EXPERIMENT 2

Digital Image Processing

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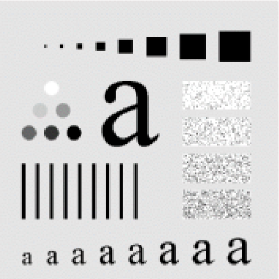

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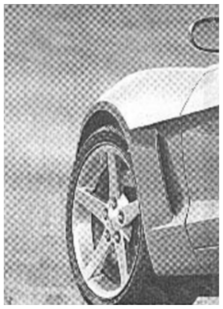
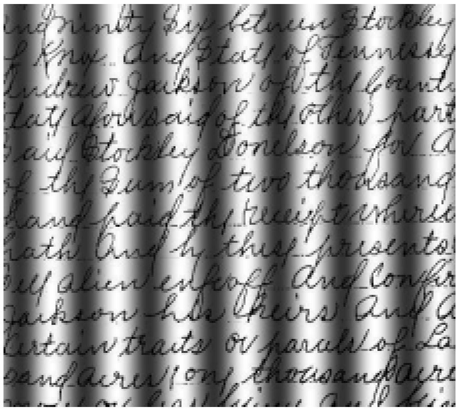


6. Try to remove the sinusoidal pattern in the img2.tif


ing ninety Six between Stokley
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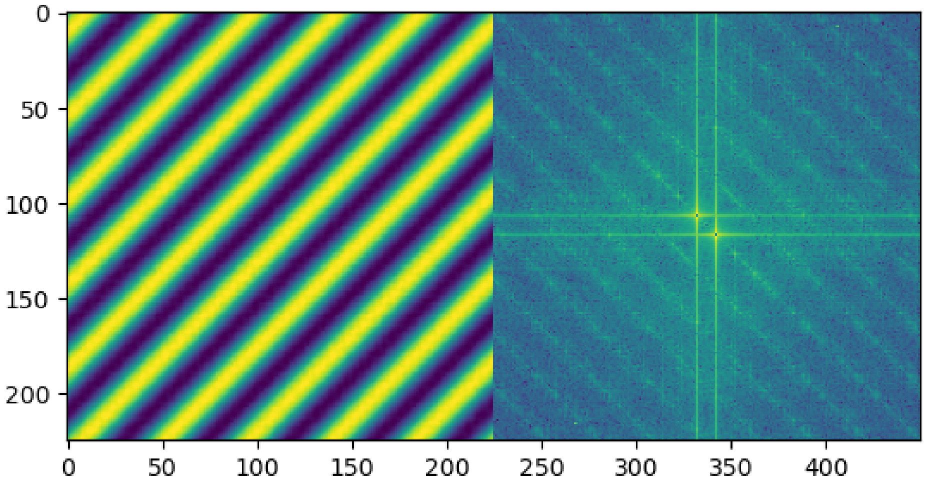
I. Getting to know the FFT method and its properties

(1.1) FFT2 transformation with Sinusoidal wave

- **With Sinusoidal waves (diagonal)**

```
import cv2 as cv

import numpy as np

im = cv.imread('wave1.jfif', 0)


f = np.fft.fft2(im)

fshift = np.fft.fftshift(f)

magnitude_spectrum = 20*np.log(np.abs(fshift))

print (magnitude_spectrum)

magnitude_spectrum = np.asarray(magnitude_spectrum, dtype=np.uint8)
```



- **Comparing 2D sinusoidal waves which are different in direction**

```
import cv2 as cv
import numpy as np


im = cv.imread('wave1.jfif', 0)


f = np.fft.fft2(im)

fshift = np.fft.fftshift(f)

magnitude_spectrum = 20*np.log(np.abs(fshift))

print (magnitude_spectrum)

magnitude_spectrum = np.asarray(magnitude_spectrum, dtype=np.uint8)
```

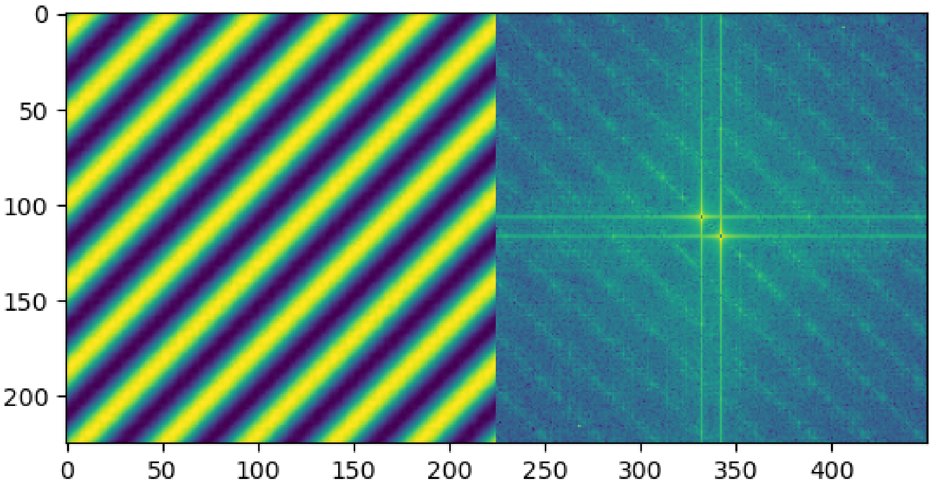


Image 1-Diagonal

```
im2 = cv.imread('wave2.jfif', 0)

fa = np.fft.fft2(im2)

fashift = np.fft.fftshift(f)

magnitude_2 = 20*np.log(np.abs(fashift))

print (magnitude_2)

magnitude_2 = np.asarray(magnitude_2, dtype=np.uint8)
```

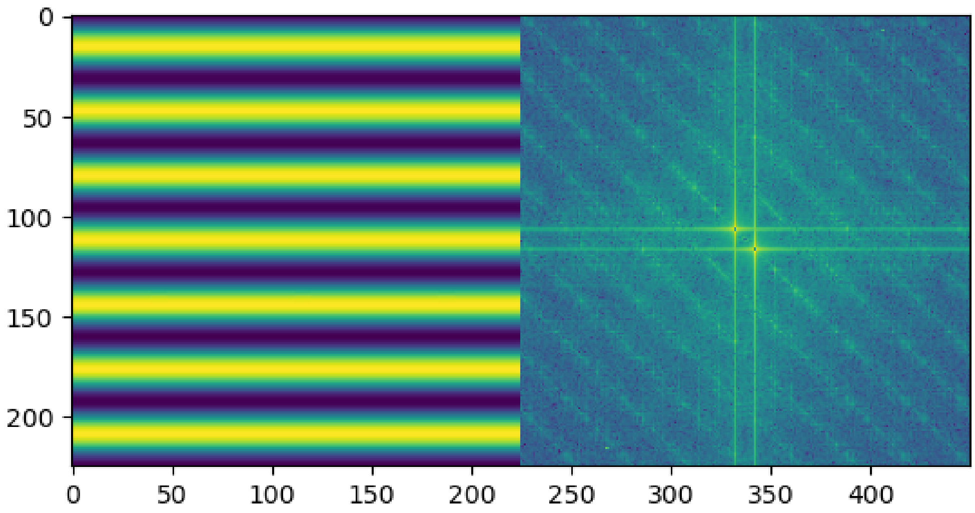


Image 2-Horizontal

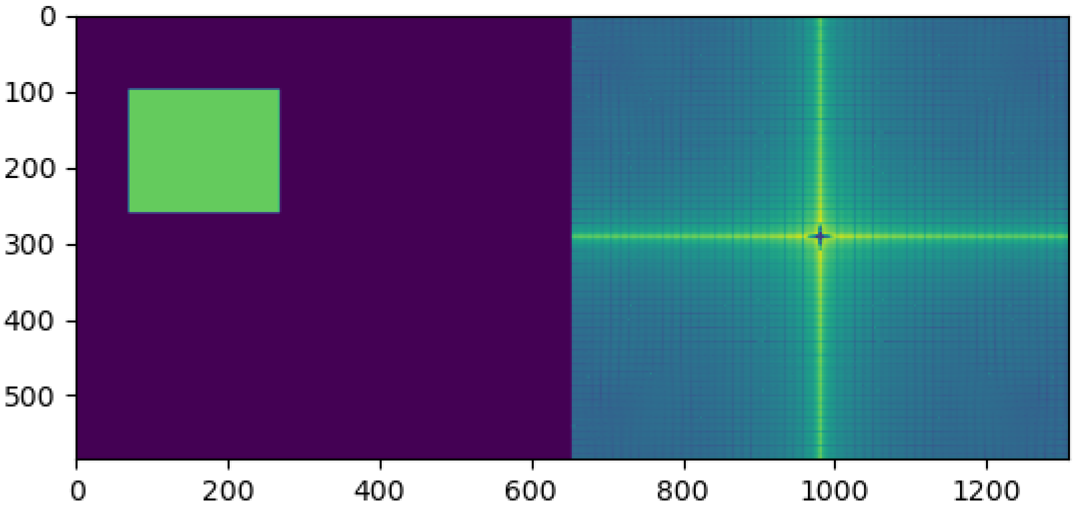
Comparing the image outputs of image 1 and 2 after adding the fourier transform - Same output

(1.2) FFT2 transformation with Rectangle

- **1 rectangle**

```
import cv2 as cv

import numpy as np


im = cv.imread('square.jpg', 0)


f = np.fft.fft2(im)

fshift = np.fft.fftshift(f)

magnitude_spectrum = 20*np.log(np.abs(fshift))

print (magnitude_spectrum)
```

```
magnitude_spectrum = np.asarray(magnitude_spectrum, dtype=np.uint8)


res = np.hstack((im, magnitude_spectrum)) #stacking images side-by-side

cv.imwrite('res.png',res)
```



- **2 rectangles but the position has changed**

```
import cv2 as cv

import numpy as np


im = cv.imread('square.jpg', 0)


f = np.fft.fft2(im)

fshift = np.fft.fftshift(f)

magnitude_spectrum = 20*np.log(np.abs(fshift))

print (magnitude_spectrum)
```

```
magnitude_spectrum = np.asarray(magnitude_spectrum, dtype=np.uint8)


res = np.hstack((im, magnitude_spectrum)) #stacking images side-by-side

cv.imwrite('res.png',res)
```

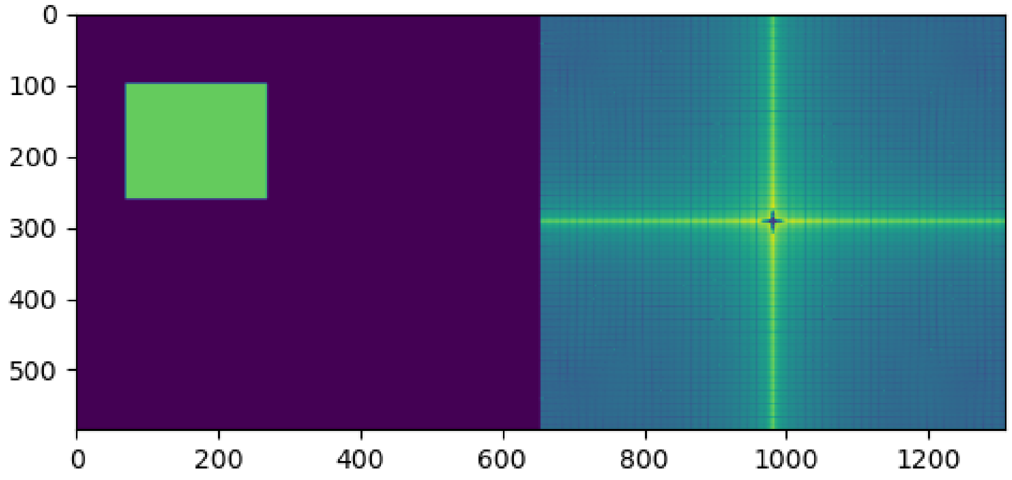


Image1-left

```
im2 = cv.imread('square2.jpg', 0)

fa = np.fft.fft2(im2)

fashift = np.fft.fftshift(fa)

magnitude_2 = 20*np.log(np.abs(fashift))

print (magnitude_2)

magnitude_2 = np.asarray(magnitude_2, dtype=np.uint8)


res2 = np.hstack((im2, magnitude_2)) #stacking images side-by-side

cv.imwrite('res2.png',res2)
```

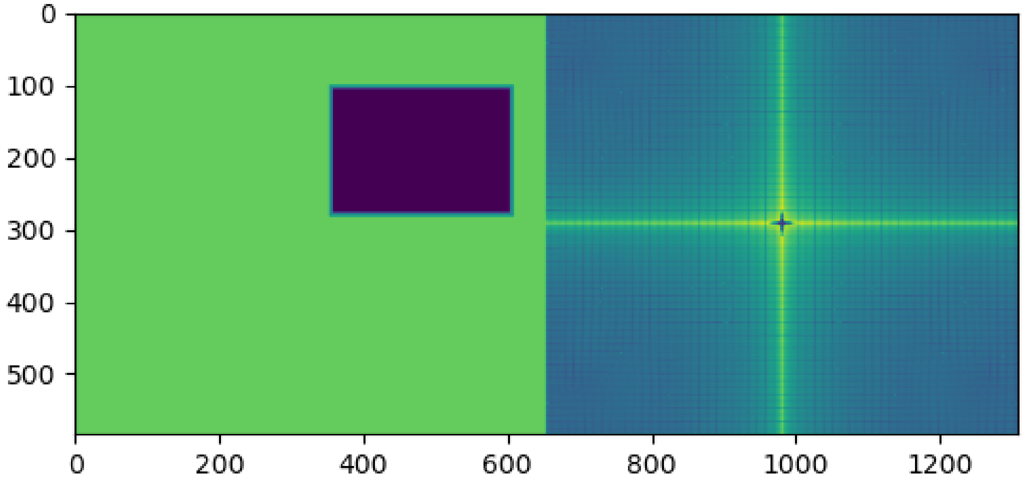


Image2-right

Comparing the image outputs of image 1 and 2 after adding the fourier transform - Same output

- **2 rectangles but the angle/direction has changed**

```
import cv2 as cv

import numpy as np


im = cv.imread('square.jpg', 0)


f = np.fft.fft2(im)

fshift = np.fft.fftshift(f)

magnitude_spectrum = 20*np.log(np.abs(fshift))

print (magnitude_spectrum)

magnitude_spectrum = np.asarray(magnitude_spectrum, dtype=np.uint8)
```

```
res = np.hstack((im, magnitude_spectrum)) #stacking images side-by-side

cv.imwrite('res.png',res)
```

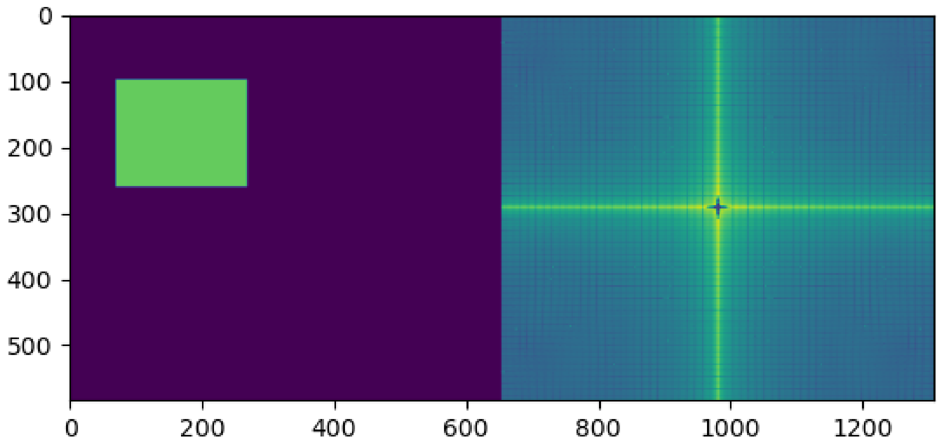


Image1-rectangle

```
im3 = cv.imread('square3.jpg', 0)

fa3 = np.fft.fft2(im2)

fa3shift = np.fft.fftshift(fa3)

magnitude_3 = 20*np.log(np.abs(fa3shift))

print (magnitude_3)

magnitude_3 = np.asarray(magnitude_3, dtype=np.uint8)


res3 = np.hstack((im3, magnitude_3)) #stacking images side-by-side

cv.imwrite('res3.png',res3)
```

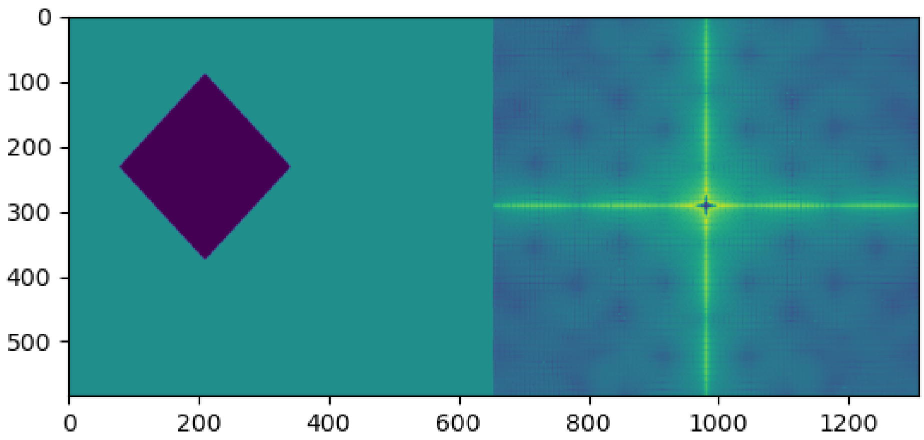


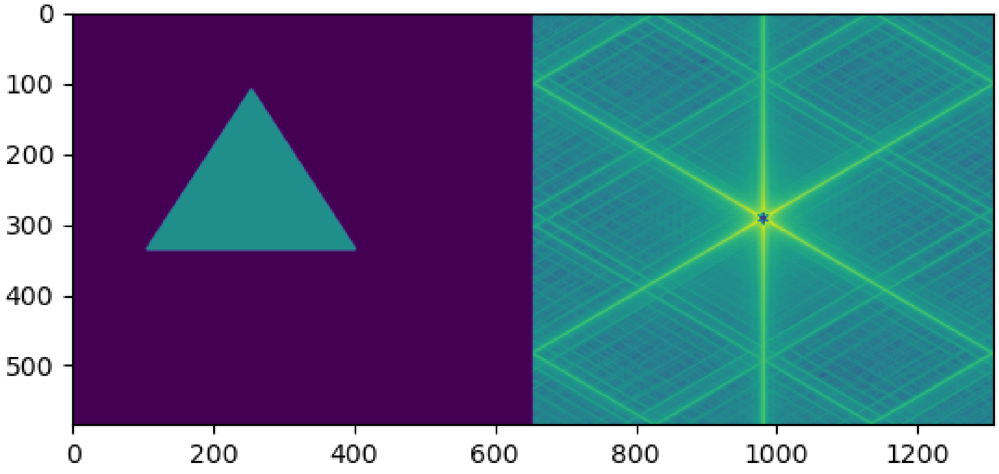
Image2- rhombus

Comparing the image outputs of image 1 and 2 after adding the fourier transform - slightly different output

(1.3) FFT2 transformation with Triangle

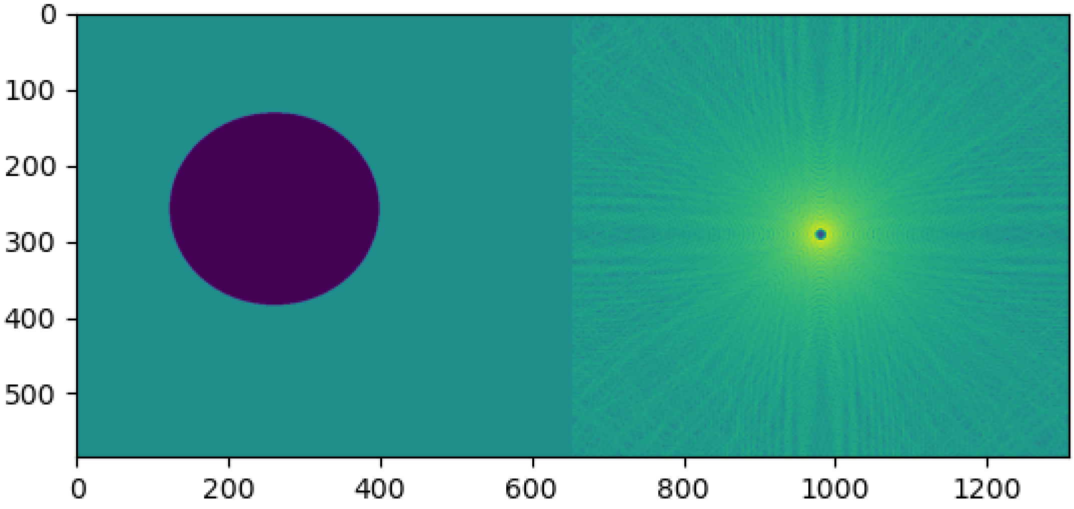
```
import cv2 as cv

import numpy as np


im = cv.imread('triangle.jpg', 0)


f = np.fft.fft2(im)

fshift = np.fft.fftshift(f)

magnitude_spectrum = 20*np.log(np.abs(fshift))

print (magnitude_spectrum)

magnitude_spectrum = np.asarray(magnitude_spectrum, dtype=np.uint8)
```

```
res = np.hstack((im, magnitude_spectrum)) #stacking images side-by-side

cv.imwrite('res.png',res)
```



(1.4) FFT2 transformation with Circle

(Same code)

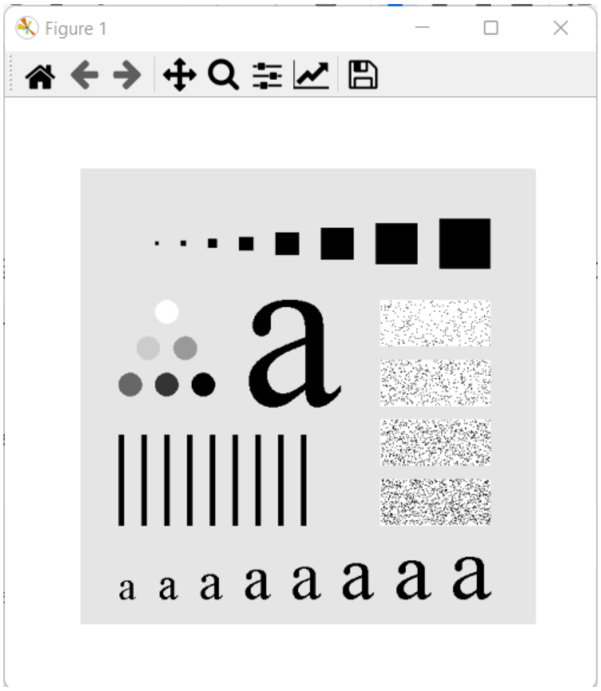


II. Filtering with the FFT method

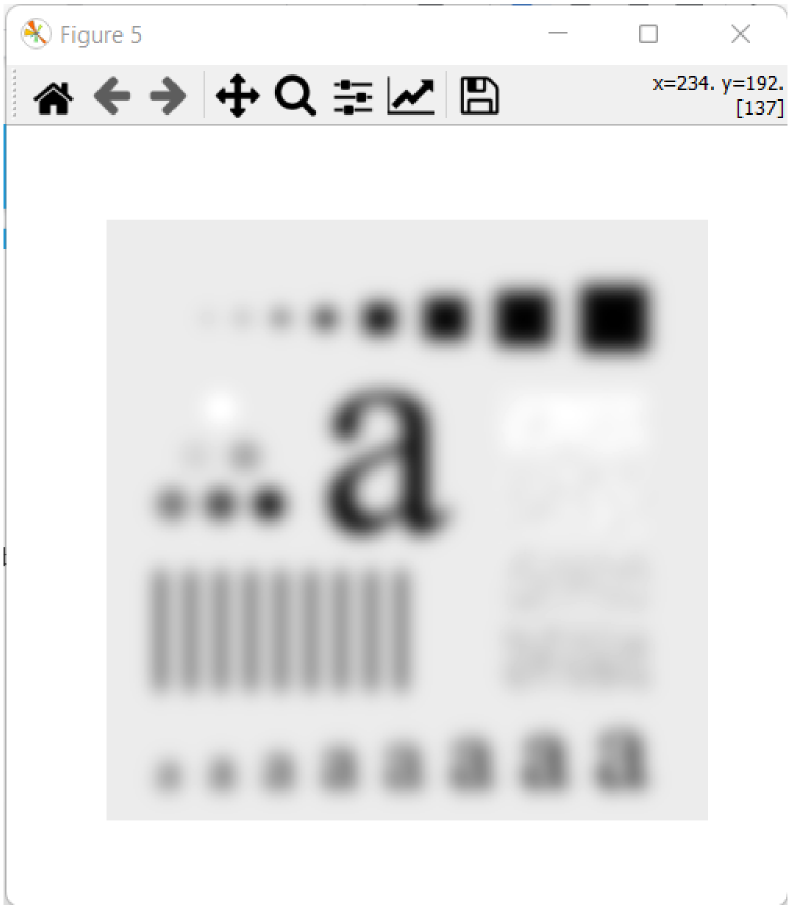
(2.1) Low pass filters the img1.tif with Gaussian, Butterworth, Hard filter and try different parameters of the filters.

- **Low pass Gaussian filter**

```
import cv2 as cv

import numpy as np

import matplotlib.pyplot as plt


# open the image f

f = cv.imread('img1.tif',0)
```



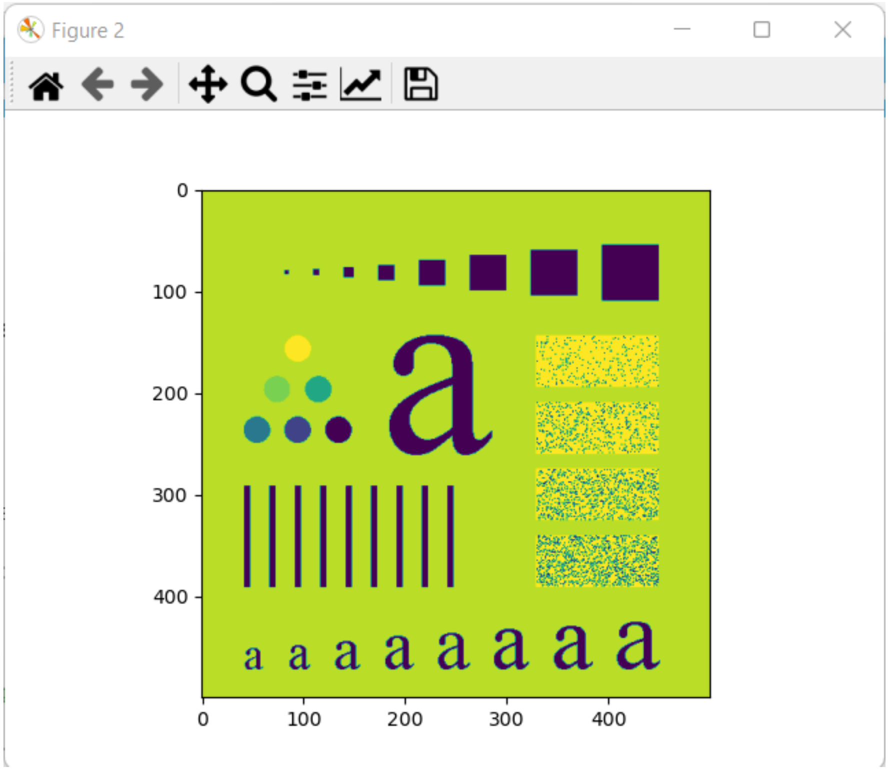
```
plt.figure(figsize=(5,5))
plt.imshow(f, cmap='gray')
plt.axis('off')
plt.show()

# transform the image into frequency domain, f --> F
F = np.fft.fft2(f)
Fshift = np.fft.fftshift(F)

plt.figure(figsize=(5,5))
plt.imshow(np.log1p(np.abs(F)), cmap='gray')
plt.axis('off')
plt.show()

plt.figure(figsize=(5,5))
plt.imshow(np.log1p(np.abs(Fshift)), cmap='gray')
plt.axis('off')
plt.show()

# Create Gaussin Filter: Low Pass Filter
M,N = f.shape
H = np.zeros((M,N), dtype=np.float32)
D0 = 10
for u in range(M):
    for v in range(N):
        D = np.sqrt((u-M/2)**2 + (v-N/2)**2)
        H[u,v] = np.exp(-D**2/(2*D0*D0))

plt.figure(figsize=(5,5))
plt.imshow(H, cmap='gray')
plt.axis('off')
plt.show()

# Image Filters
Gshift = Fshift * H
G = np.fft.ifftshift(Gshift)
g = np.abs(np.fft.ifft2(G))

plt.figure(figsize=(5,5))
plt.imshow(g, cmap='gray')
plt.axis('off')
plt.show()

plt.figure(figsize=(5,5))
plt.imshow(np.log1p(np.abs(Gshift)), cmap='gray')
plt.axis('off')
plt.show()
plt.figure(figsize=(5,5))

plt.imshow(np.log1p(np.abs(G)), cmap='gray')

plt.axis('off')

plt.show()
```



Final Output

- **Low pass Butterworth filter**

```
import cv2

import numpy as np

import matplotlib.pyplot as plt


# open the image

f = cv2.imread('img1.tif',0)
```

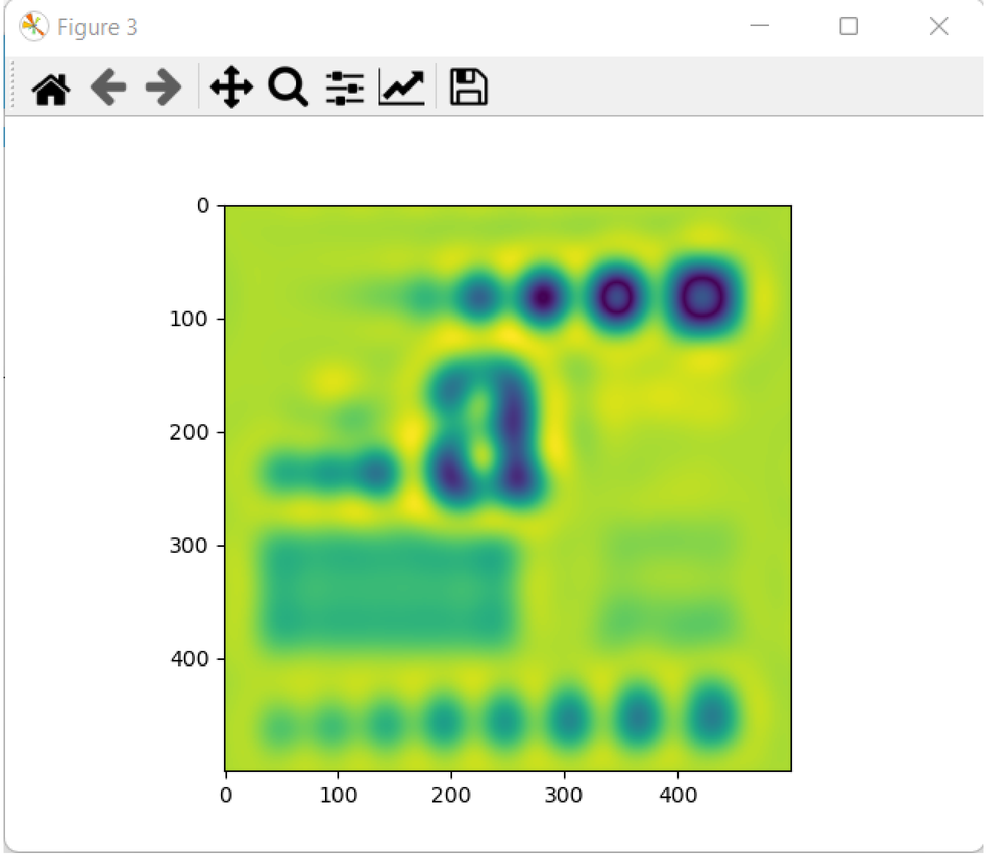


Original IMage

```
# transform image into freq. domain and shifted

F = np.fft.fft2(f)

Fshift = np.fft.fftshift(F)
```

```
plt.imshow(np.log1p(np.abs(Fshift)), cmap='gray')

plt.axis('off')

plt.show()


# Butterworth Low Pass Filter

M,N = f.shape

H = np.zeros((M,N), dtype=np.float32)

D0 = 10 # cut of frequency

n = 10 # order

for u in range(M):

    for v in range(N):

        D = np.sqrt((u-M/2)**2 + (v-N/2)**2)

        H[u,v] = 1 / (1 + (D/D0)**n)


plt.imshow(H, cmap='gray')

plt.axis('off')

plt.show()


# frequency domain image filters

Gshift = Fshift * H

G = np.fft.ifftshift(Gshift)

g = np.abs(np.fft.ifft2(G))
```

```
plt.imshow(g, cmap='gray')

plt.axis('off')

plt.show()
```

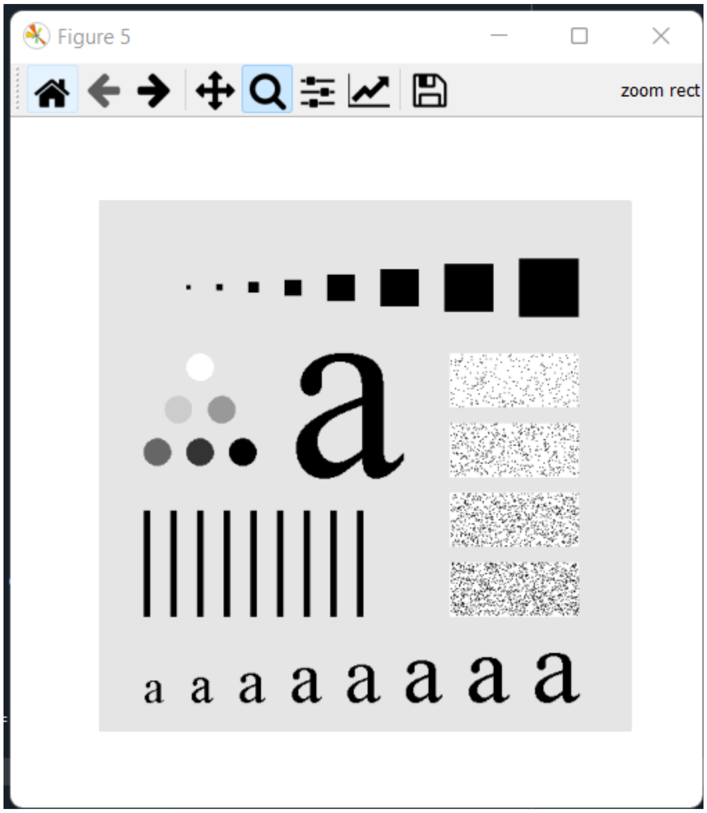


Final Output

(2.2) High pass filters the img1.tif with Gaussian, Butterworth, Hard filter and try different parameters of the filters.

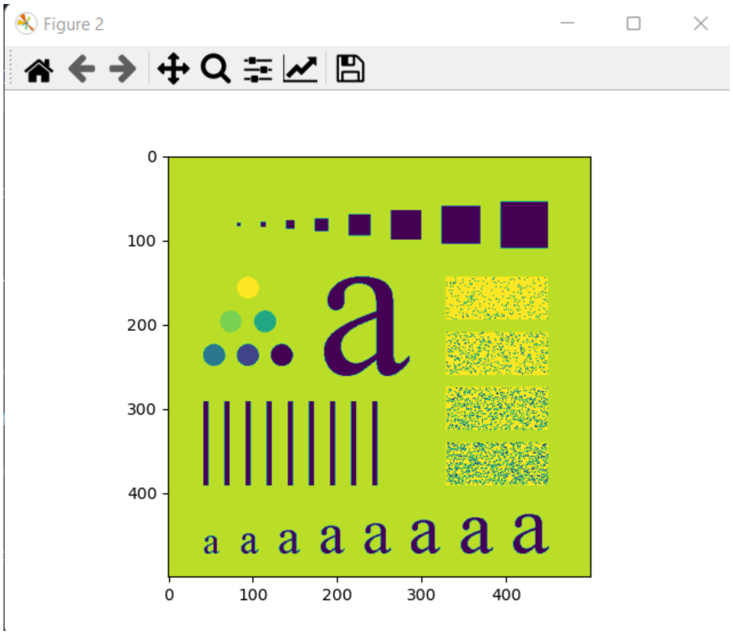
- **High pass Gaussian filter**

```
import cv2 as cv
import numpy as np
import matplotlib.pyplot as plt

# open the image f
f = cv.imread('img1.tif',0)

plt.figure(figsize=(5,5))
plt.imshow(f, cmap='gray')
plt.axis('off')
plt.show()

# transform the image into frequency domain, f --> F
F = np.fft.fft2(f)
Fshift = np.fft.fftshift(F)

plt.figure(figsize=(5,5))
plt.imshow(np.log1p(np.abs(F)), cmap='gray')
plt.axis('off')
plt.show()
plt.figure(figsize=(5,5))

plt.imshow(np.log1p(np.abs(Fshift)), cmap='gray')

plt.axis('off')

plt.show()


# Gaussian: High pass filter

M,N = f.shape

H = np.zeros((M,N), dtype=np.float32)

D0 = 10


HPF = 1 - H


plt.figure(figsize=(5,5))

plt.imshow(HPF, cmap='gray')

plt.axis('off')

plt.show()


# Image Filters

Gshift = Fshift * HPF

G = np.fft.ifftshift(Gshift)

g = np.abs(np.fft.ifft2(G))


plt.figure(figsize=(5,5))

plt.imshow(g, cmap='gray')
plt.axis('off')

plt.show()


plt.figure(figsize=(5,5))

plt.imshow(np.log1p(np.abs(Gshift)), cmap='gray')

plt.axis('off')

plt.show()


plt.figure(figsize=(5,5))

plt.imshow(np.log1p(np.abs(G)), cmap='gray')

plt.axis('off')

plt.show()
```



- **High pass Butterworth filter**

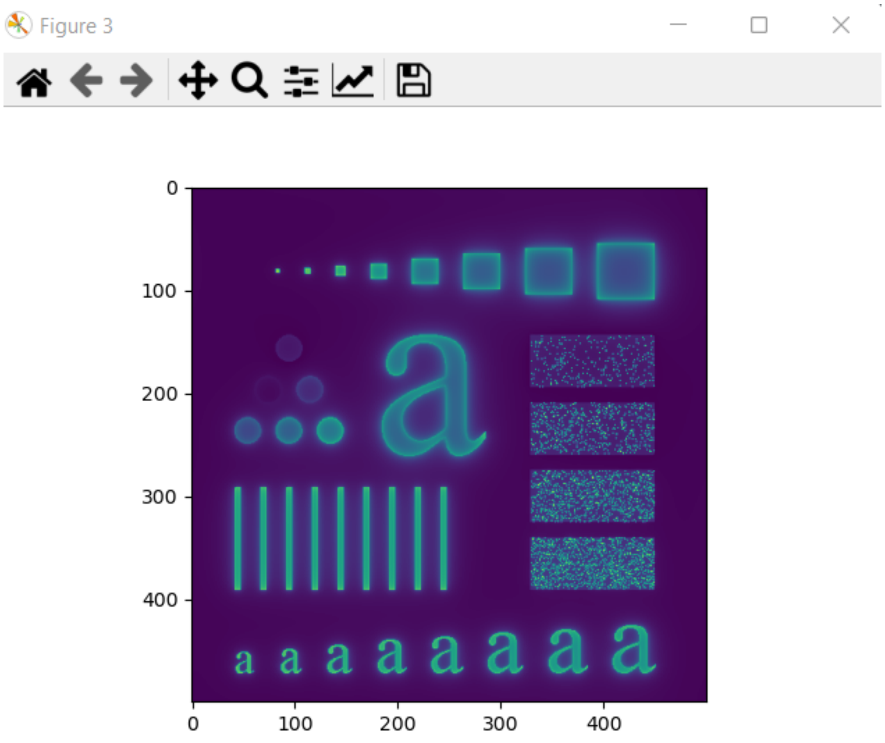
```
import cv2

import numpy as np

import matplotlib.pyplot as plt


# open the image

f = cv2.imread('img1.tif',0)
```



```
# transform image into freq. domain and shifted

F = np.fft.fft2(f)

Fshift = np.fft.fftshift(F)


plt.imshow(np.log1p(np.abs(Fshift)), cmap='gray')

plt.axis('off')

plt.show()
```

```
# Butterworth High Pass Filter
M,N = f.shape
H = np.zeros((M,N), dtype=np.float32)
D0 = 10 # cut of frequency
n = 10 # order

HPF = np.zeros((M,N), dtype=np.float32)
D0 = 10
n = 1
for u in range(M):
    for v in range(N):
        D = np.sqrt((u-M/2)**2 + (v-N/2)**2)
        HPF[u,v] = 1 / (1 + (D0/D)**n)

plt.imshow(HPF, cmap='gray')
plt.axis('off')
plt.show()

# frequency domain image filters
Gshift = Fshift * HPF
G = np.fft.ifftshift(Gshift)
g = np.abs(np.fft.ifft2(G))
```

```
plt.imshow(g, cmap='gray')

plt.axis('off')

plt.show()
```



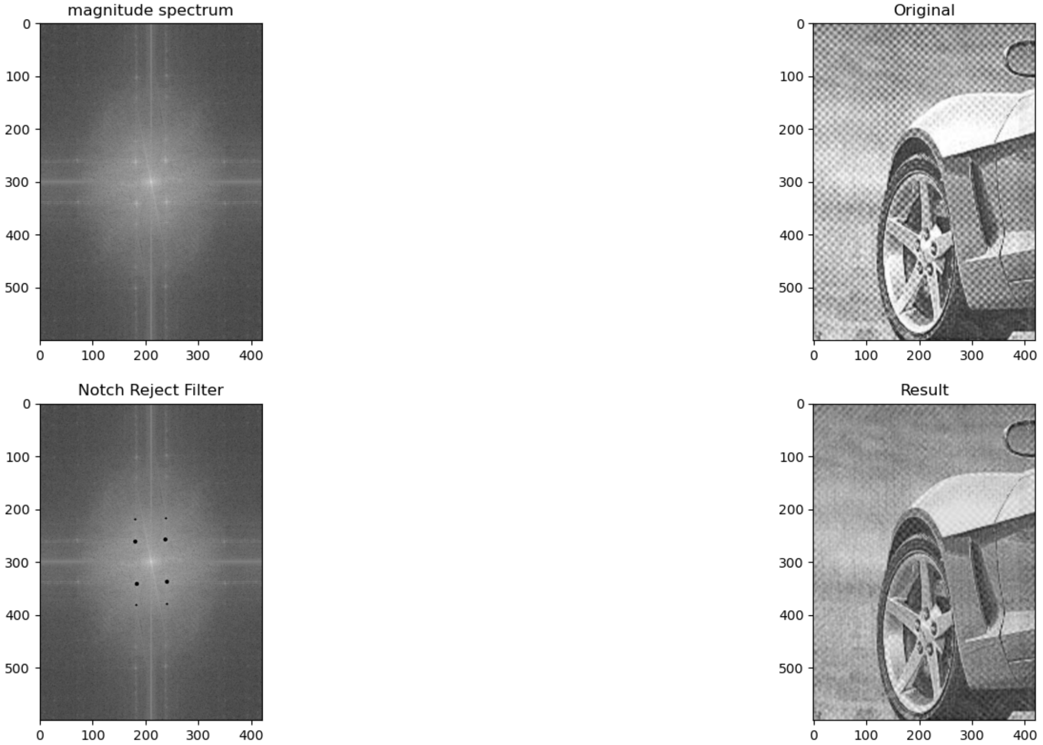
Final Output

III. Compound experiment

(3.1) Remove the dithering noise in the img4.png image with notch filtering the frequency spectrum

```
import cv2

import numpy as np

import matplotlib.pyplot as plt




def notch_reject_filter(shape, d0=9, u_k=0, v_k=0):

    P, Q = shape

    # Initialize filter with zeros

    H = np.zeros((P, Q))


    # Traverse through filter

    for u in range(0, P):

        for v in range(0, Q):

            # Get euclidean distance from point D(u,v) to the center

            D_uv = np.sqrt((u - P / 2 + u_k) ** 2 + (v - Q / 2 + v_k) ** 2)

            D_muv = np.sqrt((u - P / 2 - u_k) ** 2 + (v - Q / 2 - v_k) ** 2)


            if D_uv <= d0 or D_muv <= d0:

                H[u, v] = 0.0

            else:
                H[u, v] = 1.0

    return H

img = cv2.imread('img4.png', 0)

f = np.fft.fft2(img)
fshift = np.fft.fftshift(f)
phase_spectrumR = np.angle(fshift)
magnitude_spectrum = 20*np.log(np.abs(fshift))

img_shape = img.shape

H1 = notch_reject_filter(img_shape, 4, 38, 30)
H2 = notch_reject_filter(img_shape, 4, -42, 27)
H3 = notch_reject_filter(img_shape, 2, 80, 30)
H4 = notch_reject_filter(img_shape, 2, -82, 28)

NotchFilter = H1*H2*H3*H4
NotchRejectCenter = fshift * NotchFilter
NotchReject = np.fft.ifftshift(NotchRejectCenter)
inverse_NotchReject = np.fft.ifft2(NotchReject)  # Compute the inverse DFT of the result
```

```
Result = np.abs(inverse_NotchReject)

plt.subplot(222)
plt.imshow(img, cmap='gray')
plt.title('Original')

plt.subplot(221)
plt.imshow(magnitude_spectrum, cmap='gray')
plt.title('magnitude spectrum')

plt.subplot(223)
plt.imshow(magnitude_spectrum*NotchFilter, "gray")
plt.title("Notch Reject Filter")

plt.subplot(224)
plt.imshow(Result, "gray")
plt.title("Result")
plt.show()
```


magnitude spectrum
Original
Notch Reject Filter
Result
0
100
200
300
400
500
0
100
200
300
400

Image

(3.2) Remove the sinusoidal pattern in the img2.tif

(Apologies, I actually couldn't find a proper way to do this task)