CLASS : B.E. E &TC **SUBJECT: DIVP**

EXPT. NO. : 5 **DATE:25-09-2020**

TITLE : TO PERFORM IMAGE ENHANCEMENT IN FREQUENCY DOMAIN

CO 1:	Apply the fundamentals of digital image processing to perform various operations on an image-enhancement in spatial domain/ frequency domain, image-restoration, image compression, video filtering and video compression on a given gray image. Examine the effect of varying the mask size and density of noise in an image and comment on the obtained results.
CO4:	Carry out experiments as an individual and in a team, comprehend and write a laboratory record and draw conclusions at a technical level.

AIM :

To implement the following filters using matlab

1. Smoothing Filter
2. Sharpening Filter.

SOFTWARES REQUIRED: Matlab 7.0 or above, python

THEORY:

5.1 Basics of DFT

Image enhancement approaches fall into two broad categories: spatial domain methods and frequency domain methods. The term *spatial domain* refers to the image plane itself, and approaches in this category are based on direct manipulation of pixels in an image.

Frequency domain processing techniques are based on modifying the Fourier transform of an image. The term *spatial domain* refers to the aggregate of pixels composing an image. Spatial domain methods are procedures that operate directly on these pixels.

$$F(u,v) = \frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)e^{-j2\pi(ux/M+vy/N)}$$

$$f(x,y) \longleftrightarrow F(u,v)$$

$$f(x,y) = \sum_{u=0}^{M-1}\sum_{v=0}^{N-1} F(u,v)e^{j2\pi(ux/M+vy/N)}$$

Fig. 5.1: 2D DFT and IDFT

M, N : Image Size

x,y: Image pixel position

u,v: spatial frequency

Any signal can be represented as a linear combination of set of basic components which include Fourier Components (Sinusodial Pattern) and Fourier coefficients (Weighting factors assigned to the Fourier components). Spatial frequency is the frequency of the Fourier component

Real Part, Imaginary Part, Magnitude, Phase, Spectrum

Real part: $R = \text{Real}(F)$

Imaginary part: $I = \text{Imag}(F)$

Magnitude-phase representation: $F(u, v) = |F(u, v)|e^{-j\phi(u,v)}$

Magnitude (spectrum): $|F(u, v)| = [R^2(u, v) + I^2(u, v)]^{1/2}$

Phase (spectrum): $\phi(u, v) = \tan^{-1}\left[\frac{I(u, v)}{R(u, v)}\right]$

Power Spectrum: $P(u, v) = |F(u, v)|^2$

5 .2 Computation of 2D DFT

- To compute the 1D-DFT of a 1D signal x (as a vector):

$$\tilde{\mathbf{x}} = \mathbf{F}_N \mathbf{x}$$

To compute the inverse 1D-DFT:

$$\mathbf{x} = \frac{1}{N}\mathbf{F}_N^* \tilde{\mathbf{x}}$$

- To compute the 2D-DFT of an image X (as a matrix):

$$\tilde{\mathbf{X}} = \mathbf{F}_N \mathbf{X} \mathbf{F}_N$$

To compute the inverse 2D-DFT:

$$\mathbf{X} = \frac{1}{N^2}\mathbf{F}_N^* \tilde{\mathbf{X}} \mathbf{F}_N^*$$

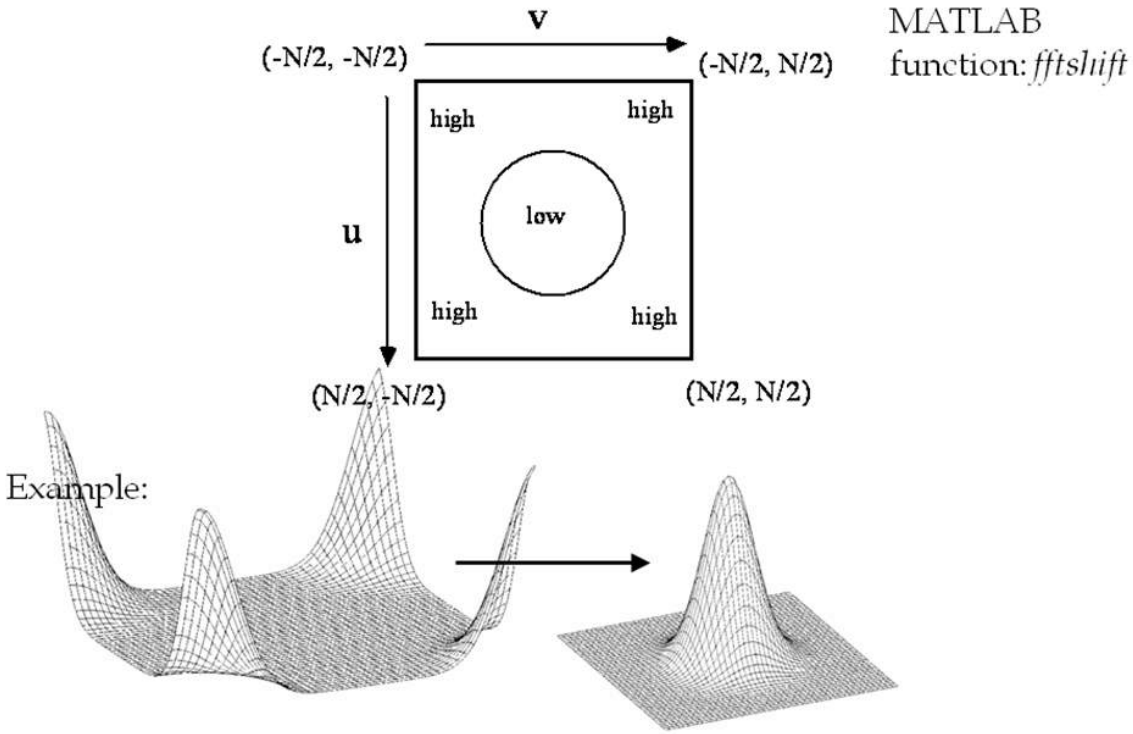


Fig. 5.2 : FFT Shift

To shift the low frequency at the centre, FFT shift is required. To see the minute details of frequencies log transform is used.

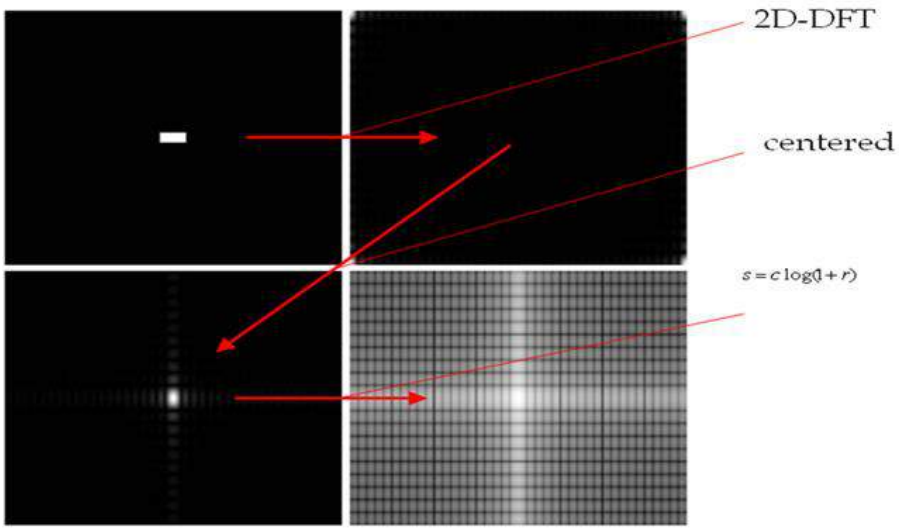


Fig. 5.3: Log magnitude visualization

5.3 Block diagram for frequency domain filtering

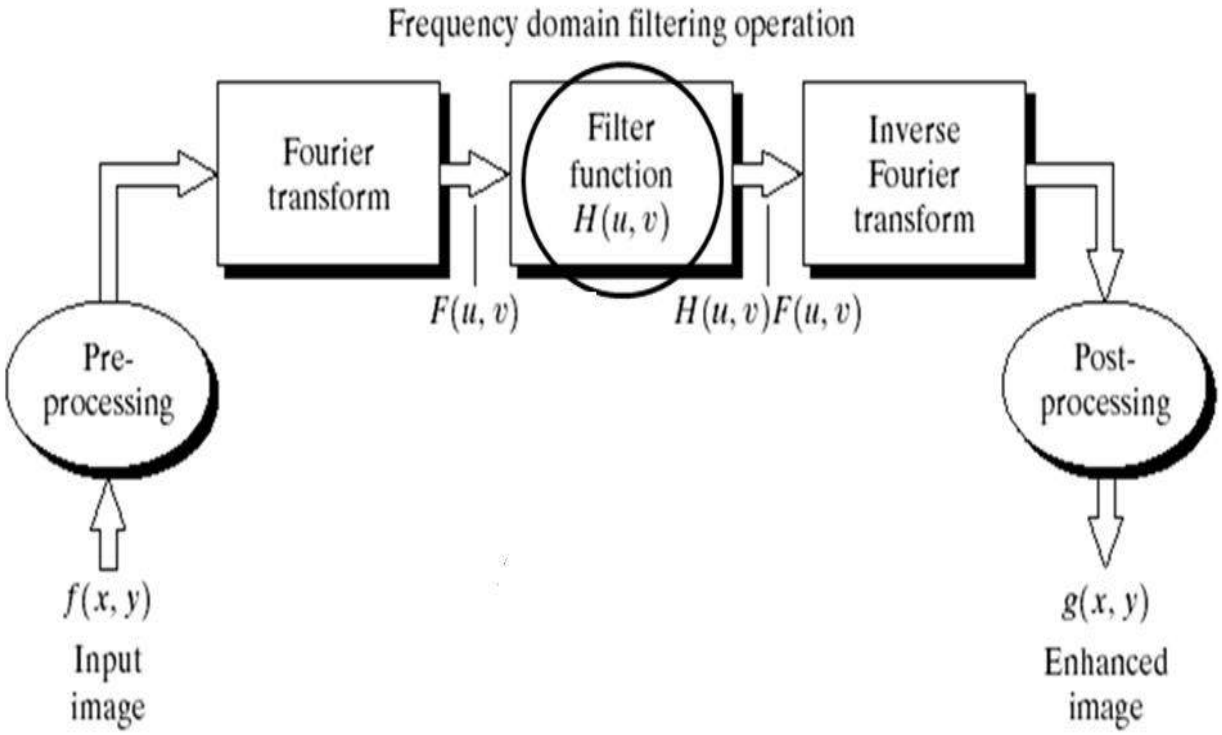


Fig. 5.4: Basic steps for filtering in the frequency domain

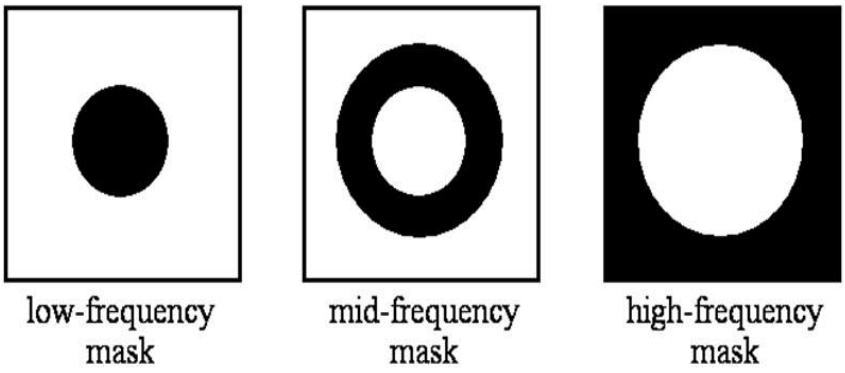
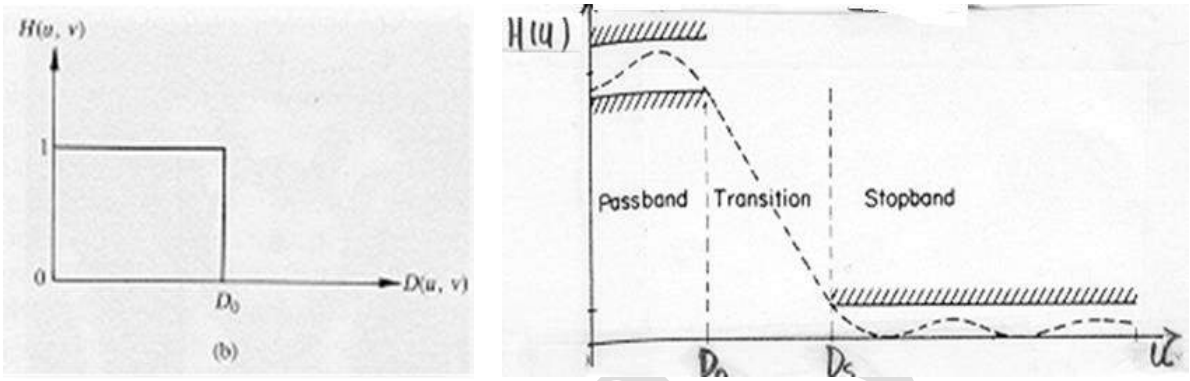


Fig 5.5: Ideal Low pass, Band pass and High pass filter masks

5.5 Low-Pass Filter:



(a) (b)

$$H(u,v) = \begin{cases} 1 & \text{if } 0 \le u \le D_0 \\ 0 & otherwise \end{cases}$$ Do :- Cutoff frequency

Fig 5.6 (a) Ideal and (b) Practical response of LPF

The ideal low-pass filter smoothes out the image, and is good for removing noise. The edges remain fairly sharp (better than mean filter).But it creates "ringing" artifacts around the edges. This is due to the sharp 0-1 transition in the filter and is called the *Gibbs phenomenon*.

$$H(u,v) = \begin{cases} 1 & \text{if } u^2 + v^2 \le D_0{}^2 \\ 0 & otherwise \end{cases}$$

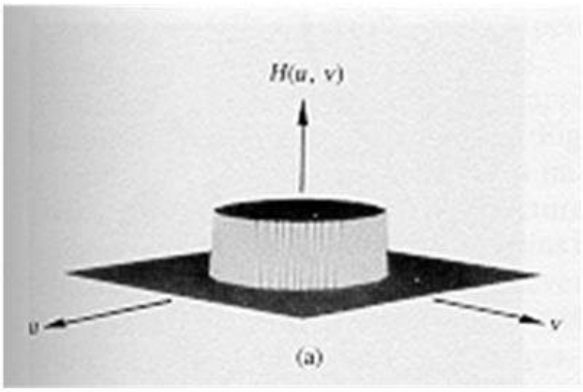
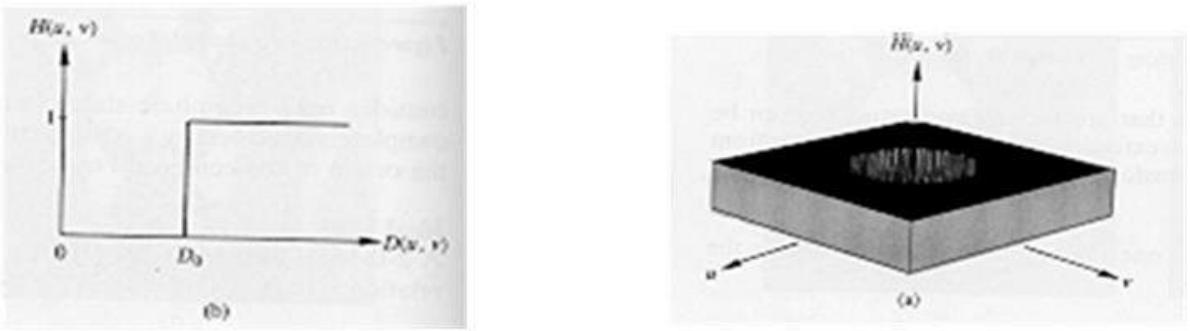


Fig 5.7: Cutoff frequencies lie on a circle

5.6 High-Pass Filter:

High pass filter preserves high frequencies and attenuates Lower frequencies**.**



$$H(u,v) = \begin{cases} 1 & \text{if} u \geq D_0 \\ 0 & otherwise \end{cases} \qquad H(u,v) = \begin{cases} 1 & \text{if} u^2 + v^2 \geq {D_0}^2 \\ 0 & otherwise \end{cases}$$

Fig 5.6 (a) Ideal and (b) Practical response of LPF

5.7 Algorithm:

1. Start
2. Import required libraries
3. Read a grayscale image
4. Compute fft of image
5. Shift the spectrum of image
6. Apply various low pass and high pass filters like ideal , butterworth , Gaussian etc. on image
7. Take ifft on each of individual image obtained in previous step
8. Display all the images
9. Study the difference between various filters.
10. End

5.8 Conclusion:

In the experiment, following filters are applied on image.

- Ideal LPF and HPF: as ideal filters have sharp frequency response at designated frequency D0 all the components less or greater than frequency gets suppressed, hence we can loss some useful information during the operations.
- Butterworth LPF and HPF: Output of this filter is dependent on inverse of distance of pixel from central pixel and order of filter, hence it gives more sharpened image. During the sharpening process the noise may get added in image.
- Gaussian LPF and HPF: Output of this filter is dependent on exponential of distance of pixel from central pixel and order of filter, hence it provides blurring of edges. It is generally use to reduce the noise and to get low contrast images.

5.9 References:

i. Gonzalez R, Woods R, "Digital image processing", Pearson Prentice Hall, 2008.
ii. Gonzalez R, Woods R, Steven E, "Digital Image Processing Using MATLAB®", McGraw Hill Education, 2010.
iii. Jayaraman S, Esakkirajan S and Veerakumar T, "Digital Image Processing" Tata McGraw Hill, 2010
iv. Joshi, Madhuri A. "Digital Image Processing: an algorithm approach", PHI Learning Pvt. Ltd., 2006.
v. Pictures taken from: http://www.imageprocessingplace.com/root_files_V3/image_databases.html

(Course Teacher)

CLASS	**:**	**B.E (E &TC)**	**COURSE**	**:**	**DIVP**
AY	**:**	**2020-21 (SEM- I)**	**DATE**	**:**	**25-09-2020**
EXPT. NO.	**:**	**5**	**CLASS & ROLL NO**	**:**	**BE VIII 42428**
TITLE	**:**	**TO PERFORM IMAGE ENHANCEMENT IN FREQUENCY DOMAIN**			

I. CODE:

Low Pass Filter

```
import cv2

# import Numpy
import numpy as np
from matplotlib import pyplot as plt

def low_pass(img):
   #filter design
   Do = 50 #value of Cutoff freq Do
   ham = np.hamming(256)[:,None] # 1D hamming
   ham2d = np.sqrt(np.dot(ham, ham.T)) ** Do # expand to 2D hamming

   #Transforming the image to freq domain, output has 2 parts: real and imaginary
   dft = cv2.dft(img.astype(np.float32), flags=cv2.DFT_COMPLEX_OUTPUT)
   #Since the center of image does not coincide with the origin
   #we have to handle this problem with np.fft.fftshift() function
   #What this function does is just divide an image into four small images
   #and then rearrange them such that it becomes symmetric about the center.
   f_shifted = np.fft.fftshift(dft)
   f_complex = f_shifted[:,:,0]*1j + f_shifted[:,:,1]

   #applying the filter to the image
   f_filtered = ham2d * f_complex

   #taking inverse FT
   f_filtered_shifted = np.fft.fftshift(f_filtered)
   inv_img = np.fft.ifft2(f_filtered_shifted)
   filtered_img = np.abs(inv_img)
   filtered_img -= filtered_img.min()
   #expand the result such that all values are between 0 and 255
   filtered_img = filtered_img*255 / filtered_img.max()
   #convert back to uint8
   filtered_img = filtered_img.astype(np.uint8)
   return filtered_img;

img = cv2.imread('../Images/lenna.jpg', 0) # gray-scale image
img = img[:500, :500] # crop to 500 x 500
filtered_img = low_pass(img)

plt.subplot(2, 2, 1), plt.imshow(img, 'gray'),plt.title('Original Image')
plt.subplot(2, 2, 2), plt.imshow(filtered_img, 'gray'),plt.title('Low Pass Filtered Image')
plt.subplot(2, 2, 3), plt.hist(img.ravel(),256,[0,256]),plt.title('Histogram of Original Image')
```

```
plt.subplot(2, 2, 4), plt.hist(filtered_img.ravel(),256,[0,256]),plt.title('Histogram of Low Pass Filte
red Image')
plt.show()
```

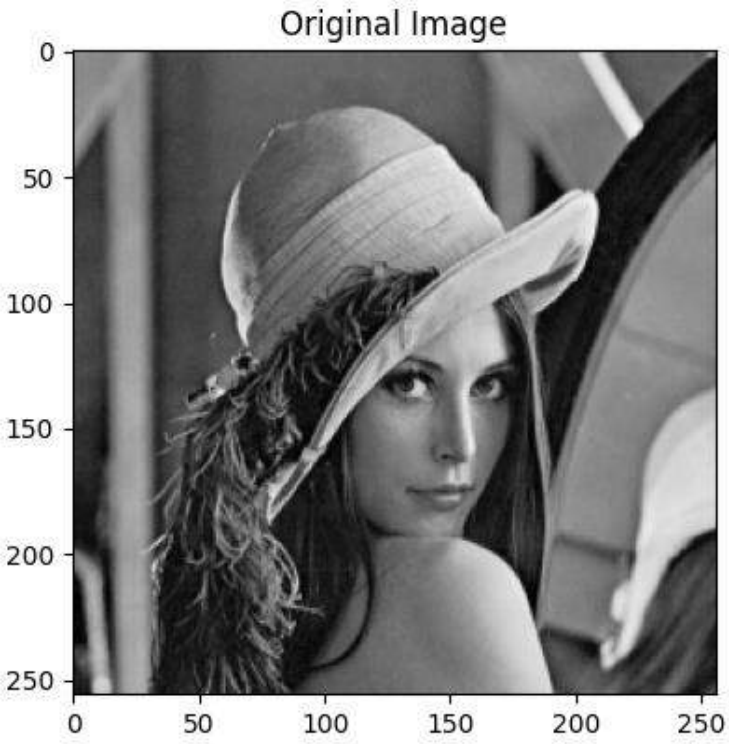
High Pass Filter

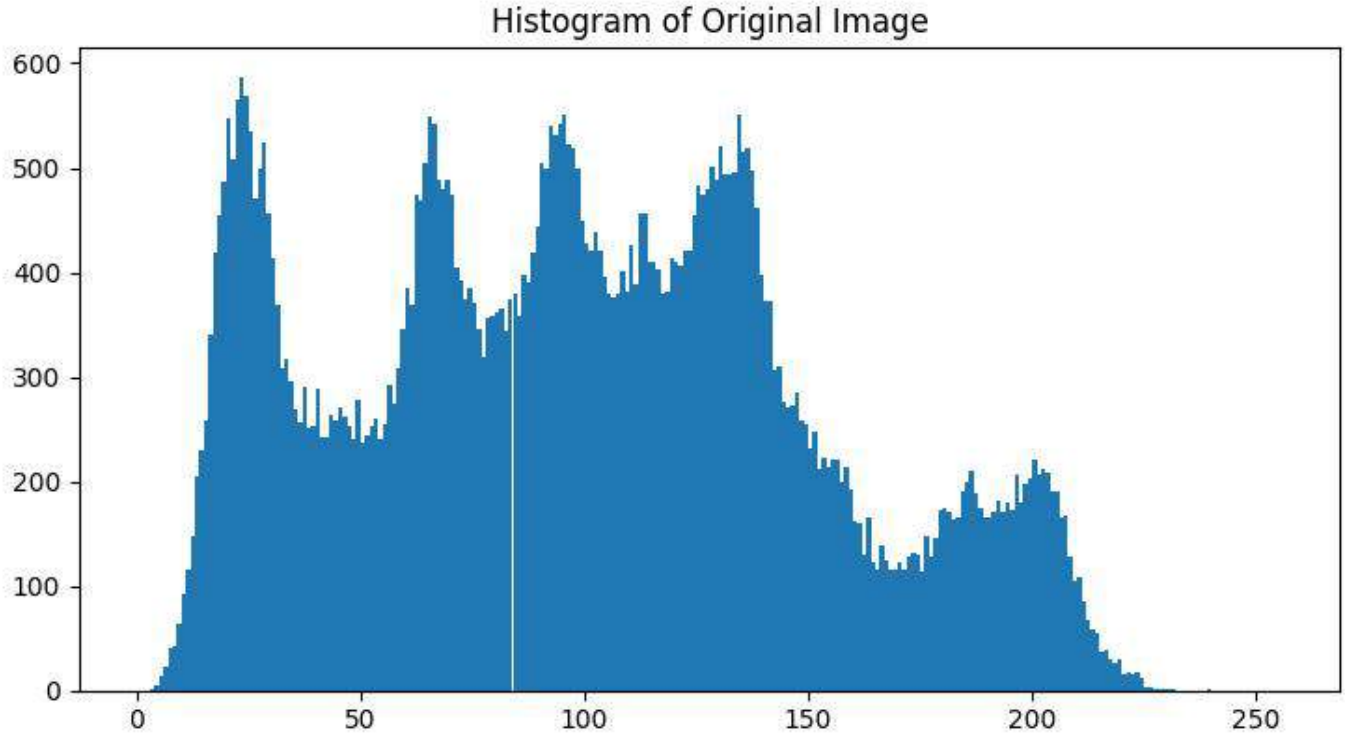
```
import cv2

# import Numpy
import numpy as np
from matplotlib import pyplot as plt

# Image read
img = cv2.imread('../Images/lotus.jpg', 0) # gray-scale image
img = cv2.resize(img, (500, 500))
size = img.shape[0]
# Cut off Frequency
Do = 50
# High pass Filter using Distance Matrix
def FilterDesign(img, size, Do):
    # D is distance Matrix
    D = np.zeros([size, size], dtype=np.uint32)
    # H is Filter
    H = np.zeros([size, size], dtype=np.uint8)
    r = img.shape[0] // 2
    c = img.shape[1] // 2
    # Distance Vector
    for u in range(0, size):
        for v in range(0, size):
            D[u, v] = abs(u - r) + abs(v - c)
    # Using Cut off frequncy applying 0 and 255 in H to make a High Pass Filter and center = 1
    for i in range(size):
        for j in range(size):
            if D[i, j] > Do:
                H[i, j] = 255
            else:
                H[i, j] = 0
    return H
# High Pass Filter
H = FilterDesign(img, size, Do)

# Applying fft and shift
input = np.fft.fftshift(np.fft.fft2(img))
# Multiplying image with High Pass Filter
out = input*H
# Taking Inverse Fourier of image
out = np.abs(np.fft.ifft2(np.fft.ifftshift(out)))
out = np.uint8(cv2.normalize(out, None, 0, 255, cv2.NORM_MINMAX, -1))
# Gradient image after applying High pass filter

plt.subplot(2, 3, 1), plt.imshow(img, 'gray'),plt.title('Original Image')
plt.subplot(2, 3, 2), plt.imshow(H, 'gray'),plt.title('High Pass Filter')
plt.subplot(2, 3, 3), plt.imshow(out, 'gray'),plt.title('High Pass Filtered Image')
```

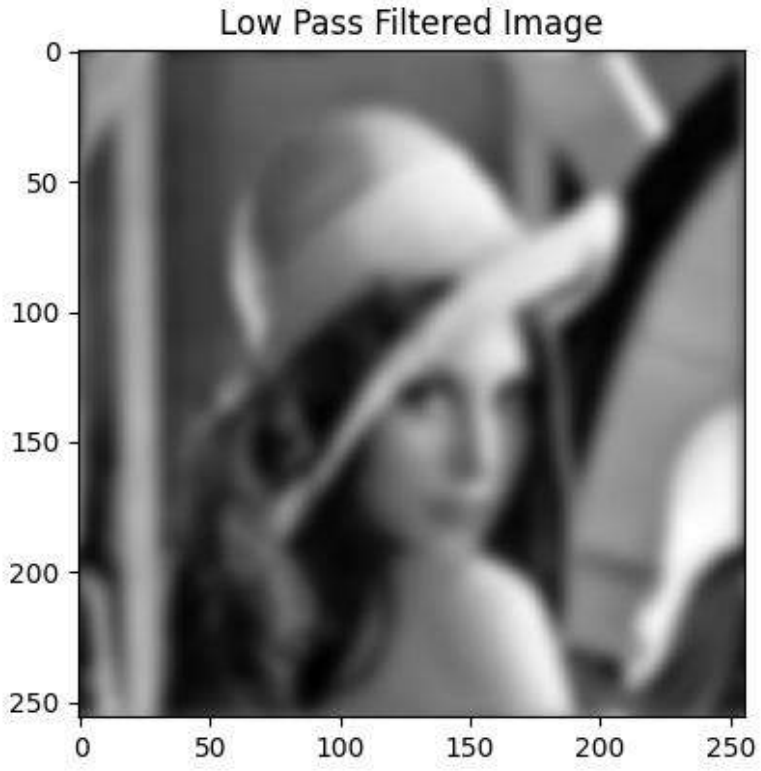
```
plt.subplot(2, 3, 4), plt.hist(img.ravel(),256,[0,256]),plt.title('Histogram of Original Image')
plt.subplot(2, 3, 6), plt.hist(out.ravel(),256,[0,256]),plt.title('Histogram of High Pass Filtered Imag
e')
plt.show()
```

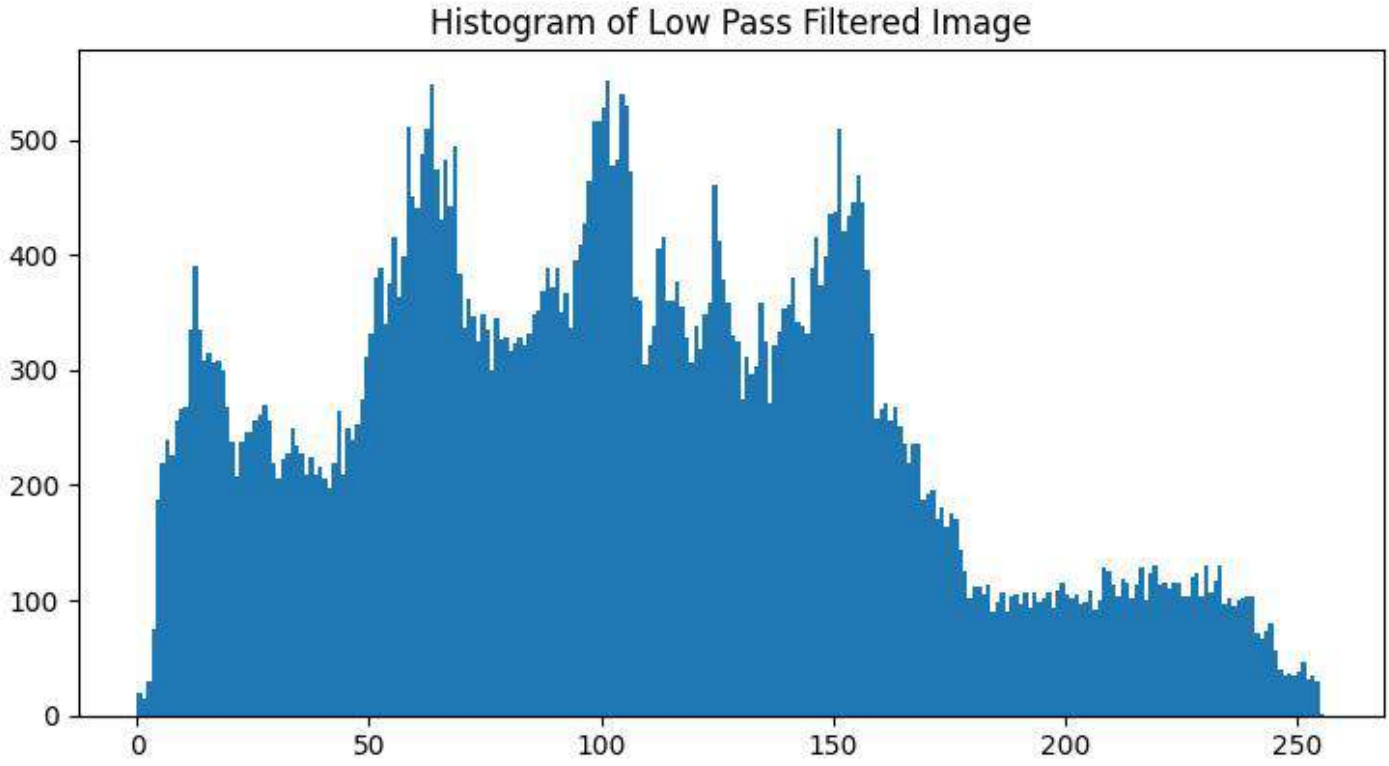
II. RESULTS:

Low Pass Filter

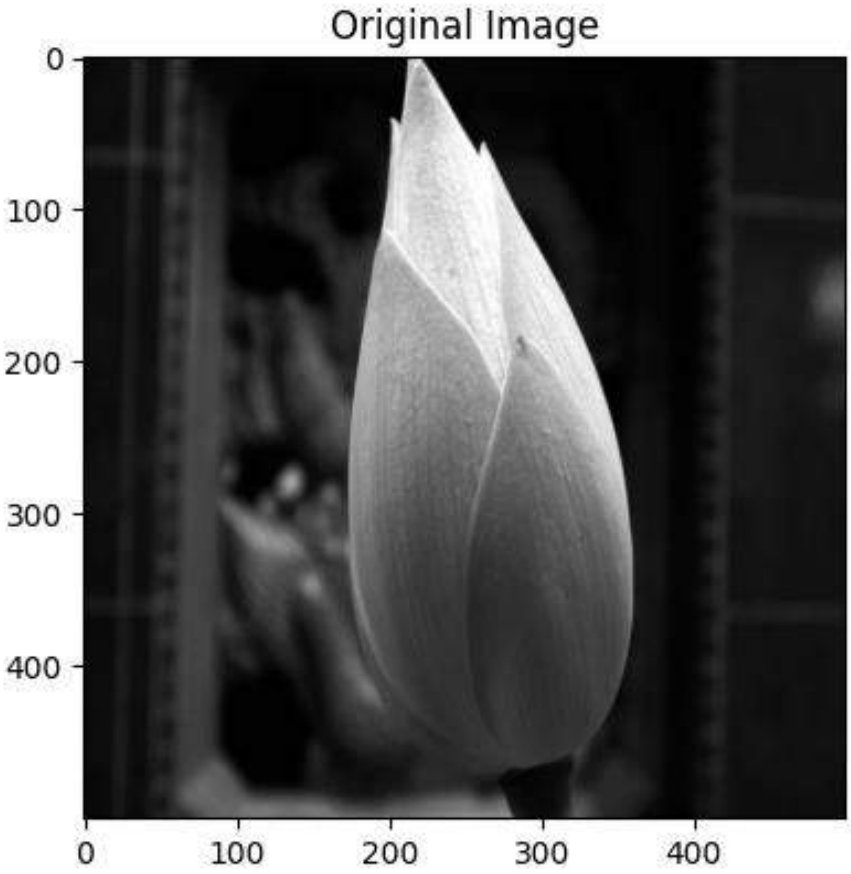


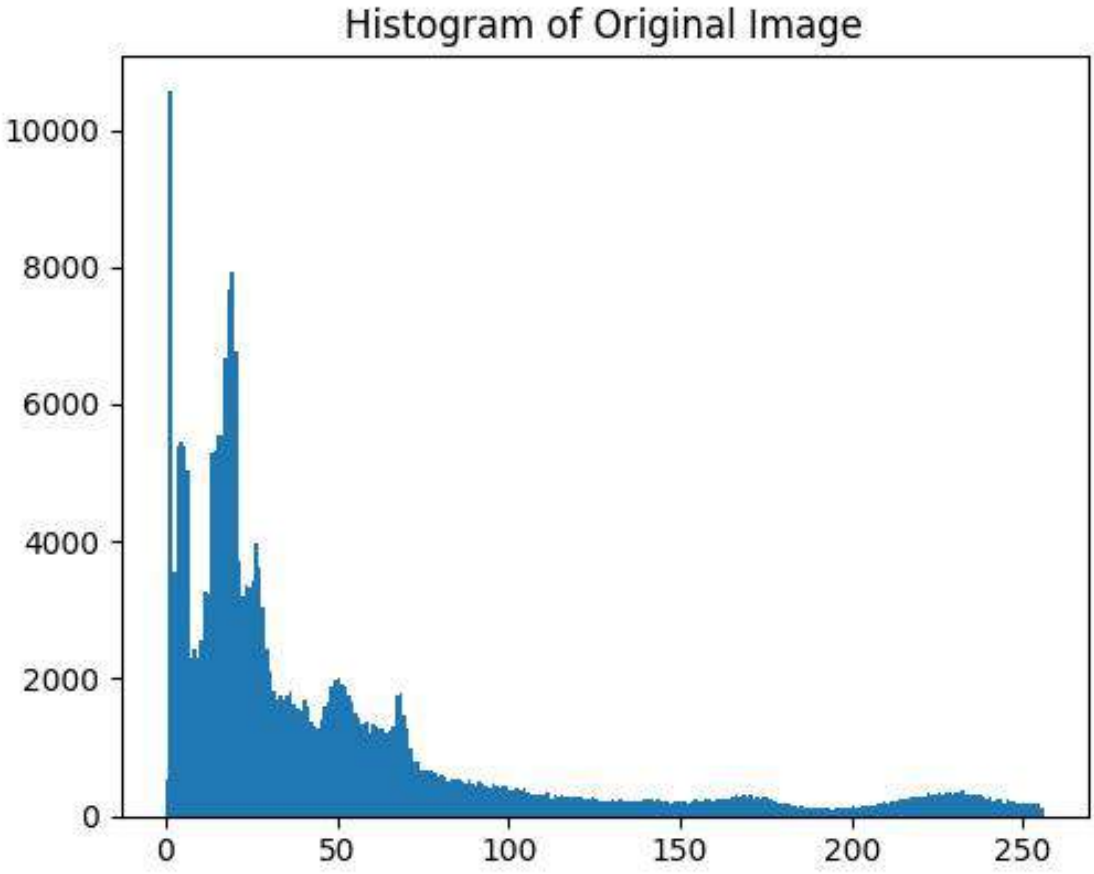


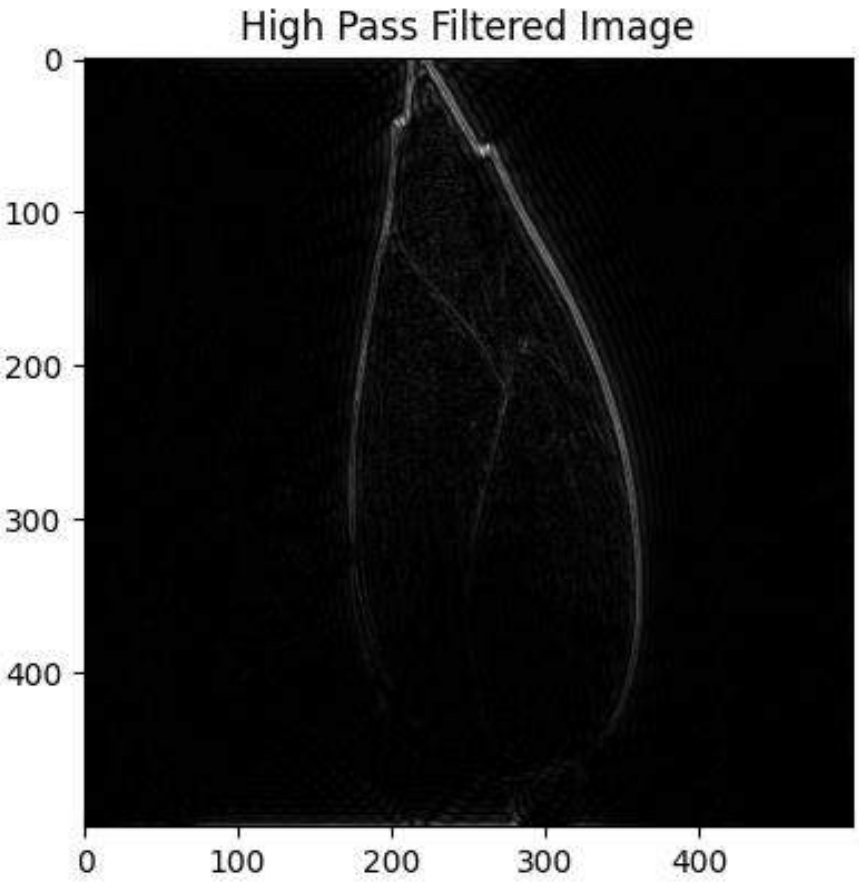

Low Pass Filtered Image
0
50
100
150
200
250
0
50
100
150
200
250

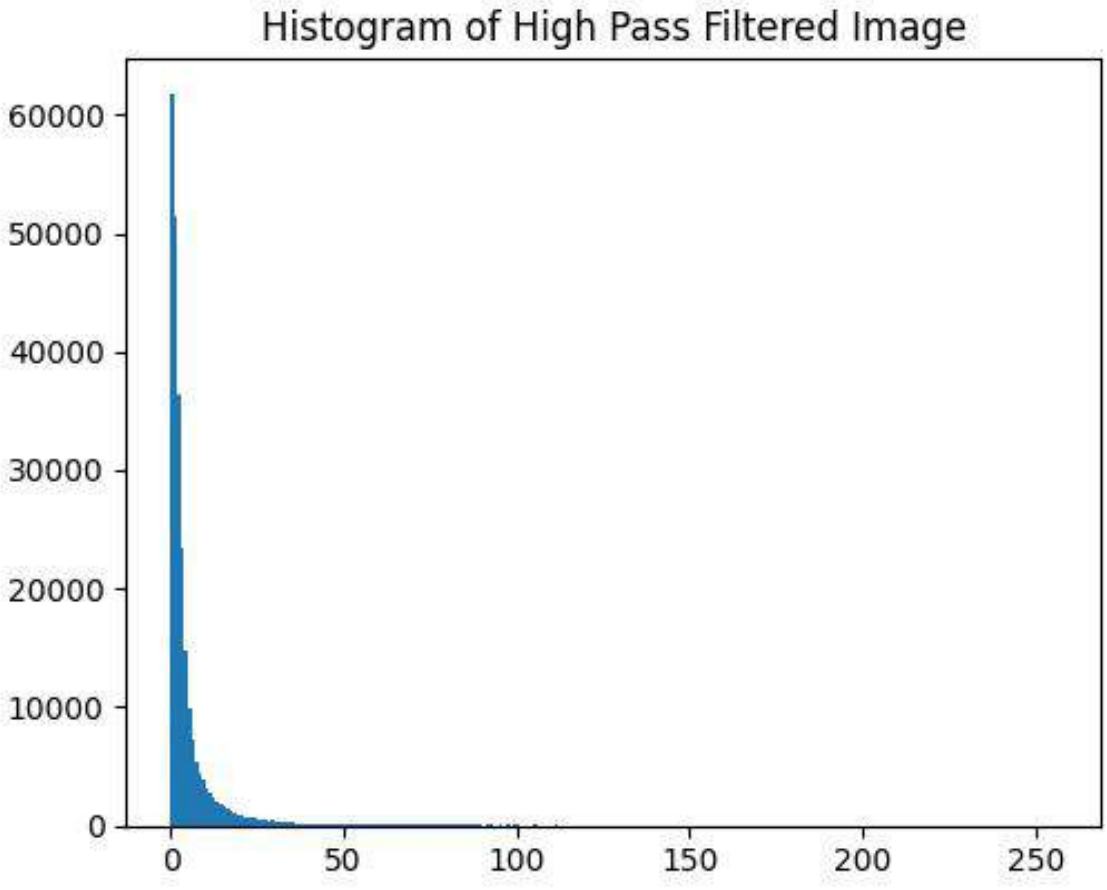

Histogram of Low Pass Filtered Image
500
400
300
200
100
0
0
50
100
150
200
250

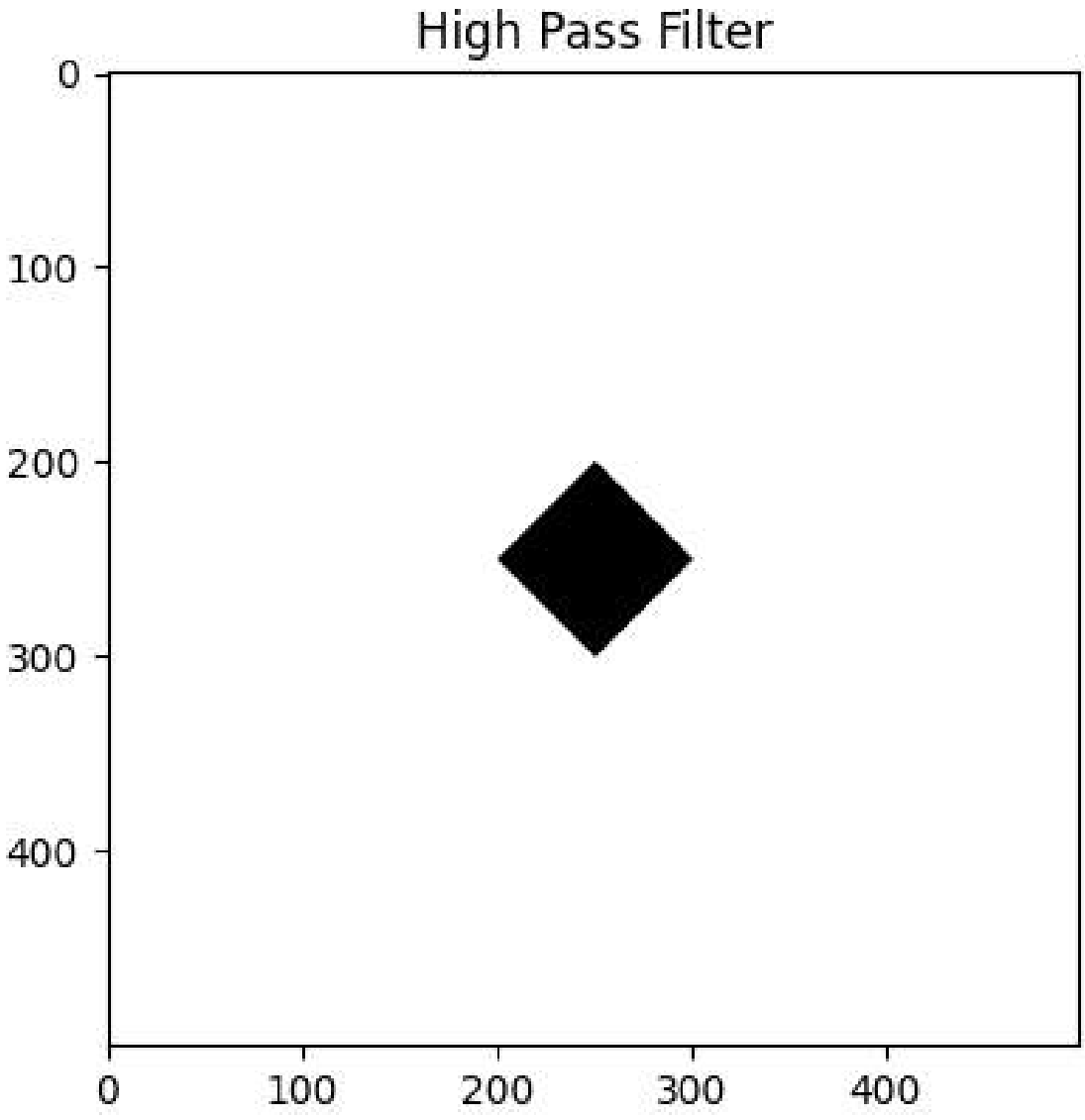
High Passs Filter






High Pass Filtered Image
0
100
200
300
400
0
100
200
300
400


Histogram of High Pass Filtered Image
60000
50000
40000
30000
20000
10000
0
0
50
100
150
200
250


High Pass Filter
0
100
200
300
400
0
100
200
300
400