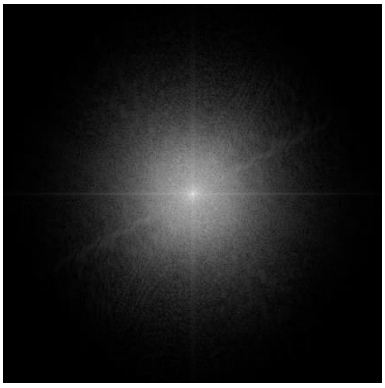


(Butterworth LPF, D0 = 50, n = 2)

25_raccoon_BLPF_50_2_idft.png

(Butterworth LPF, D0 = 50, n = 2)

26_raccoon_BLPF_50_3_magnitude_spectrum.png

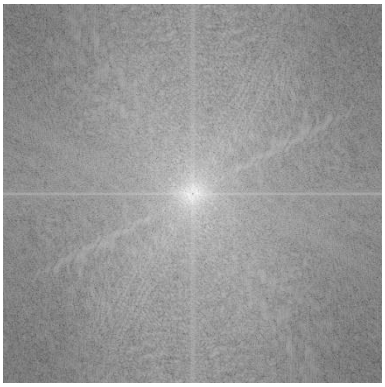


(Butterworth LPF, D0 = 50, n = 3)

27_raccoon_BLPF_50_3_idft.png

(Butterworth LPF, D0 = 50, n = 3)

28_raccoon_BHPF_5_1_magnitude_spectrum.png

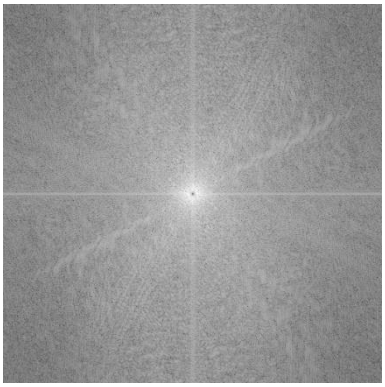


(Butterworth HPF, D0 = 5, n = 1)

29_raccoon_BHPF_5_1_idft.png

(Butterworth HPF, D0 = 5, n = 1)

30_raccoon_BHPF_5_2_magnitude_spectrum.png

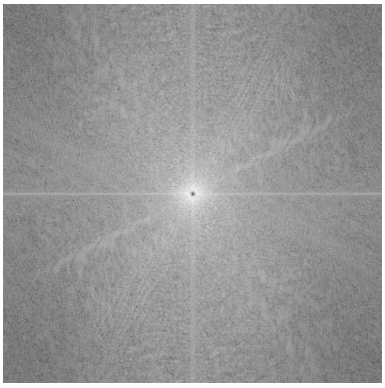


(Butterworth HPF, D0 = 5, n = 2)

31_raccoon_BHPF_5_2_idft.png

(Butterworth HPF, D0 = 5, n = 2)

32_raccoon_BHPF_5_3_magnitude_spectrum.png

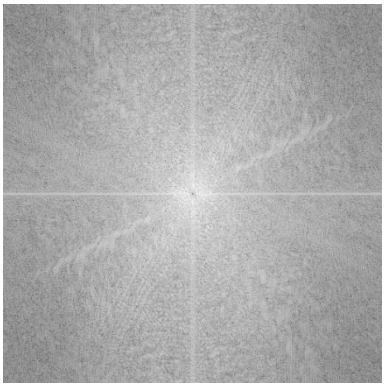


(Butterworth HPF, D0 = 5, n = 3)

33_raccoon_BHPF_5_3_idft.png

(Butterworth HPF, D0 = 5, n = 3)

34_raccoon_BHPF_20_1_magnitude_spectrum.png

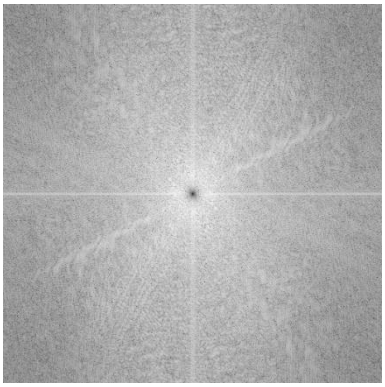


(Butterworth HPF, D0 = 20, n = 1)

35_raccoon_BHPF_20_1_idft.png

(Butterworth HPF, D0 = 20, n = 1)

36_raccoon_BHPF_20_2_magnitude_spectrum.png

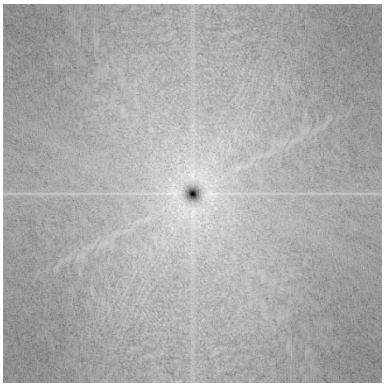


(Butterworth HPF, D0 = 20, n = 2)

37_raccoon_BHPF_20_2_idft.png

(Butterworth HPF, D0 = 20, n = 2)

38_raccoon_BHPF_20_3_magnitude_spectrum.png

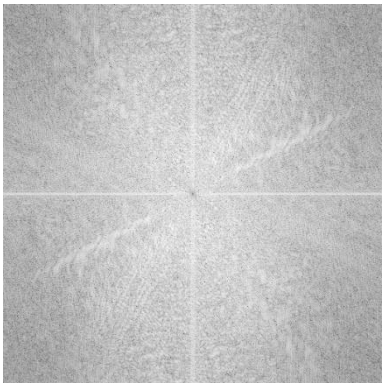


(Butterworth HPF, D0 = 20, n = 3)

39_raccoon_BHPF_20_3_idft.png

(Butterworth HPF, D0 = 20, n = 3)

40_raccoon_BHPF_50_1_magnitude_spectrum.png

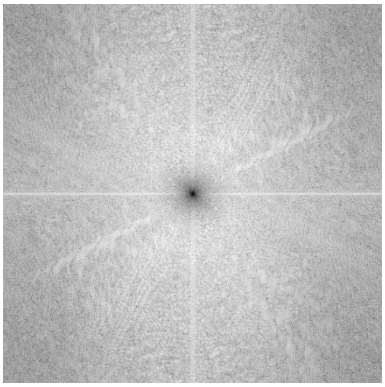


(Butterworth HPF, D0 = 50, n = 1)

41_raccoon_BHPF_50_1_idft.png

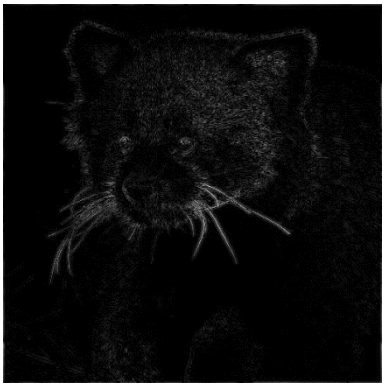
(Butterworth HPF, D0 = 50, n = 1)

42_raccoon_BHPF_50_2_magnitude_spectrum.png



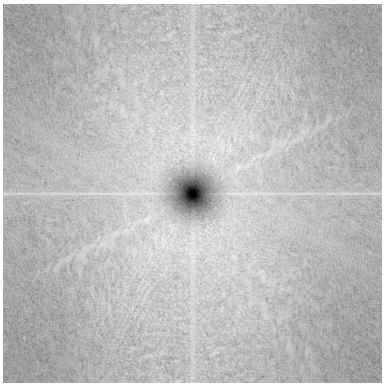
(Butterworth HPF, D0 = 50, n = 2)

43_raccoon_BHPF_50_2_idft.png



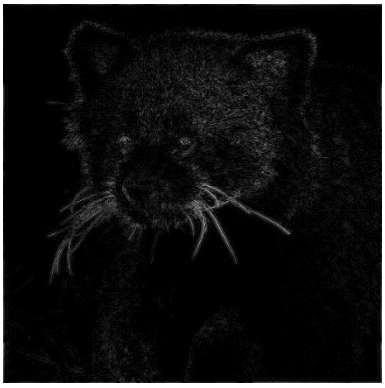
(Butterworth HPF, D0 = 50, n = 2)

44_raccoon_BHPF_50_3_magnitude_spectrum.png



(Butterworth HPF, D0 = 50, n = 3)

45_raccoon_BHPF_50_3_idft.png



(Butterworth HPF, D0 = 50, n = 3)

Discussion

調整參數過程發現 D0 越小，LPF 會越模糊，HPF 則是保留的細節越多；n 越大時，LPF 會越模糊，HPF 則是保留的細節會越少。

2.(2)

Figure

46_owl_HFE_idft.png

(D0 = 50, n = 2, a = 0.5, b = 1)

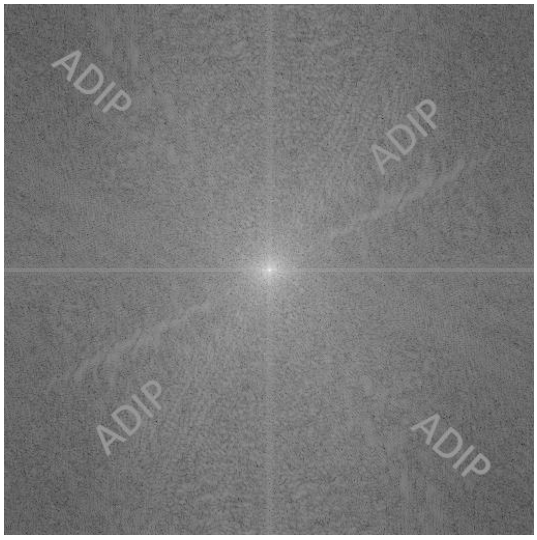
Discussion

本題使用 Gaussian HPF，調整參數過程想辦法儘量讓翅膀以及木頭的線條紋理更明顯，如圖所示。

3.(1)

Figure

47_raccoon_mark_i_raccoon_mark_i_magnitude_spectrum.png



48_raccoon_mark_i_raccoon_mark_i_out_idft.png

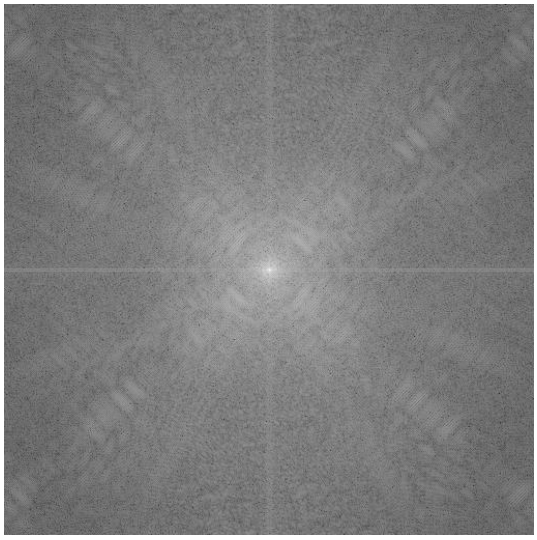
Discussion

本題使用 method i，加上浮水印的時域，其中 w = 100，剛開始 w 設比較小發現頻譜圖都看不到浮水印，因此最後才將 w 調到 100。

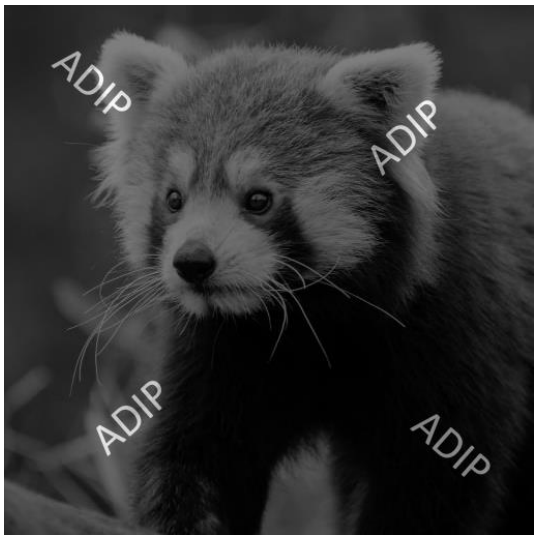
3.(2)

Figure

49_raccoon_mark_ii_raccoon_mark_ii_magnitude_spectrum.png



50_raccoon_mark_ii_raccoon_mark_ii_out_idft.png



Discussion

本題使用 method ii，加上浮水印的頻域，其中 w = 1，在調整 w 時發現 w 越大原圖影像會越暗，浮水印則會越明顯。

4.
Figure
51_house_homomorphic.png  (rH = 1.3, rL = 0.85, c = 0.35, D0 = 0.4) 52_house_histogram_equalization.png 
Discussion
本題調整參數過程讓 rH > 1, rL < 1 並調整 c 想辦法讓對比度出來，觀察使用 histogram equalization 方法的輸出影像對比度佳，但是暗細節上的顏色有很多片雜訊。