Lab 5

March 23, 2022

1 CO543 – Image Processing

2 Lab 05

3 Fourier Transformation

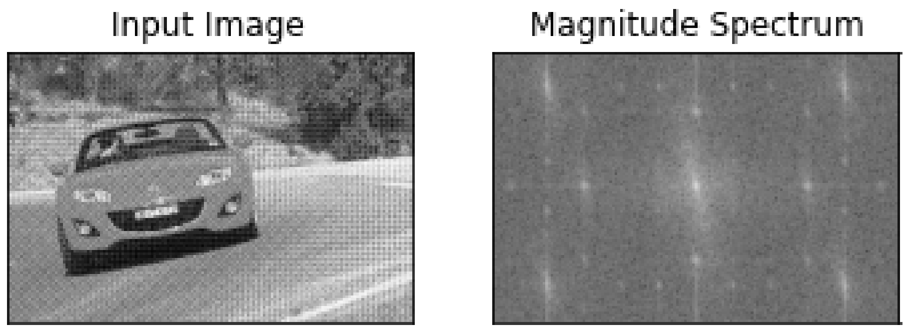
3.0.1 E/17/297

[40]:
```
folder = "/content/drive/MyDrive/CO543/Lab 5/"
```

[41]:
```
import cv2
import numpy as np
from matplotlib import pyplot as plt
```

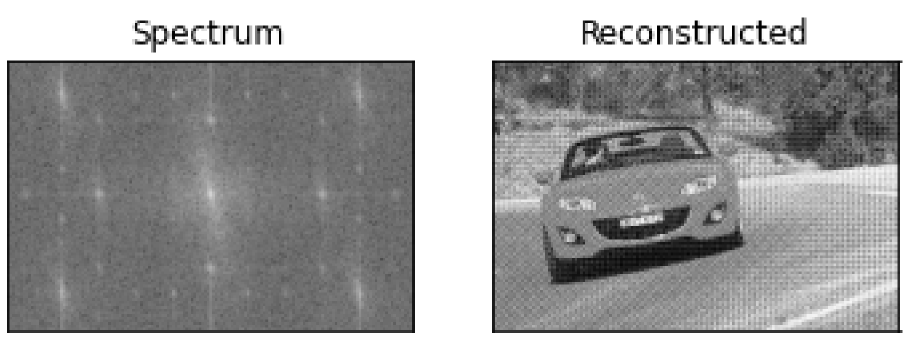
[42]:
```
img = cv2.imread(folder+'car-2.jpg',0)

#pass grayscale image
f = np.fft.fft2(img)

# Shift the zero-frequency component to the center of the spectrum.
fshift = np.fft.fftshift(f)

# apply logarithm, otherwise the image can not identify easily, change and see␣
↪the changes.
magnitude_spectrum = 20*np.log(np.abs(fshift))
```

[43]:
```
plt.subplot(121),plt.imshow(img, cmap='gray')
plt.title('Input Image'), plt.xticks([]), plt.yticks([])
plt.subplot(122),plt.imshow(magnitude_spectrum, cmap = 'gray')
plt.title('Magnitude Spectrum'), plt.xticks([]), plt.yticks([])
plt.show()
```



3.0.2 Reconstruct image from inverse fourier transform (spectrum)

[44]:
```
# f is transformed image
I2 = np.fft.ifft2(f)

#get the real part
I3 = np.real(I2)

plt.subplot(121), plt.imshow(magnitude_spectrum, cmap = 'gray')
plt.title('Spectrum'), plt.xticks([]), plt.yticks([])
plt.subplot(122),plt.imshow(I3, cmap = 'gray')
plt.title('Reconstructed'), plt.xticks([]), plt.yticks([])
plt.show()
```



[44]:
```
```

3.0.3 Apply low-pass filter for an image

[45]:
```
img_float32 = np.float32(img)

dft = cv2.dft(img_float32, flags = cv2.DFT_COMPLEX_OUTPUT)

dft_shift = np.fft.fftshift(dft)

rows, cols = img.shape
crow, ccol = rows//2 , cols//2 #center

# create a mask first, center square is 1, remaining all zeros
mask = np.zeros((rows, cols, 2), np.uint8)
mask[crow-30:crow+30, ccol-30:ccol+30] = 1
```

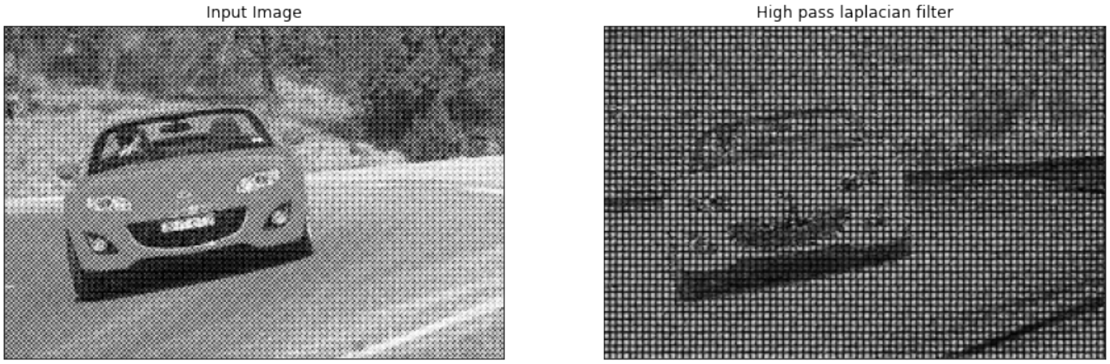
[46]:
```
# apply mask and inverse DFT
fshift = dft_shift*mask
f_ishift = np.fft.ifftshift(fshift)

img_back = cv2.idft(f_ishift)
img_back = cv2.magnitude(img_back[:,:,0], img_back[:,:,1])

plt.subplot(121),plt.imshow(img, cmap = 'gray')
plt.title('Input Image'), plt.xticks([]), plt.yticks([])
plt.subplot(122),plt.imshow(img_back, cmap = 'gray')
plt.title('Low-pass Image'), plt.xticks([]), plt.yticks([])
plt.show()
```

4 LAB TASKS

4.0.1 1. Apply high pass laplacian filter on Car.jpg image.

[47]:
```
img_float32 = np.float32(img)

dft = cv2.dft(img_float32, flags = cv2.DFT_COMPLEX_OUTPUT)

dft_shift = np.fft.fftshift(dft)

rows, cols = img.shape
crow, ccol = rows//2 , cols//2 #center

# create a mask for highpass laplacian filter
mask = np.ones((rows, cols, 2), np.float32)

for i in range(rows):
  for j in range(cols):
    distance = np.sqrt((i-crow)**2 + (j-ccol)**2)
    laplaceEq = -4 * (np.pi**2) * distance**2
    mask[i][j] = [laplaceEq, laplaceEq]

# apply mask and inverse DFT
fshift = dft_shift*mask
f_ishift = np.fft.ifftshift(fshift)

img_high_pass_laplacian = cv2.idft(f_ishift)
img_high_pass_laplacian = cv2.magnitude(img_high_pass_laplacian[:,:,0],
 ↪img_high_pass_laplacian[:,:,1])
```

[48]:
```
plt.figure(figsize= (15,10))
plt.subplot(121),plt.imshow(img, cmap = 'gray')
plt.title('Input Image'), plt.xticks([]), plt.yticks([])
plt.subplot(122),plt.imshow(img_high_pass_laplacian, cmap = 'gray')
plt.title('High pass laplacian filter'), plt.xticks([]), plt.yticks([])
plt.show()
```

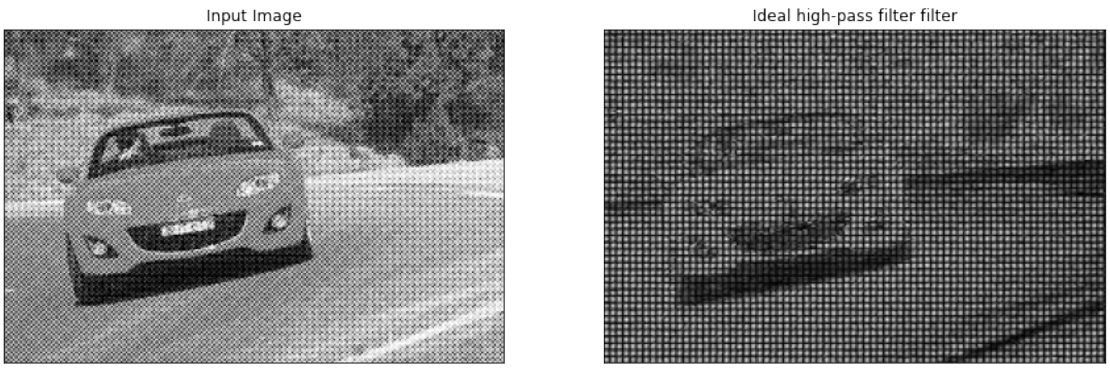


4.0.2 2. Apply ideal high-pass filter on Car.jpg image for D0=100

[49]:
```
img_float32 = np.float32(img)

dft = cv2.dft(img_float32, flags = cv2.DFT_COMPLEX_OUTPUT)

dft_shift = np.fft.fftshift(dft)

D0 = 100
rows, cols = img.shape
crow, ccol = rows//2 , cols//2 #center

# create a mask for ideal highpass filter
mask = np.ones((rows, cols, 2), np.uint8)


for i in range(rows):
  for j in range(cols):
    distance = np.sqrt((i-crow)**2 + (j-ccol)**2)
    if distance <= D0:
      mask[i][j] = [0,0]

# apply mask and inverse DFT
fshift = dft_shift*mask
f_ishift = np.fft.ifftshift(fshift)

img_high_pass = cv2.idft(f_ishift)
img_high_pass = cv2.magnitude(img_high_pass[:,:,0], img_high_pass[:,:,1])
```

[50]:
```
plt.figure(figsize= (15,10))
plt.subplot(121),plt.imshow(img, cmap = 'gray')
plt.title('Input Image'), plt.xticks([]), plt.yticks([])
```

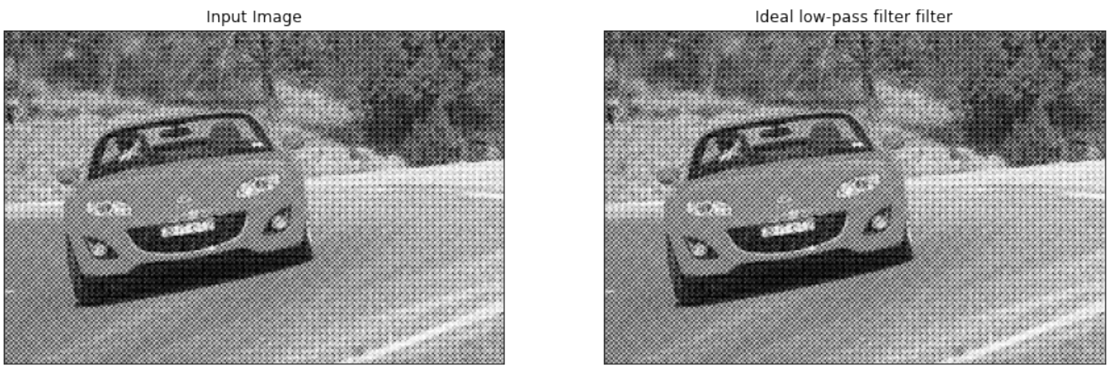
```
plt.subplot(122),plt.imshow(img_high_pass, cmap = 'gray')
plt.title('Ideal high-pass filter filter'), plt.xticks([]), plt.yticks([])
plt.show()
```



4.0.3 3. Apply ideal low-pass filter on Car.jpg image for D0=100

[51]:
```
img_float32 = np.float32(img)

dft = cv2.dft(img_float32, flags = cv2.DFT_COMPLEX_OUTPUT)

dft_shift = np.fft.fftshift(dft)

D0 = 100
rows, cols = img.shape
crow, ccol = rows//2 , cols//2 #center

# create a mask for ideal highpass filter
mask = np.ones((rows, cols, 2), np.uint8)


for i in range(rows):
  for j in range(cols):
    distance = np.sqrt((i-crow)**2 + (j-ccol)**2)
    if distance <= D0:
      mask[i][j] = [1,1]

# apply mask and inverse DFT
fshift = dft_shift*mask
f_ishift = np.fft.ifftshift(fshift)

img_low_pass = cv2.idft(f_ishift)
img_low_pass = cv2.magnitude(img_low_pass[:,:,0], img_low_pass[:,:,1])
```

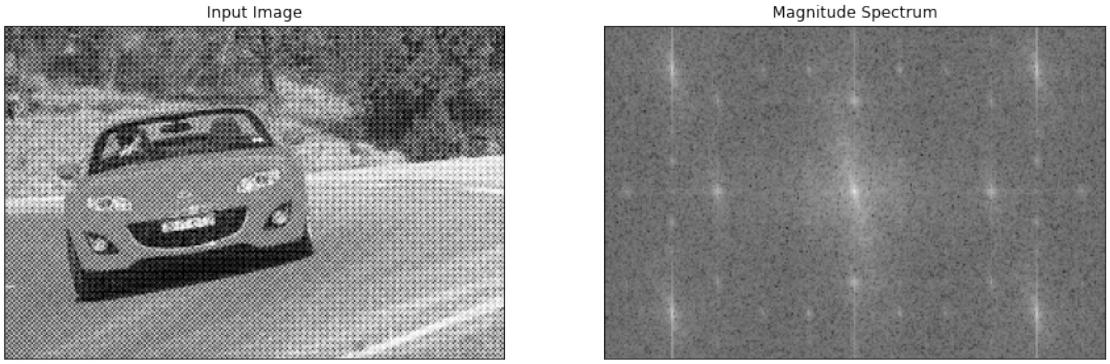
[52]:
```
plt.figure(figsize= (15,10))
plt.subplot(121),plt.imshow(img, cmap = 'gray')
plt.title('Input Image'), plt.xticks([]), plt.yticks([])
plt.subplot(122),plt.imshow(img_low_pass, cmap = 'gray')
plt.title('Ideal low-pass filter filter'), plt.xticks([]), plt.yticks([])
plt.show()
```



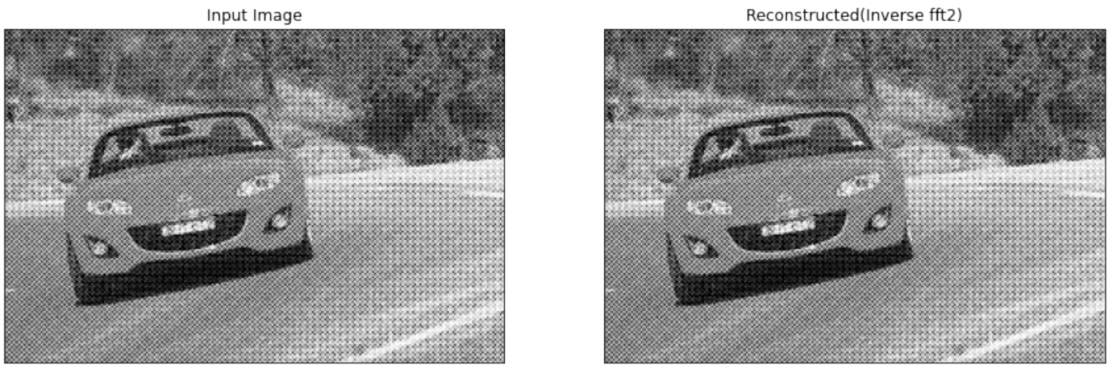
4.0.4 4. Apply FFT2, IFFT2, low-pass Gaussian filter, and high-pass laplacian filter on Car.jpg image.

[53]:
```
# FFT2

#pass grayscale image
f = np.fft.fft2(img)

# Shift the zero-frequency component to the center of the spectrum.
fshift = np.fft.fftshift(f)

# apply logarithm, otherwise the image can not identify easily.
magnitude_spectrum = 20*np.log(np.abs(fshift))
```

[54]:
```
plt.figure(figsize= (15,10))
plt.subplot(121),plt.imshow(img, cmap='gray')
plt.title('Input Image'), plt.xticks([]), plt.yticks([])
plt.subplot(122),plt.imshow(magnitude_spectrum, cmap = 'gray')
plt.title('Magnitude Spectrum'), plt.xticks([]), plt.yticks([])
plt.show()
```



[55]:
```
# IFFT2
# f is transformed image
I2 = np.fft.ifft2(f)

#get the real part
I3 = np.real(I2)

plt.figure(figsize= (15,10))
plt.subplot(121), plt.imshow(img, cmap = 'gray')
plt.title('Input Image'), plt.xticks([]), plt.yticks([])
plt.subplot(122),plt.imshow(I3, cmap = 'gray')
plt.title('Reconstructed(Inverse fft2)'), plt.xticks([]), plt.yticks([])
plt.show()
```

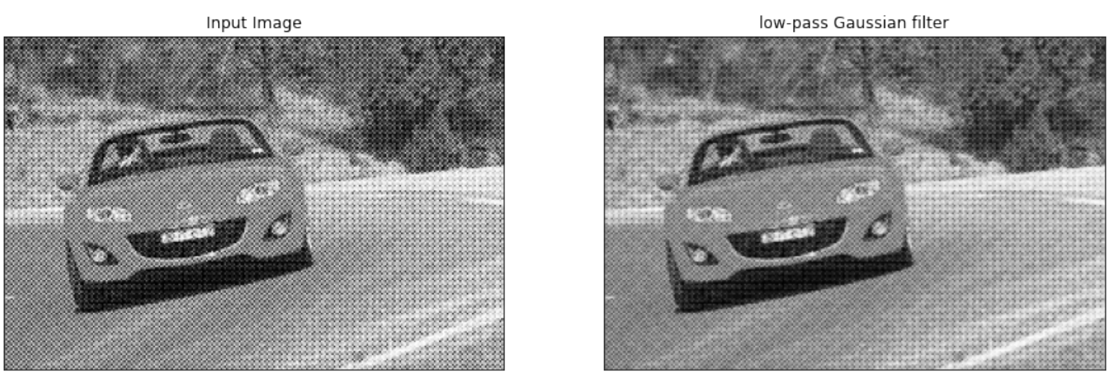


low-pass Gaussian filter

[56]:
```
img_float32 = np.float32(img)

dft = cv2.dft(img_float32, flags = cv2.DFT_COMPLEX_OUTPUT)
```

```python
dft_shift = np.fft.fftshift(dft)

D0 = 100
rows, cols = img.shape
crow, ccol = rows//2 , cols//2 #center

# create a mask for low-pass Gaussian filter
mask = np.ones((rows, cols, 2), np.float32)

for i in range(rows):
  for j in range(cols):
    distance = np.sqrt((i-crow)**2 + (j-ccol)**2)
    gaussianEq = np.exp((-1*distance**2)/(2*D0**2))
    mask[i][j] = [gaussianEq,gaussianEq]

# apply mask and inverse DFT
fshift = dft_shift*mask
f_ishift = np.fft.ifftshift(fshift)

img_low_pass_gaussian = cv2.idft(f_ishift)
img_low_pass_gaussian = cv2.magnitude(img_low_pass_gaussian[:,:,0],␣
↪img_low_pass_gaussian[:,:,1])
```

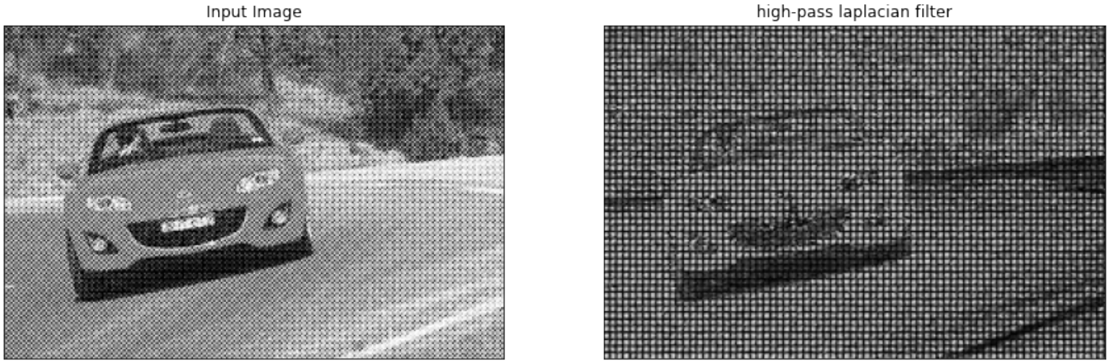
[57]:
```python
plt.figure(figsize= (15,10))
plt.subplot(121), plt.imshow(img, cmap = 'gray')
plt.title('Input Image'), plt.xticks([]), plt.yticks([])
plt.subplot(122),plt.imshow(img_low_pass_gaussian, cmap = 'gray')
plt.title('low-pass Gaussian filter'), plt.xticks([]), plt.yticks([])
plt.show()
```



high-pass laplacian filter

[58]:
```
img_float32 = np.float32(img)

dft = cv2.dft(img_float32, flags = cv2.DFT_COMPLEX_OUTPUT)

dft_shift = np.fft.fftshift(dft)

D0 = 100
rows, cols = img.shape
crow, ccol = rows//2 , cols//2 #center

# create a mask for high-pass laplacian filter
mask = np.ones((rows, cols, 2), np.float32)

for i in range(rows):
  for j in range(cols):
    distance = np.sqrt((i-crow)**2 + (j-ccol)**2)
    laplaceEq = -4 * (np.pi**2) * distance**2
    mask[i][j] = [laplaceEq,laplaceEq]

# apply mask and inverse DFT
fshift = dft_shift*mask
f_ishift = np.fft.ifftshift(fshift)

img_high_pass_laplacian = cv2.idft(f_ishift)
img_high_pass_laplacian = cv2.magnitude(img_high_pass_laplacian[:,:,0],
 ↪img_high_pass_laplacian[:,:,1])
```

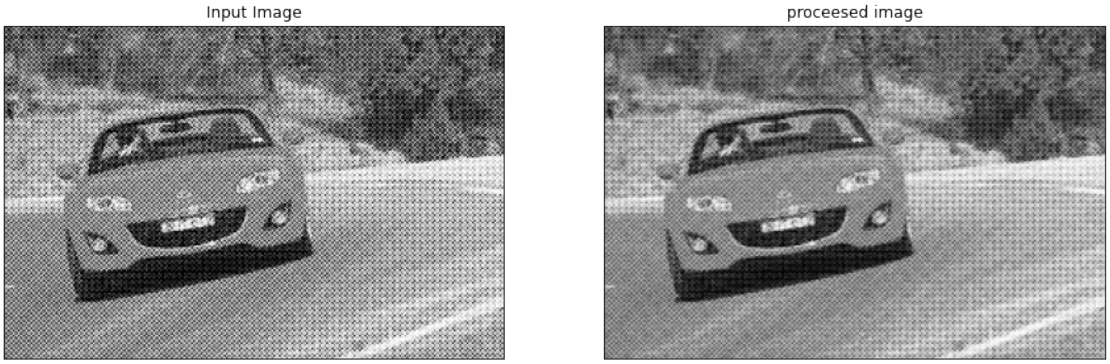
[59]:
```
plt.figure(figsize= (15,10))
plt.subplot(121), plt.imshow(img, cmap = 'gray')
plt.title('Input Image'), plt.xticks([]), plt.yticks([])
plt.subplot(122),plt.imshow(img_high_pass_laplacian, cmap = 'gray')
plt.title('high-pass laplacian filter'), plt.xticks([]), plt.yticks([])
plt.show()
```



4.0.5 5. Apply the necessary filter and correct the noise in the image. Image file is uploaded.

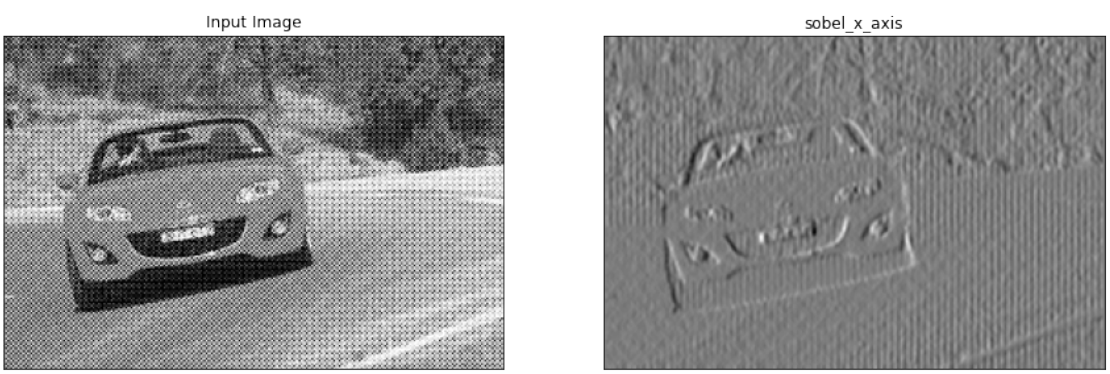
[65]:

```
img_float32 = np.float32(img)

dft = cv2.dft(img_float32, flags = cv2.DFT_COMPLEX_OUTPUT)

dft_shift = np.fft.fftshift(dft)

D0 = 100
rows, cols = img.shape
crow, ccol = rows//2 , cols//2 #center

# low-pass Gaussian filter
mask_low_pass_gaussian = np.zeros((rows,cols,2), dtype=np.float32)

for i in range(rows):
  for j in range(cols):
    distance = np.sqrt((i-crow)**2 + (j-ccol)**2)
    mask_low_pass_gaussian[i][j] = np.exp((-1*distance**2)/(2*D0**2))

# low-pass ideal
D01 = 150
mask_low_pass_ideal = np.zeros((rows,cols,2), dtype=np.uint8)

for i in range(rows):
  for j in range(cols):
    distance = np.sqrt((i-crow)**2 + (j-ccol)**2)
    mask_low_pass_ideal[i][j] = 255 if distance <= D01 else 0


# apply mask and inverse DFT
fshift = dft_shift*mask_low_pass_gaussian*mask_low_pass_ideal
f_ishift = np.fft.ifftshift(fshift)

img_proceesed = cv2.idft(f_ishift)
img_proceesed = cv2.magnitude(img_proceesed[:,:,0], img_proceesed[:,:,1])


plt.figure(figsize= (15,10))
plt.subplot(121), plt.imshow(img, cmap = 'gray')
plt.title('Input Image'), plt.xticks([]), plt.yticks([])
plt.subplot(122),plt.imshow(img_proceesed, cmap = 'gray')
plt.title('proceesed image'), plt.xticks([]), plt.yticks([])
plt.show()
```



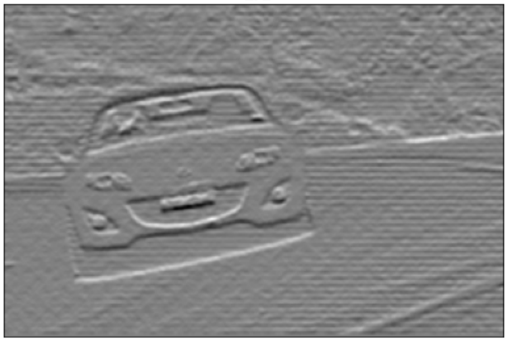
4.0.6 6. Apply the sobel operator (filter) on Car.jpg in the Fourier domain to detect edges.

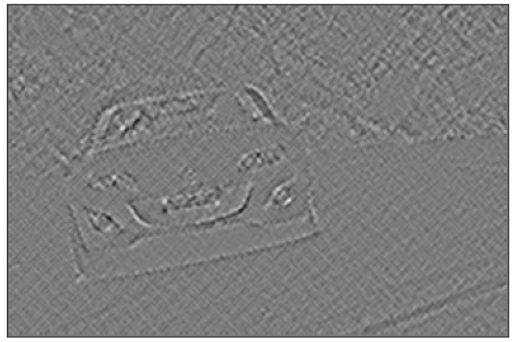
[68]:
```
sobel_x_axis = cv2.Sobel(src=img, ddepth=cv2.CV_64F, dx=1, dy=0, ksize=5)

sobel_y_axis = cv2.Sobel(src=img, ddepth=cv2.CV_64F, dx=0, dy=1, ksize=5)

sobel_xy_axis = cv2.Sobel(src=img, ddepth=cv2.CV_64F, dx=1, dy=1, ksize=5)

plt.figure(figsize= (15,10))
plt.subplot(121), plt.imshow(img, cmap = 'gray')
plt.title('Input Image'), plt.xticks([]), plt.yticks([])
plt.subplot(122),plt.imshow(sobel_x_axis, cmap = 'gray')
plt.title('sobel_x_axis'), plt.xticks([]), plt.yticks([])
plt.show()
```



[69]:
```
plt.figure(figsize= (15,10))
plt.subplot(121), plt.imshow(sobel_y_axis, cmap = 'gray')
plt.title('sobel_y_axis'), plt.xticks([]), plt.yticks([])
```

```
plt.subplot(122),plt.imshow(sobel_xy_axis, cmap = 'gray')
plt.title('sobel_xy_axis'), plt.xticks([]), plt.yticks([])
plt.show()
```



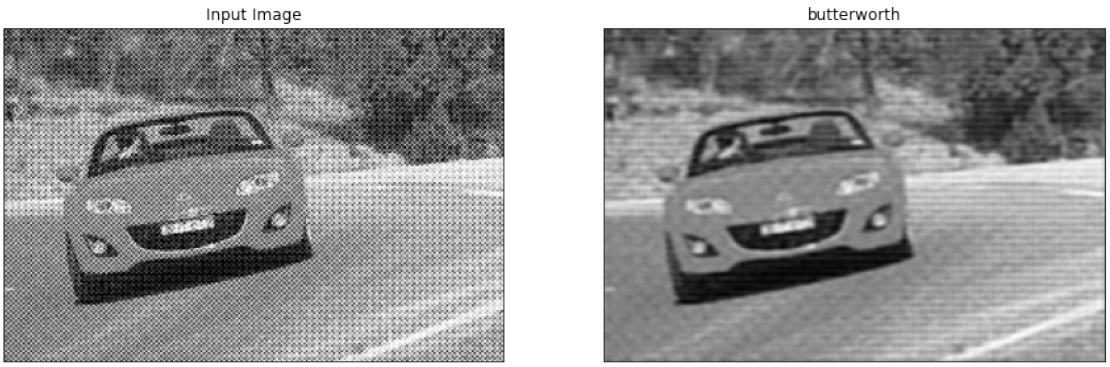


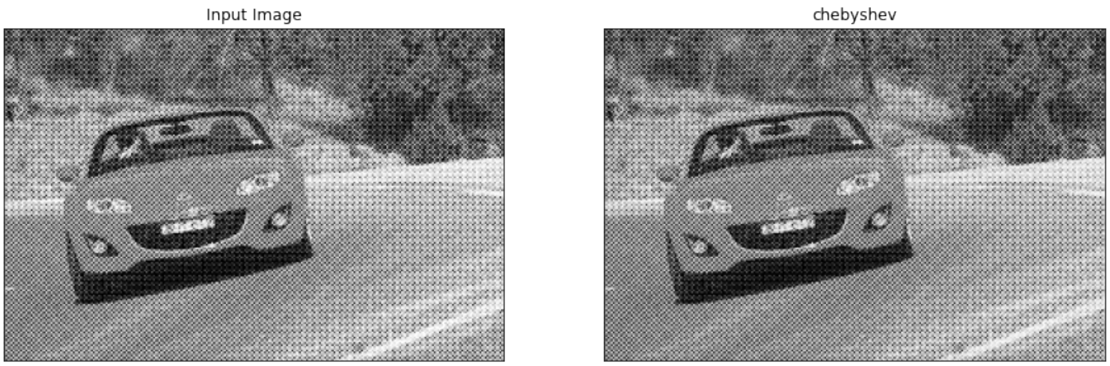
4.0.7 7. Discuss applying Butterworth and Chebyshev filters and compare the output image with the Gaussian Filter image (You may use a preferred image to discuss the characteristics of the output images in Q7.)

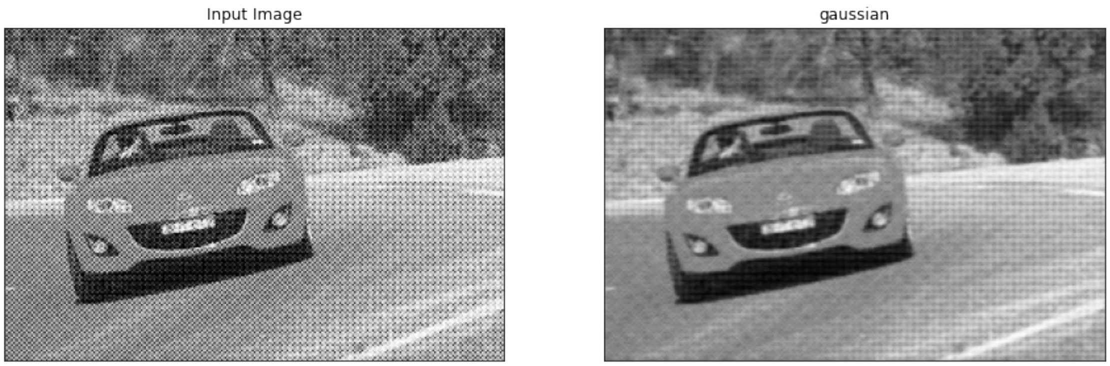
[77]:
```
img_float32 = np.float32(img)

dft_butterworth = cv2.dft(img_float32, flags = cv2.DFT_COMPLEX_OUTPUT)
dft_chebyshev = cv2.dft(img_float32, flags = cv2.DFT_COMPLEX_OUTPUT)
dft_gaussian = cv2.dft(img_float32, flags = cv2.DFT_COMPLEX_OUTPUT)

dft_shift_butterworth = np.fft.fftshift(dft_butterworth)
dft_shift_chebyshev = np.fft.fftshift(dft_chebyshev)
dft_shift_gaussian = np.fft.fftshift(dft_gaussian)

rows, cols = img.shape
crow, ccol = rows//2 , cols//2 #center

cut_off_frequncy_butterworth = 50
order_butterworth = 3
mask_butterworth = np.zeros((rows,cols,2), dtype=np.float32)
for i in range(rows):
  for j in range(cols):
    distance = np.sqrt((i-crow)**2 + (j-ccol)**2)
    mask_butterworth[i][j] = 1/(1+((distance/cut_off_frequncy_butterworth) **
↪(2*order_butterworth)))

cut_off_frequncy_chebyshev = 50
order_chebyshev = 3
```

```
ripple = 0.25
mask_chebyshev = np.zeros((rows,cols,2), dtype=np.float32)
for i in range(rows):
  for j in range(cols):
    distance = np.sqrt((i-crow)**2 + (j-ccol)**2)
    Cn = np.cos(order_chebyshev * np.arccos(distance/
↪cut_off_frequncy_chebyshev)) if np.abs(distance/cut_off_frequncy_chebyshev)␣
↪<= 1 else np.cos(order_chebyshev * np.arccosh(distance/
↪cut_off_frequncy_chebyshev))
    mask_chebyshev[i][j] = 1/(1+(ripple**2)*(Cn**2))


D0 = 50
mask_gaussian = np.zeros((rows, cols, 2), dtype=np.float32)
for i in range(rows):
  for j in range(cols):
    distance = np.sqrt((i-crow)**2 + (j-ccol)**2)
    mask_gaussian[i][j] = np.exp(-(distance**2)/(2*(D0**2)))



# apply mask and inverse DFT
fshift_butterworth = dft_shift_butterworth * mask_butterworth
f_ishift_butterworth = np.fft.ifftshift(fshift_butterworth)
img_butterworth = cv2.idft(f_ishift_butterworth)
img_butterworth = cv2.magnitude(img_butterworth[:,:,0], img_butterworth[:,:,1])

fshift_chebyshev = dft_shift_chebyshev * mask_chebyshev
f_ishift_chebyshev = np.fft.ifftshift(fshift_chebyshev)
img_chebyshev = cv2.idft(f_ishift_chebyshev)
img_chebyshev = cv2.magnitude(img_chebyshev[:,:,0], img_chebyshev[:,:,1])

fshift_gaussian = dft_shift_gaussian * mask_gaussian
f_ishift_gaussian = np.fft.ifftshift(fshift_gaussian)
img_gaussian = cv2.idft(f_ishift_gaussian)
img_gaussian = cv2.magnitude(img_gaussian[:,:,0], img_gaussian[:,:,1])



plt.figure(figsize= (15,10))
plt.subplot(121), plt.imshow(img, cmap = 'gray')
plt.title('Input Image'), plt.xticks([]), plt.yticks([])
plt.subplot(122),plt.imshow(img_butterworth, cmap = 'gray')
plt.title('butterworth'), plt.xticks([]), plt.yticks([])
plt.show()

plt.figure(figsize= (15,10))
```

```
plt.subplot(121), plt.imshow(img, cmap = 'gray')
plt.title('Input Image'), plt.xticks([]), plt.yticks([])
plt.subplot(122),plt.imshow(img_chebyshev, cmap = 'gray')
plt.title('chebyshev'), plt.xticks([]), plt.yticks([])
plt.show()

plt.figure(figsize= (15,10))
plt.subplot(121), plt.imshow(img, cmap = 'gray')
plt.title('Input Image'), plt.xticks([]), plt.yticks([])
plt.subplot(122),plt.imshow(img_gaussian, cmap = 'gray')
plt.title('gaussian'), plt.xticks([]), plt.yticks([])
plt.show()
```







[78]:
```
%%capture
!wget -nc https://raw.githubusercontent.com/brpy/colab-pdf/master/colab_pdf.py
from colab_pdf import colab_pdf
colab_pdf('Lab02.ipynb',folder)
```

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)

<ipython-input-78-4ccbf7c88b5d> in <module>()
      1 get_ipython().system('wget -nc https://raw.githubusercontent.com/brpy/colab-pdf/master/colab_pdf.py')
      2 from colab_pdf import colab_pdf
----> 3 colab_pdf('Lab02.ipynb',folder)


/content/colab_pdf.py in colab_pdf(file_name, notebookpath)
     20     # Check if the notebook exists in the Drive.
     21     if not os.path.isfile(os.path.join(notebookpath, file_name)):
---> 22         raise ValueError(f"file '{file_name}' not found in path '{notebookpath}'.")
     23 
     24     # Installing all the recommended packages.


ValueError: file 'Lab02.ipynb' not found in path '/content/drive/MyDrive/CO543/Lab 5/'.
```

[ ]:
```

```