EN3160 Assignment 1

Intensity Transformations and Neighbourhood Filtering

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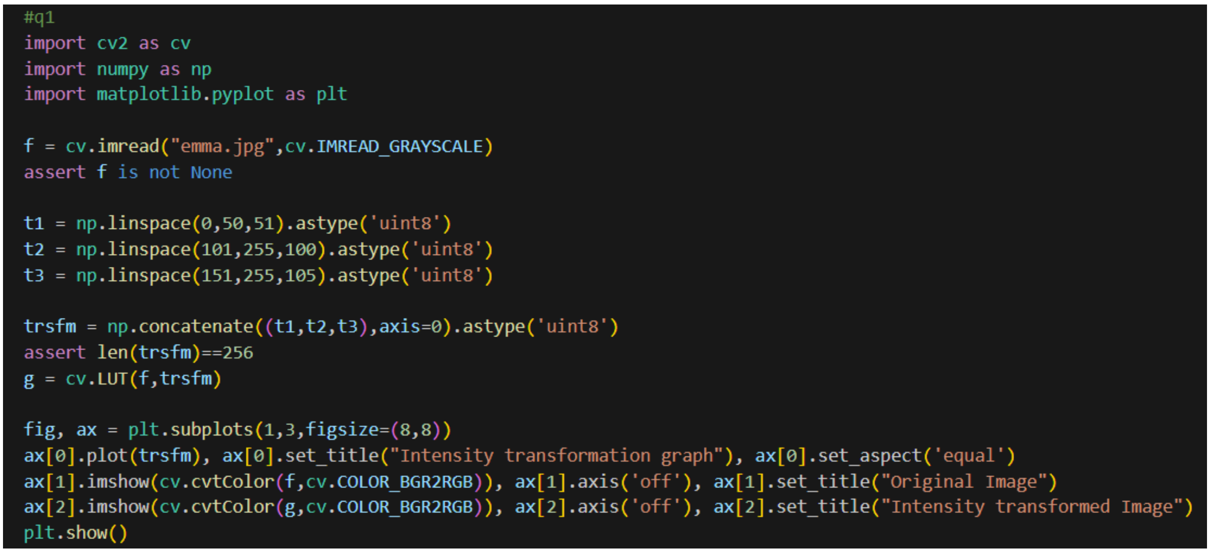
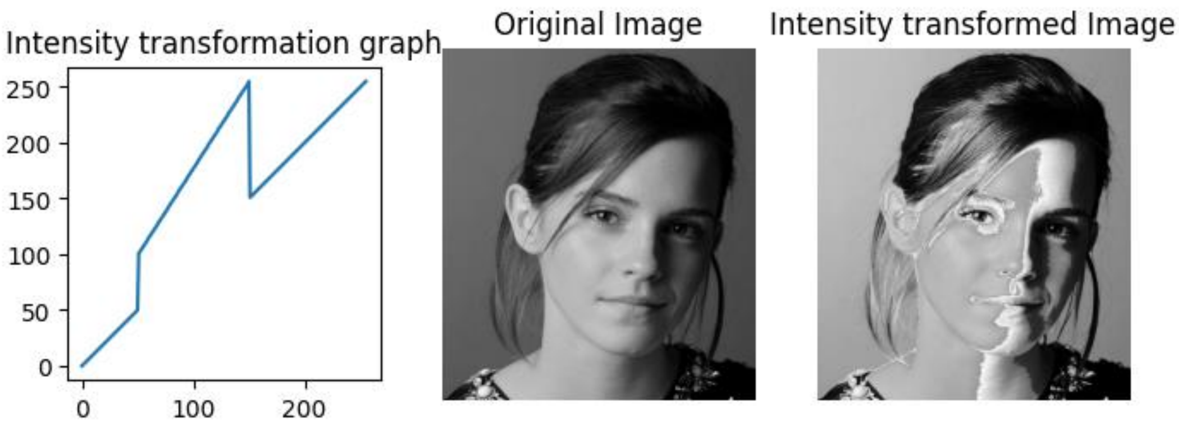
GitHub link: https://github.com/malithJayalath/Image_processing_ass_1.git

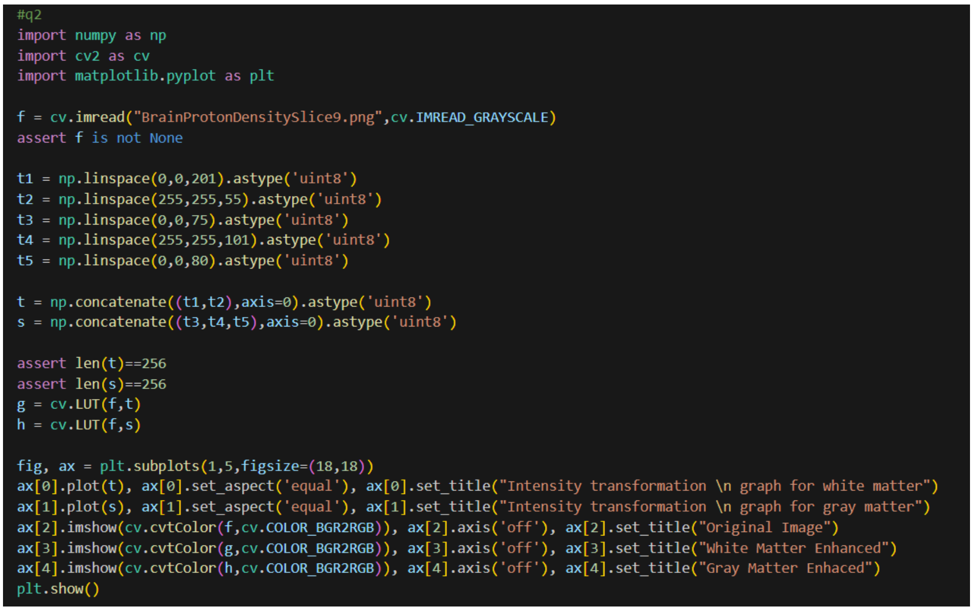
Q1)



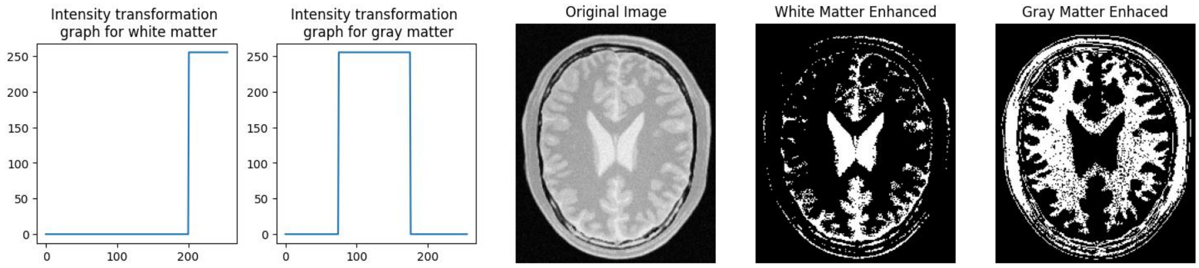
```
#q1
import cv2 as cv
import numpy as np
import matplotlib.pyplot as plt

f = cv.imread("emma.jpg",cv.IMREAD_GRAYSCALE)
assert f is not None

t1 = np.linspace(0,50,51).astype('uint8')
t2 = np.linspace(101,255,100).astype('uint8')
t3 = np.linspace(151,255,105).astype('uint8')

trsfm = np.concatenate((t1,t2,t3),axis=0).astype('uint8')
assert len(trsfm)==256
g = cv.LUT(f,trsfm)

fig, ax = plt.subplots(1,3,figsize=(8,8))
ax[0].plot(trsfm), ax[0].set_title("Intensity transformation graph"), ax[0].set_aspect('equal')
ax[1].imshow(cv.cvtColor(f,cv.COLOR_BGR2RGB)), ax[1].axis('off'), ax[1].set_title("Original Image")
ax[2].imshow(cv.cvtColor(g,cv.COLOR_BGR2RGB)), ax[2].axis('off'), ax[2].set_title("Intensity transformed Image")
plt.show()
```



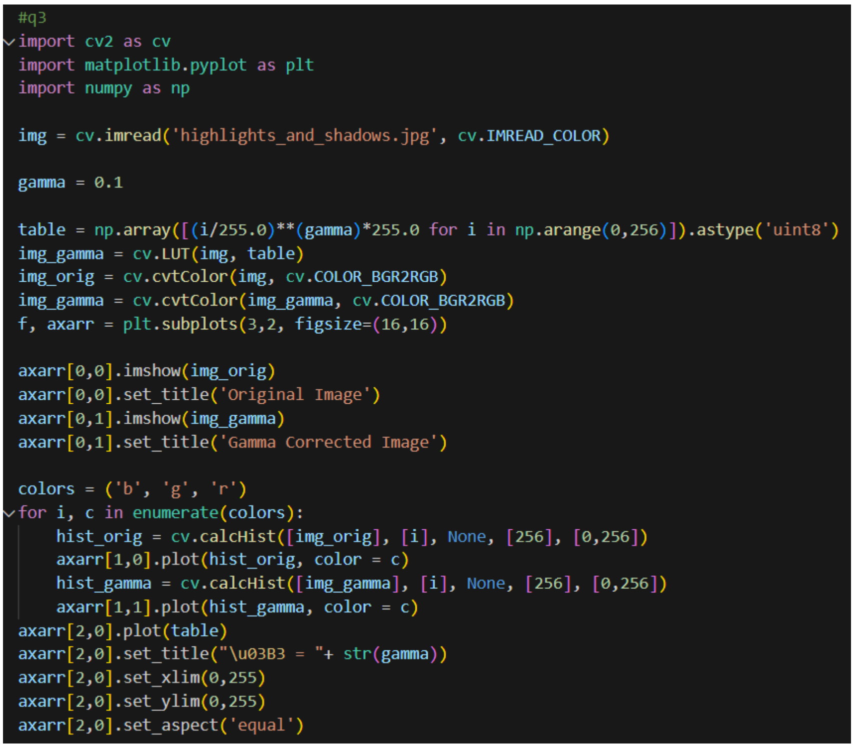
Q2)



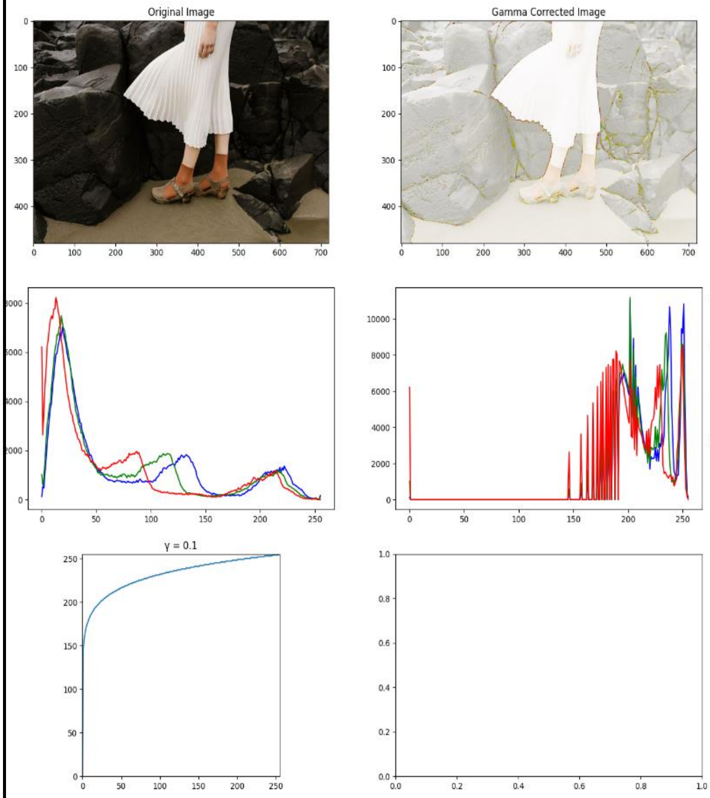
```
#q2
import numpy as np
import cv2 as cv
import matplotlib.pyplot as plt

f = cv.imread("BrainProtonDensitySlice9.png",cv.IMREAD_GRAYSCALE)
assert f is not None

t1 = np.linspace(0,0,201).astype('uint8')
t2 = np.linspace(255,255,55).astype('uint8')
t3 = np.linspace(0,0,75).astype('uint8')
t4 = np.linspace(255,255,101).astype('uint8')
t5 = np.linspace(0,0,80).astype('uint8')

t = np.concatenate((t1,t2),axis=0).astype('uint8')
s = np.concatenate((t3,t4,t5),axis=0).astype('uint8')

assert len(t)==256
assert len(s)==256
g = cv.LUT(f,t)
h = cv.LUT(f,s)

fig, ax = plt.subplots(1,5,figsize=(18,18))
ax[0].plot(t), ax[0].set_aspect('equal'), ax[0].set_title("Intensity transformation \n graph for white matter")
ax[1].plot(s), ax[1].set_aspect('equal'), ax[1].set_title("Intensity transformation \n graph for gray matter")
ax[2].imshow(cv.cvtColor(f,cv.COLOR_BGR2RGB)), ax[2].axis('off'), ax[2].set_title("Original Image")
ax[3].imshow(cv.cvtColor(g,cv.COLOR_BGR2RGB)), ax[3].axis('off'), ax[3].set_title("White Matter Enhanced")
ax[4].imshow(cv.cvtColor(h,cv.COLOR_BGR2RGB)), ax[4].axis('off'), ax[4].set_title("Gray Matter Enhaced")
plt.show()
```



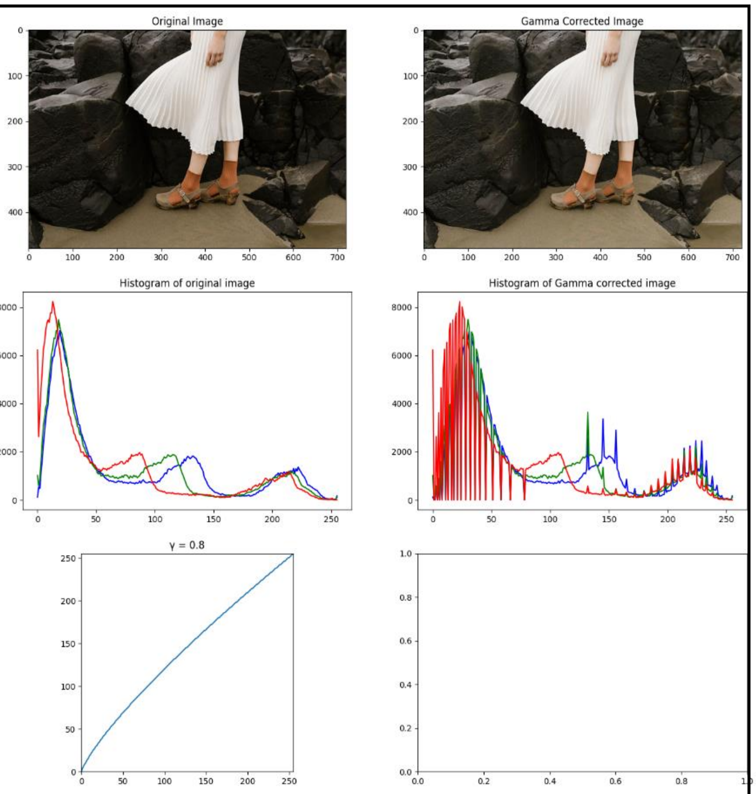
Q3)



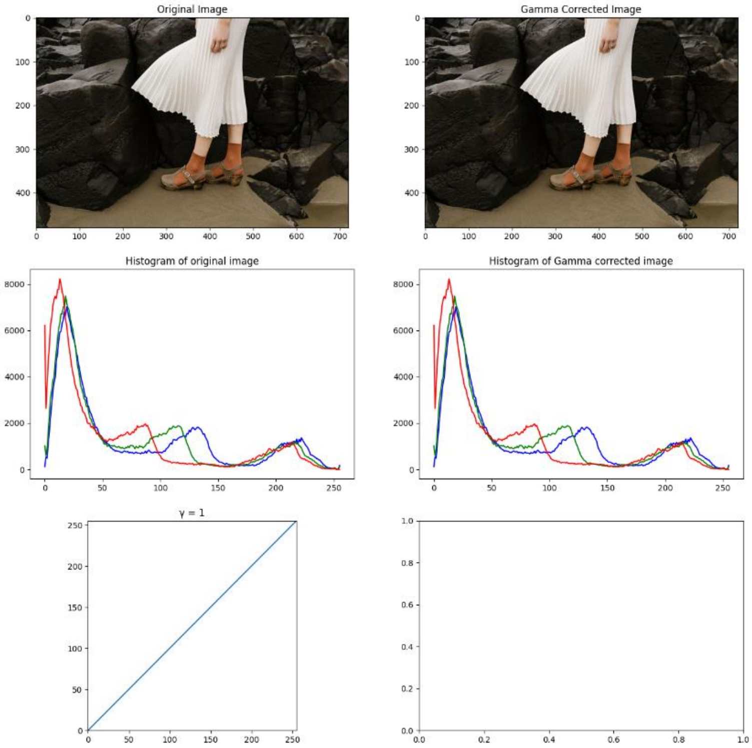
```
#q3
import cv2 as cv
import matplotlib.pyplot as plt
import numpy as np

img = cv.imread('highlights_and_shadows.jpg', cv.IMREAD_COLOR)

gamma = 0.1

table = np.array([(i/255.0)**(gamma)*255.0 for i in np.arange(0,256)]).astype('uint8')
img_gamma = cv.LUT(img, table)
img_orig = cv.cvtColor(img, cv.COLOR_BGR2RGB)
img_gamma = cv.cvtColor(img_gamma, cv.COLOR_BGR2RGB)
f, axarr = plt.subplots(3,2, figsize=(16,16))

axarr[0,0].imshow(img_orig)
axarr[0,0].set_title('Original Image')
axarr[0,1].imshow(img_gamma)
axarr[0,1].set_title('Gamma Corrected Image')

colors = ('b', 'g', 'r')
for i, c in enumerate(colors):
    hist_orig = cv.calcHist([img_orig], [i], None, [256], [0,256])
    axarr[1,0].plot(hist_orig, color = c)
    hist_gamma = cv.calcHist([img_gamma], [i], None, [256], [0,256])
    axarr[1,1].plot(hist_gamma, color = c)
axarr[2,0].plot(table)
axarr[2,0].set_title("\u03B3 = "+ str(gamma))
axarr[2,0].set_xlim(0,255)
axarr[2,0].set_ylim(0,255)
axarr[2,0].set_aspect('equal')
```



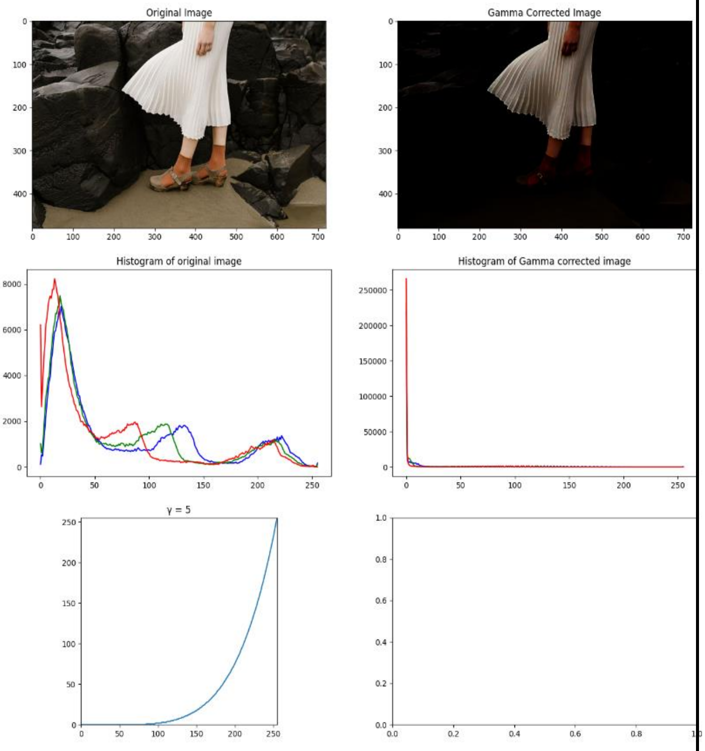
$\gamma = 0.1$



$\gamma = 0.8$



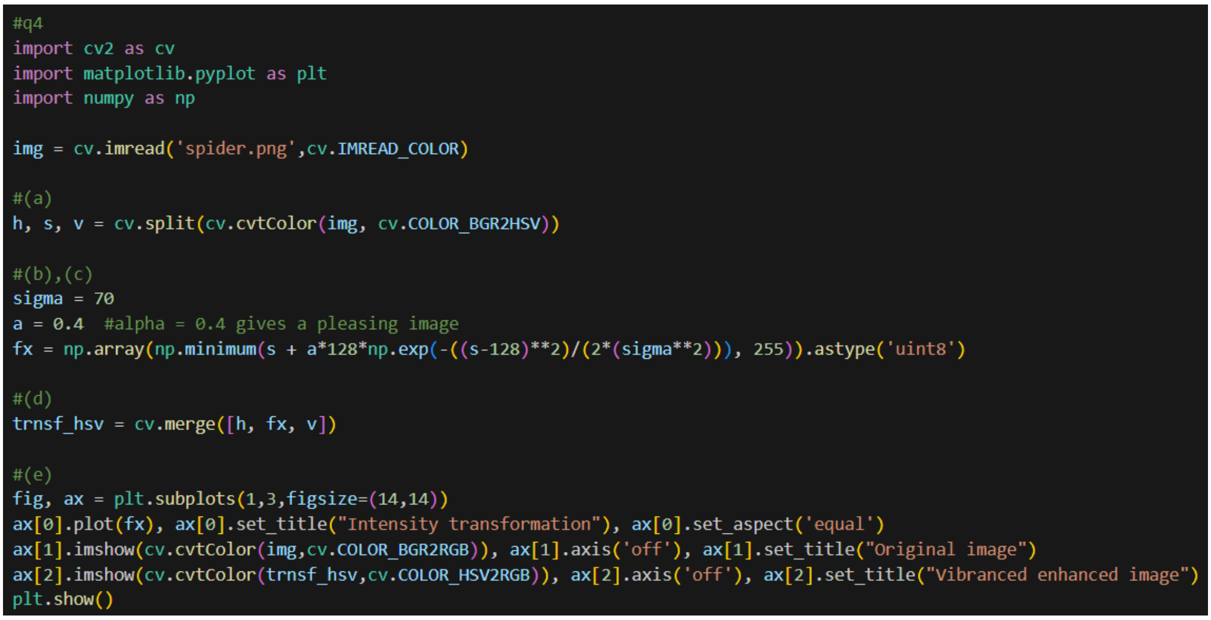
$\gamma = 1$



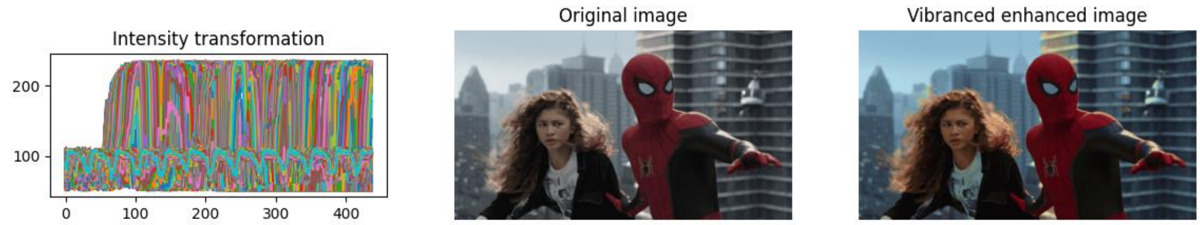
$\gamma = 5$

- When gamma is less than 1, original picture becomes brighter. When gamma is greater than 1, original picture becomes darker. When the gamma value is increased the darker intensities of the picture also increases therefore the histogram of gamma corrected picture is moved to the left side of the plot.

Q4)

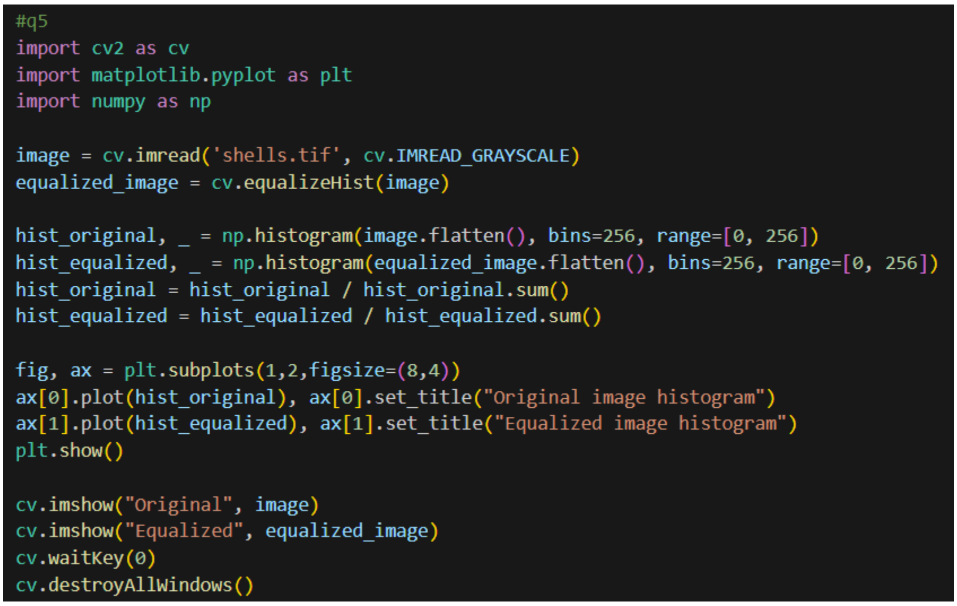


```
#q4
import cv2 as cv
import matplotlib.pyplot as plt
import numpy as np

img = cv.imread('spider.png',cv.IMREAD_COLOR)

#(a)
h, s, v = cv.split(cv.cvtColor(img, cv.COLOR_BGR2HSV))

#(b),(c)
sigma = 70
a = 0.4  #alpha = 0.4 gives a pleasing image
fx = np.array(np.minimum(s + a*128*np.exp(-((s-128)**2)/(2*(sigma**2))), 255)).astype('uint8')

#(d)
trnsf_hsv = cv.merge([h, fx, v])

#(e)
fig, ax = plt.subplots(1,3,figsize=(14,14))
ax[0].plot(fx), ax[0].set_title("Intensity transformation"), ax[0].set_aspect('equal')
ax[1].imshow(cv.cvtColor(img,cv.COLOR_BGR2RGB)), ax[1].axis('off'), ax[1].set_title("Original image")
ax[2].imshow(cv.cvtColor(trnsf_hsv,cv.COLOR_HSV2RGB)), ax[2].axis('off'), ax[2].set_title("Vibranced enhanced image")
plt.show()
```

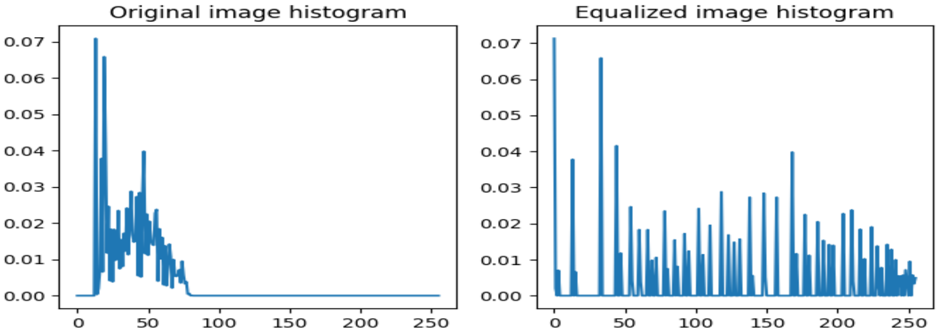


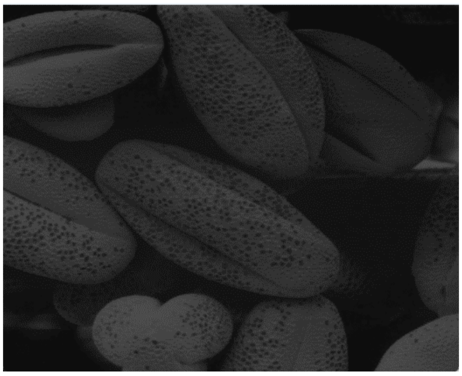
- I have decided to put the value of alpha as 0.4 after checking the output several times.

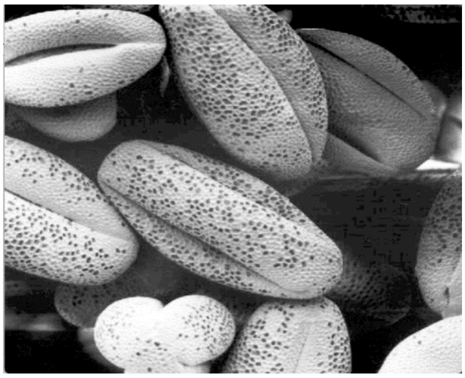
Q5)



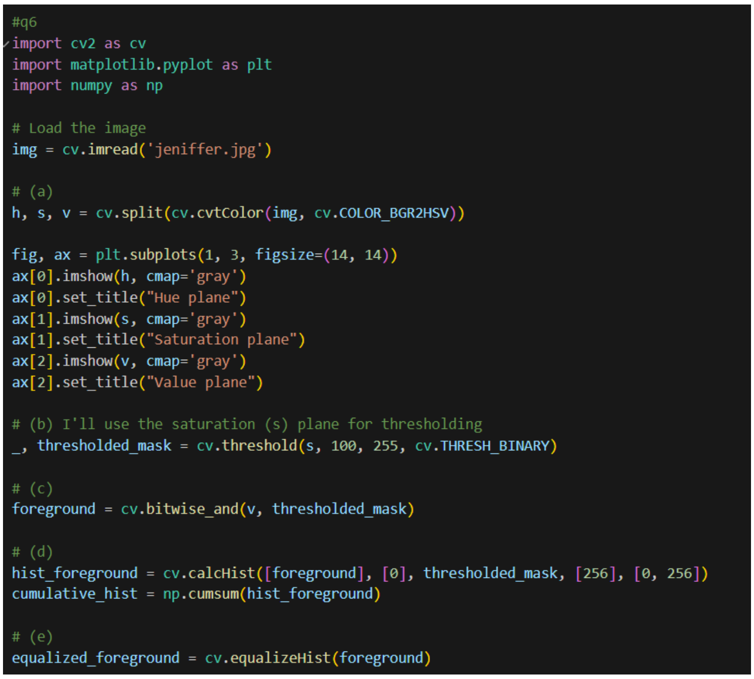
```
#q5
import cv2 as cv
import matplotlib.pyplot as plt
import numpy as np

image = cv.imread('shells.tif', cv.IMREAD_GRAYSCALE)
equalized_image = cv.equalizeHist(image)

hist_original, _ = np.histogram(image.flatten(), bins=256, range=[0, 256])
hist_equalized, _ = np.histogram(equalized_image.flatten(), bins=256, range=[0, 256])
hist_original = hist_original / hist_original.sum()
hist_equalized = hist_equalized / hist_equalized.sum()

fig, ax = plt.subplots(1,2,figsize=(8,4))
ax[0].plot(hist_original), ax[0].set_title("Original image histogram")
ax[1].plot(hist_equalized), ax[1].set_title("Equalized image histogram")
plt.show()

cv.imshow("Original", image)
cv.imshow("Equalized", equalized_image)
cv.waitKey(0)
cv.destroyAllWindows()
```



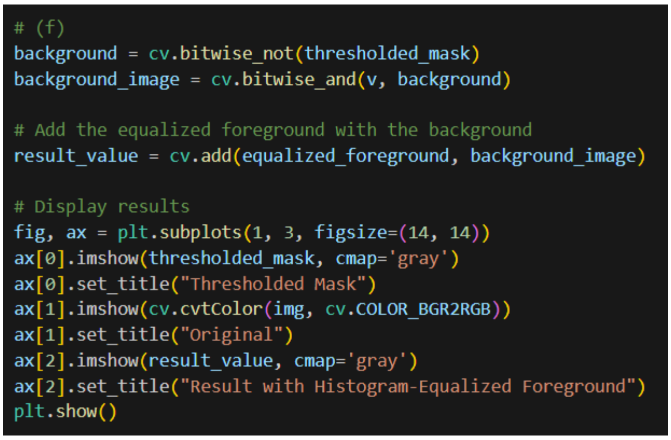




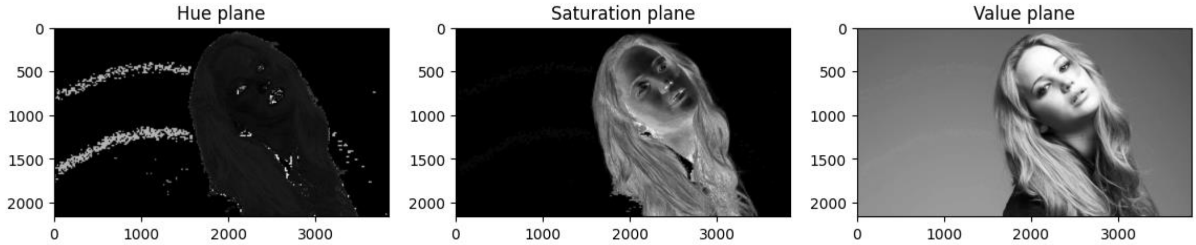
Q6)

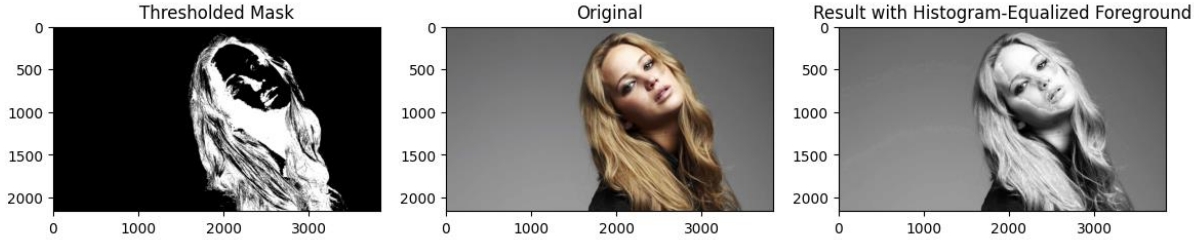


```
#q6
import cv2 as cv
import matplotlib.pyplot as plt
import numpy as np

# Load the image
img = cv.imread('jeniffer.jpg')

# (a)
h, s, v = cv.split(cv.cvtColor(img, cv.COLOR_BGR2HSV))

fig, ax = plt.subplots(1, 3, figsize=(14, 14))
ax[0].imshow(h, cmap='gray')
ax[0].set_title("Hue plane")
ax[1].imshow(s, cmap='gray')
ax[1].set_title("Saturation plane")
ax[2].imshow(v, cmap='gray')
ax[2].set_title("Value plane")

# (b) I'll use the saturation (s) plane for thresholding
_, thresholded_mask = cv.threshold(s, 100, 255, cv.THRESH_BINARY)

# (c)
foreground = cv.bitwise_and(v, thresholded_mask)

# (d)
hist_foreground = cv.calcHist([foreground], [0], thresholded_mask, [256], [0, 256])
cumulative_hist = np.cumsum(hist_foreground)

# (e)
equalized_foreground = cv.equalizeHist(foreground)
```

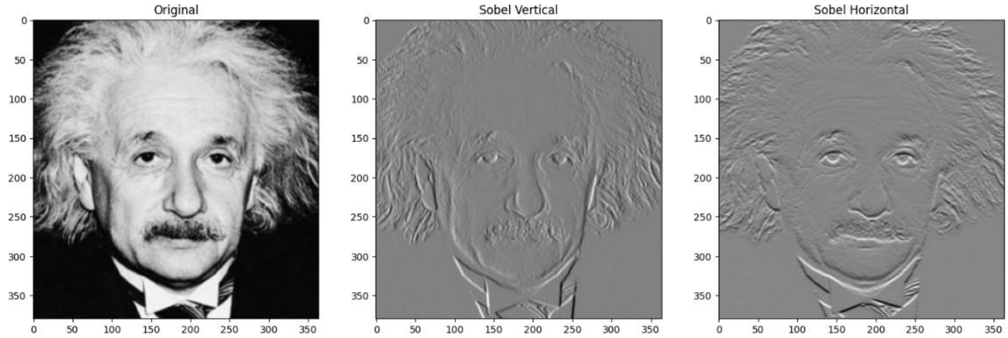


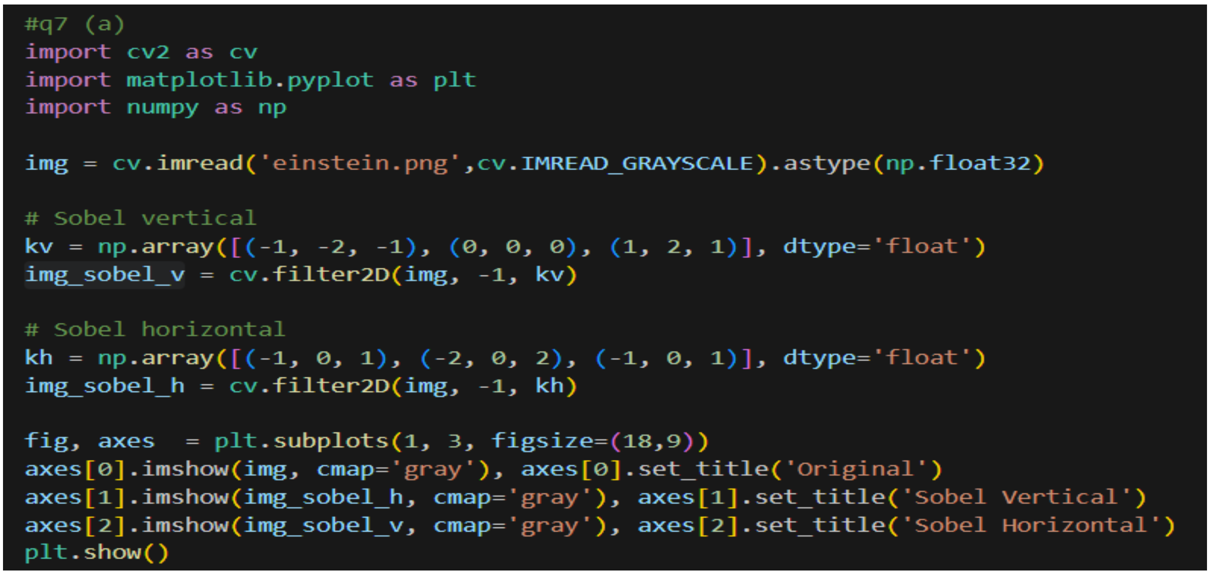
```
# (f)
background = cv.bitwise_not(thresholded_mask)
background_image = cv.bitwise_and(v, background)

# Add the equalized foreground with the background
result_value = cv.add(equalized_foreground, background_image)

# Display results
fig, ax = plt.subplots(1, 3, figsize=(14, 14))
ax[0].imshow(thresholded_mask, cmap='gray')
ax[0].set_title("Thresholded Mask")
ax[1].imshow(cv.cvtColor(img, cv.COLOR_BGR2RGB))
ax[1].set_title("Original")
ax[2].imshow(result_value, cmap='gray')
ax[2].set_title("Result with Histogram-Equalized Foreground")
plt.show()
```



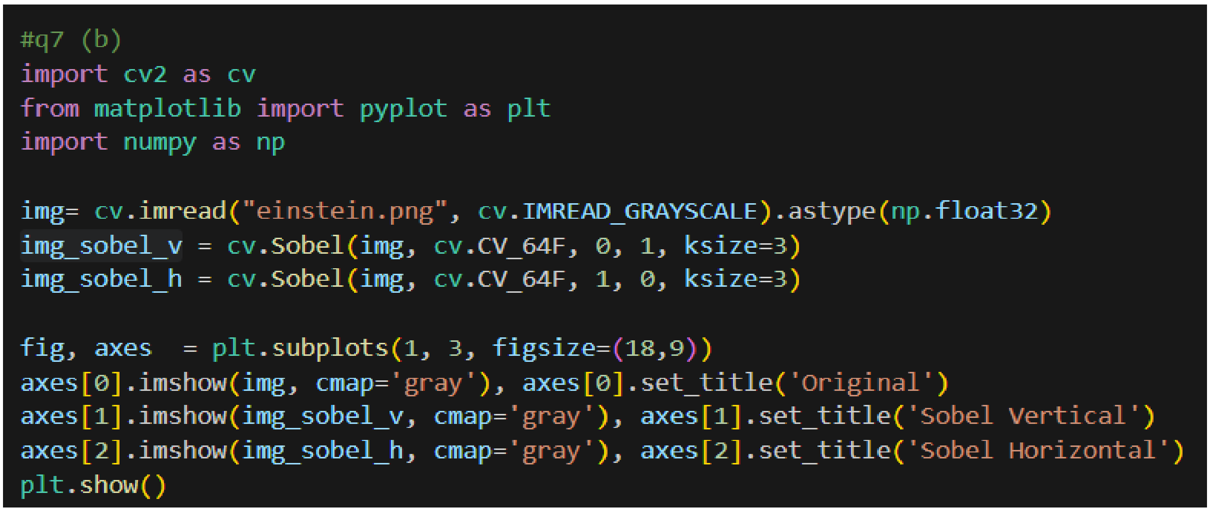


Q7)

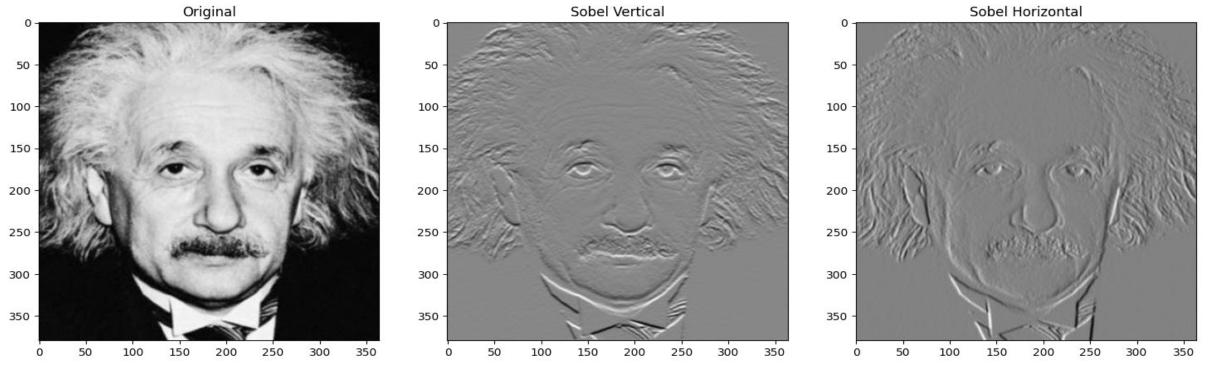


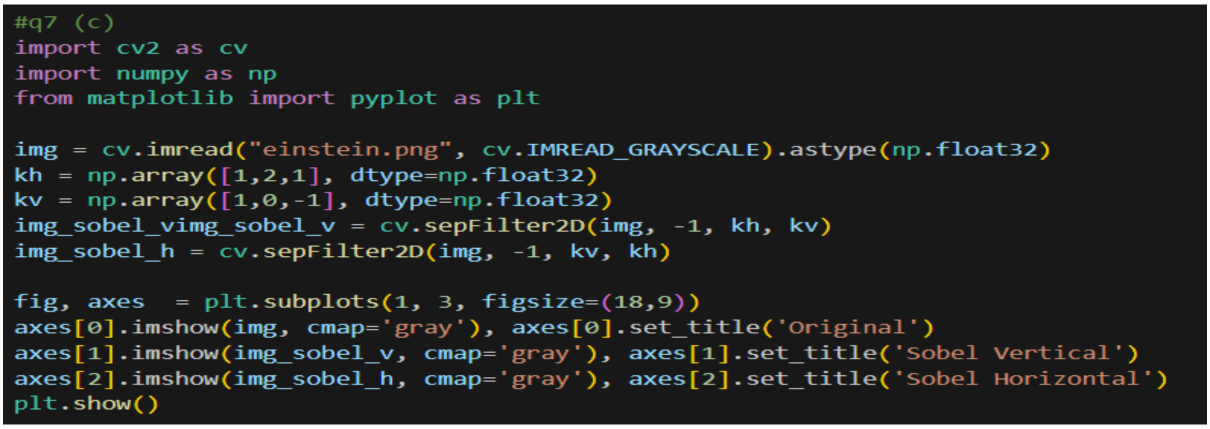


```python
#q7 (a)
import cv2 as cv
import matplotlib.pyplot as plt
import numpy as np

img = cv.imread('einstein.png',cv.IMREAD_GRAYSCALE).astype(np.float32)

# Sobel vertical
kv = np.array([(-1, -2, -1), (0, 0, 0), (1, 2, 1)], dtype='float')
img_sobel_v = cv.filter2D(img, -1, kv)

# Sobel horizontal
kh = np.array([(-1, 0, 1), (-2, 0, 2), (-1, 0, 1)], dtype='float')
img_sobel_h = cv.filter2D(img, -1, kh)

fig, axes  = plt.subplots(1, 3, figsize=(18,9))
axes[0].imshow(img, cmap='gray'), axes[0].set_title('Original')
axes[1].imshow(img_sobel_h, cmap='gray'), axes[1].set_title('Sobel Vertical')
axes[2].imshow(img_sobel_v, cmap='gray'), axes[2].set_title('Sobel Horizontal')
plt.show()
```

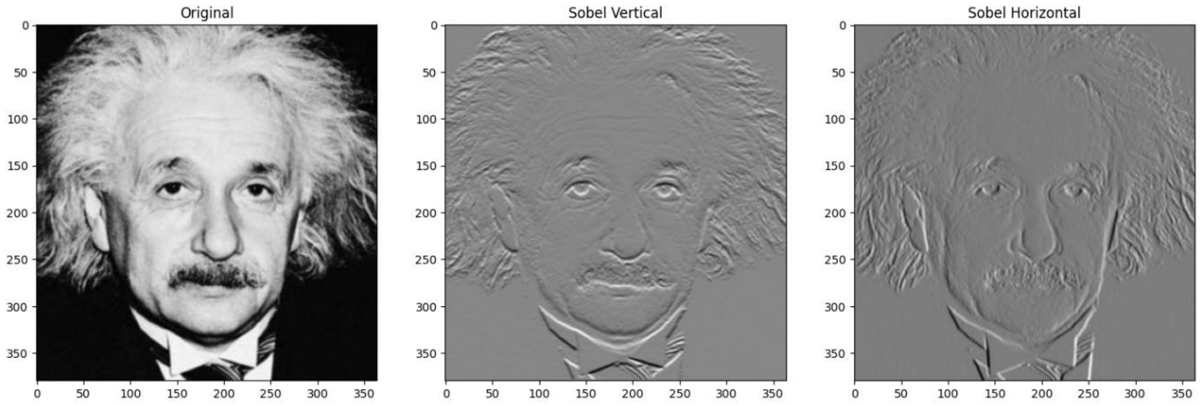


```python
#q7 (b)
import cv2 as cv
from matplotlib import pyplot as plt
import numpy as np

img= cv.imread("einstein.png", cv.IMREAD_GRAYSCALE).astype(np.float32)
img_sobel_v = cv.Sobel(img, cv.CV_64F, 0, 1, ksize=3)
img_sobel_h = cv.Sobel(img, cv.CV_64F, 1, 0, ksize=3)

fig, axes  = plt.subplots(1, 3, figsize=(18,9))
axes[0].imshow(img, cmap='gray'), axes[0].set_title('Original')
axes[1].imshow(img_sobel_v, cmap='gray'), axes[1].set_title('Sobel Vertical')
axes[2].imshow(img_sobel_h, cmap='gray'), axes[2].set_title('Sobel Horizontal')
plt.show()
```

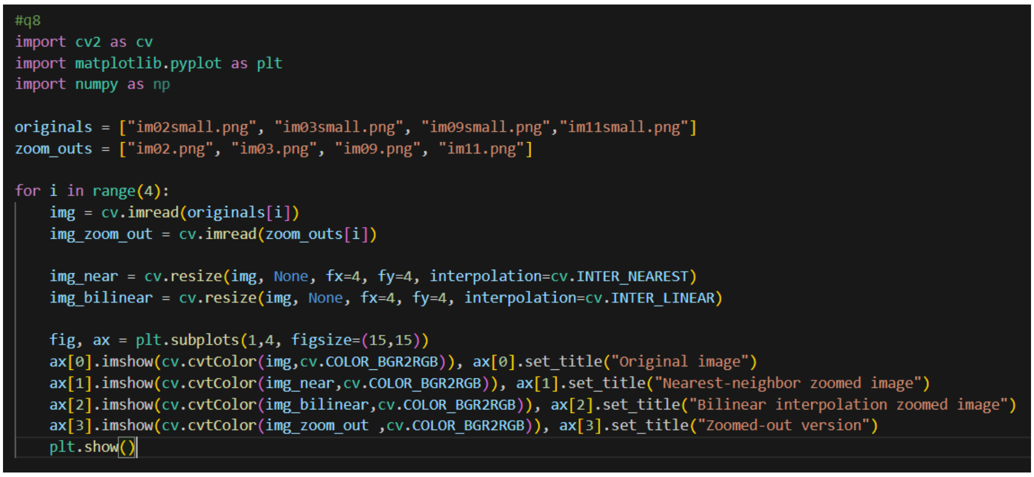




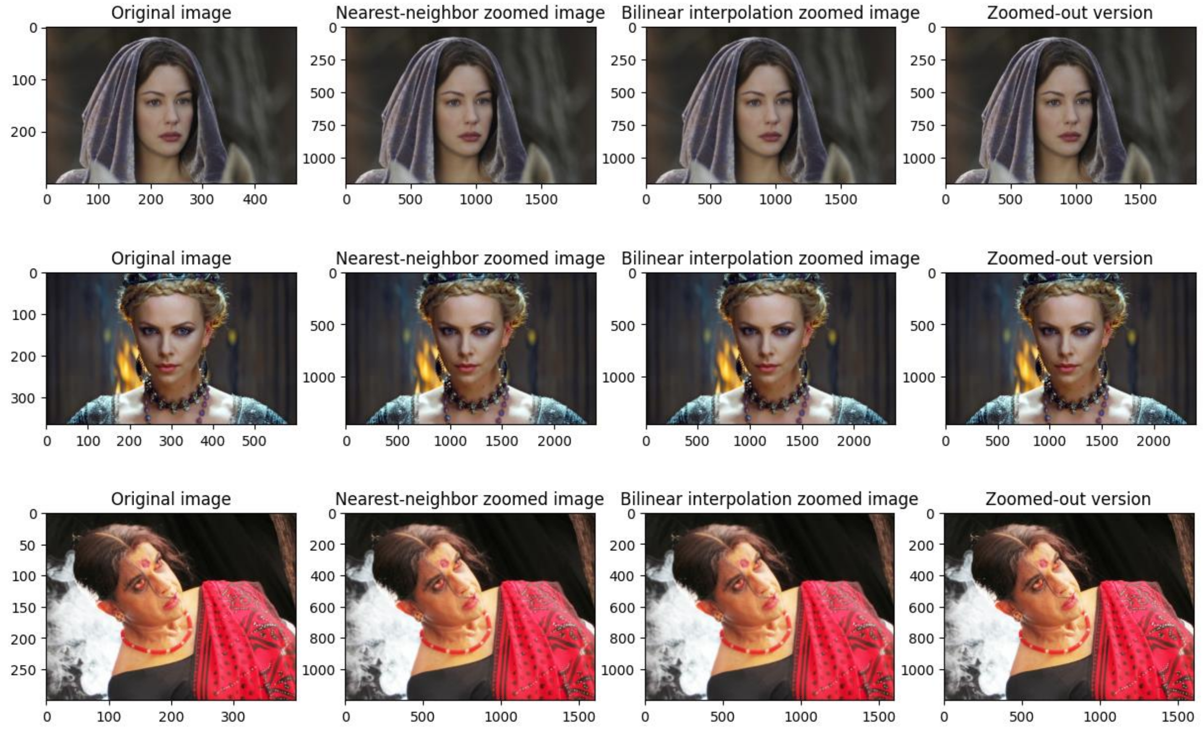
```python
#q7 (c)
import cv2 as cv
import numpy as np
from matplotlib import pyplot as plt

img = cv.imread("einstein.png", cv.IMREAD_GRAYSCALE).astype(np.float32)
kh = np.array([1,2,1], dtype=np.float32)
kv = np.array([1,0,-1], dtype=np.float32)
img_sobel_vimg_sobel_v = cv.sepFilter2D(img, -1, kh, kv)
img_sobel_h = cv.sepFilter2D(img, -1, kv, kh)

fig, axes  = plt.subplots(1, 3, figsize=(18,9))
axes[0].imshow(img, cmap='gray'), axes[0].set_title('Original')
axes[1].imshow(img_sobel_v, cmap='gray'), axes[1].set_title('Sobel Vertical')
axes[2].imshow(img_sobel_h, cmap='gray'), axes[2].set_title('Sobel Horizontal')
plt.show()
```

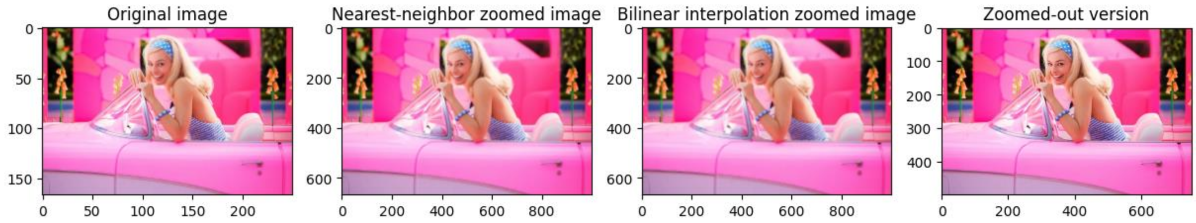


Q8)

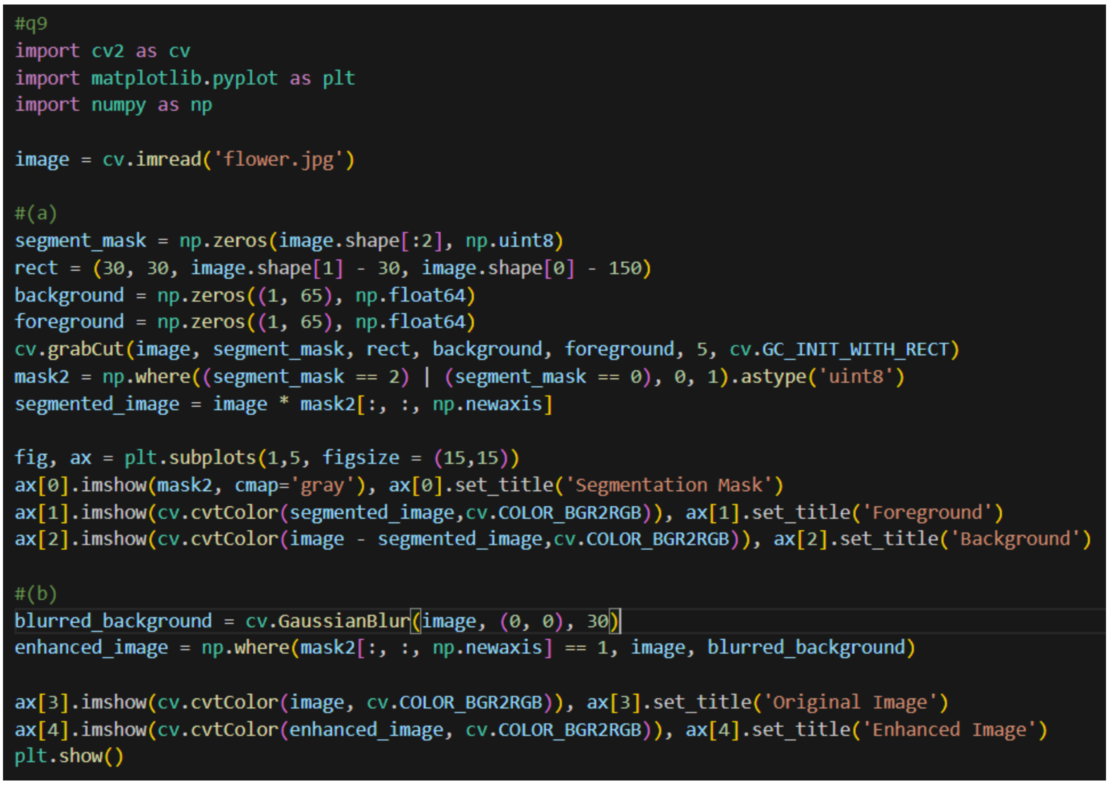


```
#q8
import cv2 as cv
import matplotlib.pyplot as plt
import numpy as np

originals = ["im02small.png", "im03small.png", "im09small.png","im11small.png"]
zoom_outs = ["im02.png", "im03.png", "im09.png", "im11.png"]

for i in range(4):
    img = cv.imread(originals[i])
    img_zoom_out = cv.imread(zoom_outs[i])

    img_near = cv.resize(img, None, fx=4, fy=4, interpolation=cv.INTER_NEAREST)
    img_bilinear = cv.resize(img, None, fx=4, fy=4, interpolation=cv.INTER_LINEAR)

    fig, ax = plt.subplots(1,4, figsize=(15,15))
    ax[0].imshow(cv.cvtColor(img,cv.COLOR_BGR2RGB)), ax[0].set_title("Original image")
    ax[1].imshow(cv.cvtColor(img_near,cv.COLOR_BGR2RGB)), ax[1].set_title("Nearest-neighbor zoomed image")
    ax[2].imshow(cv.cvtColor(img_bilinear,cv.COLOR_BGR2RGB)), ax[2].set_title("Bilinear interpolation zoomed image")
    ax[3].imshow(cv.cvtColor(img_zoom_out ,cv.COLOR_BGR2RGB)), ax[3].set_title("Zoomed-out version")
    plt.show()
```

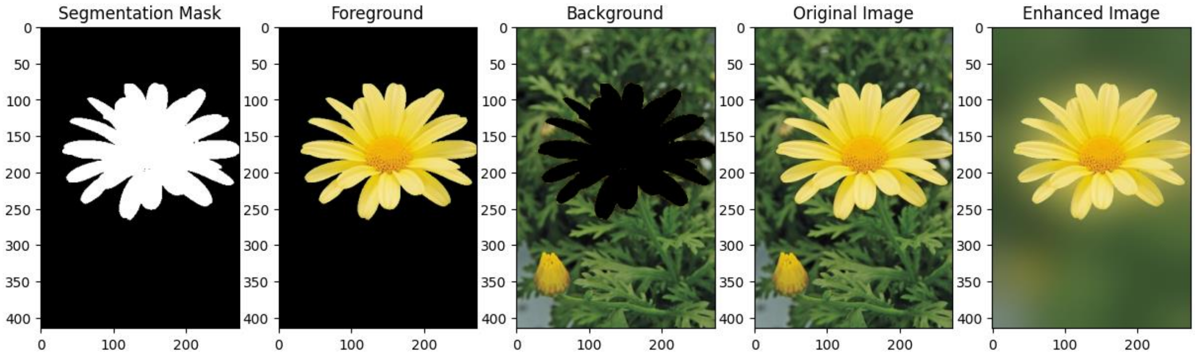



Original image
Nearest-neighbor zoomed image
Bilinear interpolation zoomed image
Zoomed-out version
0
50
100
150
200
400
600
800
300

Q9)



```
#q9
import cv2 as cv
import matplotlib.pyplot as plt
import numpy as np

image = cv.imread('flower.jpg')

#(a)
segment_mask = np.zeros(image.shape[:2], np.uint8)
rect = (30, 30, image.shape[1] - 30, image.shape[0] - 150)
background = np.zeros((1, 65), np.float64)
foreground = np.zeros((1, 65), np.float64)
cv.grabCut(image, segment_mask, rect, background, foreground, 5, cv.GC_INIT_WITH_RECT)
mask2 = np.where((segment_mask == 2) | (segment_mask == 0), 0, 1).astype('uint8')
segmented_image = image * mask2[:, :, np.newaxis]

fig, ax = plt.subplots(1,5, figsize = (15,15))
ax[0].imshow(mask2, cmap='gray'), ax[0].set_title('Segmentation Mask')
ax[1].imshow(cv.cvtColor(segmented_image,cv.COLOR_BGR2RGB)), ax[1].set_title('Foreground')
ax[2].imshow(cv.cvtColor(image - segmented_image,cv.COLOR_BGR2RGB)), ax[2].set_title('Background')

#(b)
blurred_background = cv.GaussianBlur(image, (0, 0), 30)
enhanced_image = np.where(mask2[:, :, np.newaxis] == 1, image, blurred_background)

ax[3].imshow(cv.cvtColor(image, cv.COLOR_BGR2RGB)), ax[3].set_title('Original Image')
ax[4].imshow(cv.cvtColor(enhanced_image, cv.COLOR_BGR2RGB)), ax[4].set_title('Enhanced Image')
plt.show()
```



- When the foreground image and the blurred background image is added on top of each other the dark(black) pixels get added up to the blurred image. Therefore, the edge of the flower is dark.