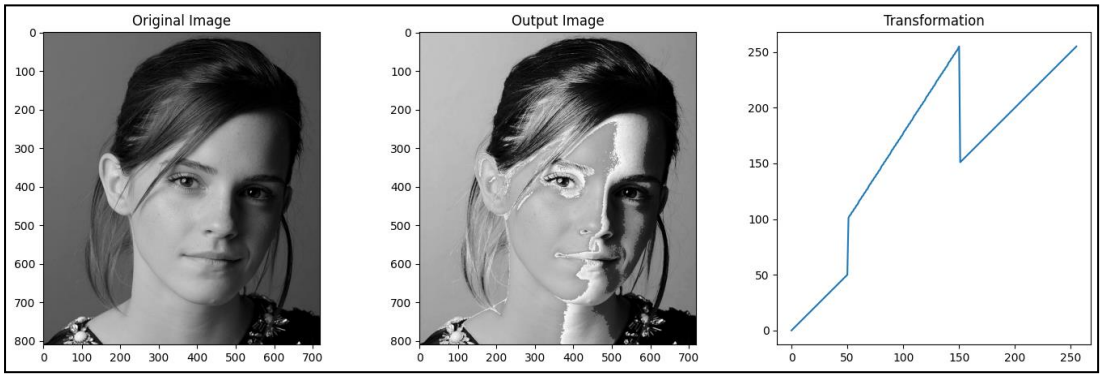
Only the necessary parts of the codes are included. (No imread,imshow functions are showed)

Question 01

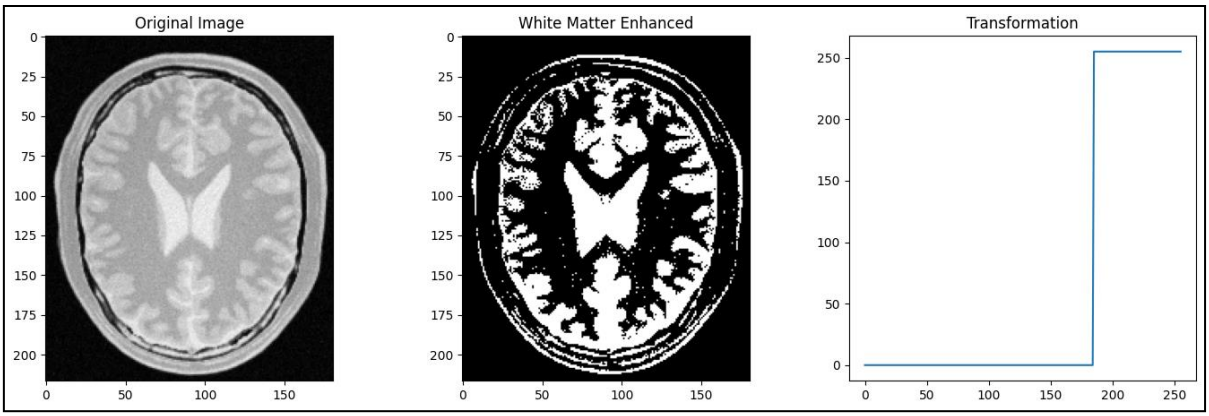
```
import cv2 as cv
import numpy as np
import matplotlib.pyplot as plt

coordinates = np.array([(0,0),(50,50),(50,100),(150,250),(150,150),(255,255)])
trans = np.array([0])
for i in range(int(len(coordinates)/2)):
    line = np.linspace(coordinates[0+2*i ,1], coordinates[1+2*i , 0] - coordinates[0+2*i , 0] + 1)
    trans = np.concatenate((trans , line)).astype(np.uint8)
transformed = trans[image1]
```



Question 02

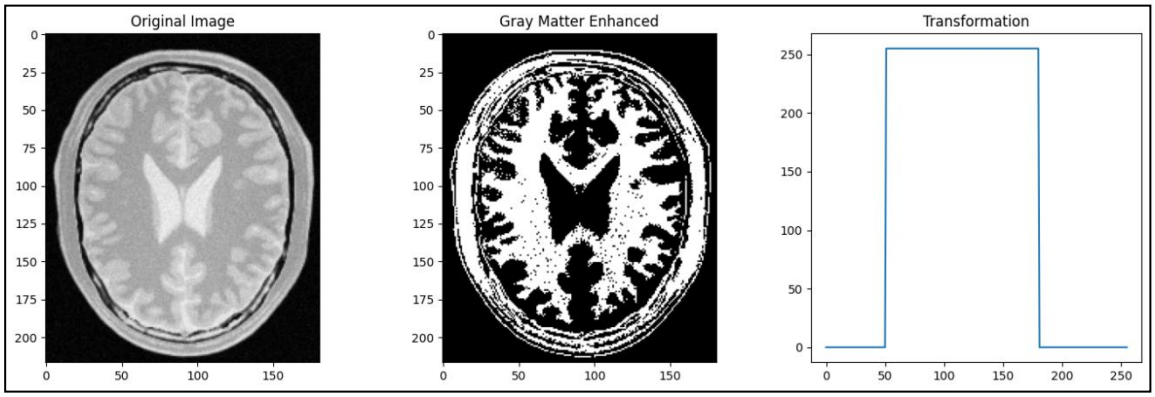
a)White Matter Enhanced

```
x = np.arange(0,256).astype(np.uint8)
divert_point = 184
coordinates = np.array([(1,0),(divert_point,0),(divert_point+1,255),(255,255)])
trans = np.array([0])

for i in range(int(len(coordinates)/2)):
    line = np.linspace(coordinates[0+2*i ,1], coordinates[1+2*i , 0] - coordinates[0+2*i , 0] + 1)
    trans = np.concatenate((trans , line)).astype(np.uint8)
transformed = trans[image2]
```



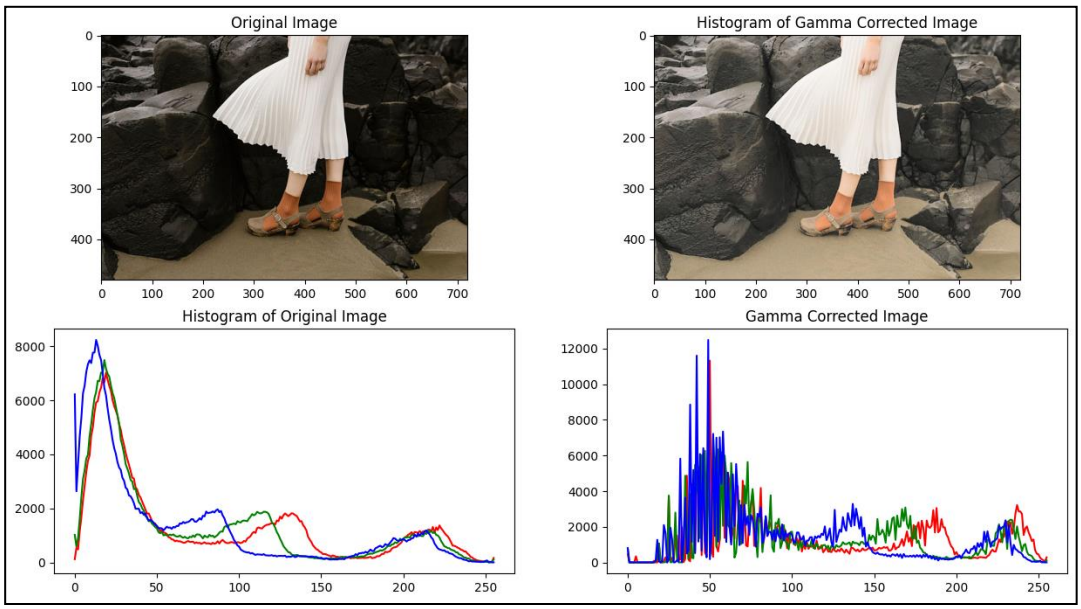
b) Gray Matter Enhanced

```
coordinates = np.array([(1,0),( 50,0),( 50+1,255),( 180,255),(180+1,0),(255,0)])
trans = np.array([0])
for i in range(int(len(coordinates)/2)):
    line = np.linspace(coordinates[0+2*i ,1], coordinates[1+2*i ,1], coordinates[1+2*i ,0] -  coordinates[0+2*i , 0] + 1)
    trans = np.concatenate((trans, line)).astype(np.uint8)
transformed = trans[image2]
```



Question 03

```
image3_copy = image3.copy()
image3_copy = cv.cvtColor(image3_copy,cv.COLOR_BGR2RGB)
image3 = cv.cvtColor(image3, cv.COLOR_BGR2LAB)
l_img , a_img , b_img = cv.split(image3)

gamma = 0.5

table = np.array([(i/255.0)**(gamma)*255.0 for i in np.arange(0,256)]).astype(np.uint8)
img_gamma = cv.LUT(l_img, table)
final_image = cv.merge((img_gamma, a_img, b_img))
final_image = cv.cvtColor(final_image, cv.COLOR_LAB2RGB)
```



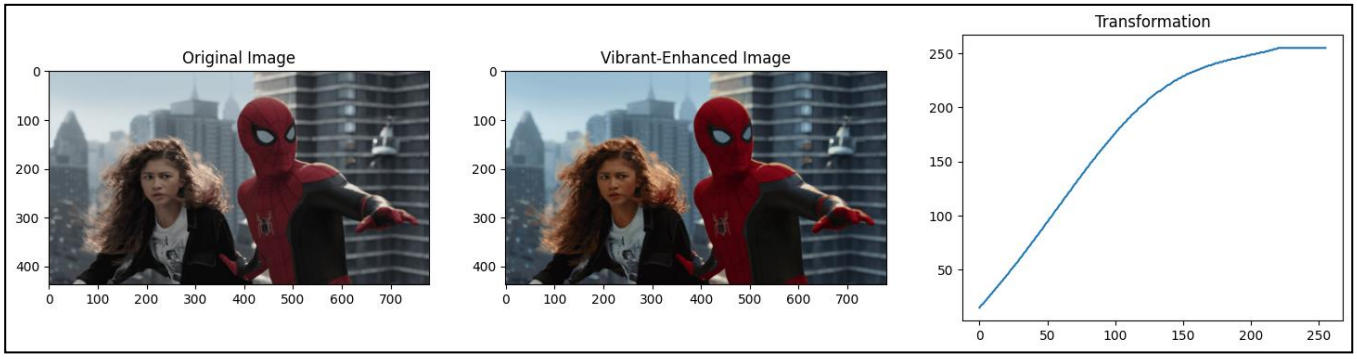
Discussion

- L channel : This plane represent the Lightness / Brightness of image.When adding gamma correction with gamma=0.5,it will increase the brightness of the L plane and the final output image.
- A plane : This plane represent the color from green to red. Negative value correspond to green while positive values correspond to red.
- B plane : This plane represent the color from blue to yellow. Negative value correspond to blue while positive values correspond to yellow.

Question 04

```
hsv_image = cv.cvtColor(image4, cv.COLOR_BGR2HSV)
hue, saturation, value = cv.split(hsv_image)
a , alpha = 0.65, 70
x = np.arange(0,256,1).astype(np.uint8)
table = np.array([min(255, (x + (a * 128) * np.exp(-((x - 128) ** 2) / (2 * alpha ** 2)))) for x in np.arange(0,
256)]).astype('uint8')
sat_update = cv.LUT(saturation, table)
merge_img = cv.merge((hue, sat_update , value))
merge_img = cv.cvtColor(merge_img, cv.COLOR_HSV2RGB)
```

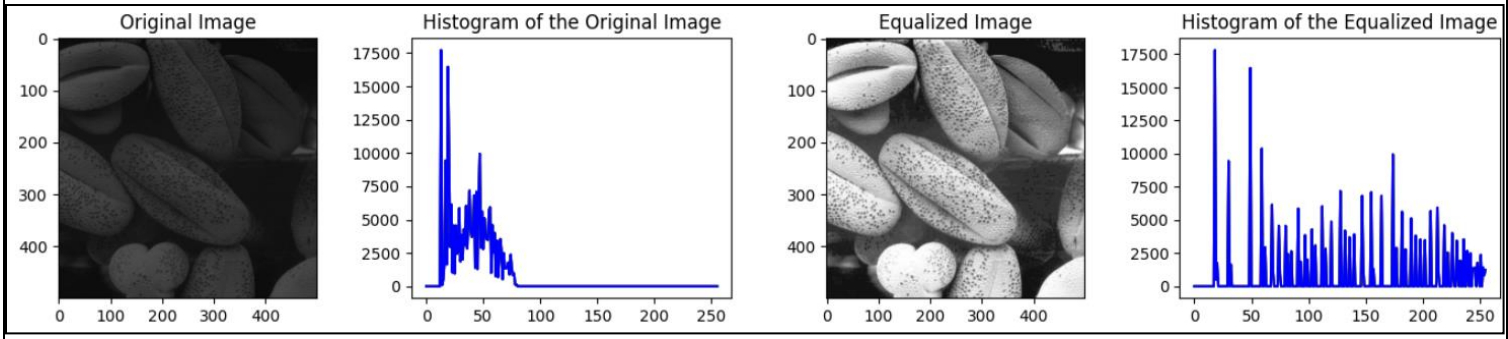
'a' value that output a visually pleasing image : 0.65



Question 05

```
height, width = image5.shape[0], image5.shape[1]
r_plane, g_plane, b_plane = cv.split(image5)
def intensity_count(plane) :
    count_list = np.zeros(256).astype(np.uint16)
    for i in range(height) :
        for j in range(width) :
            count_list[plane[i][j]] += 1
    return count_list

def histogram_eq(plane, intensity_count) :
    equalized_intensities = np.zeros(256).astype(np.uint16)
    count = 0
    for i in range(len(intensity_count)) :
        count += intensity_count[i]
        new_val = (255/(height*width)) * count
        new_val = round(new_val)
        equalized_intensities[i] = new_val
```

```
    for h in range(height) :
        for w in range(width) :
            plane[h][w] = equalized_intensities[plane[h][w]]
    return plane

r_plane_count = intensity_count(r_plane)
eq_r_plane = histogram_eq(r_plane, r_plane_count)
g_plane_count = intensity_count(g_plane)
eq_g_plane = histogram_eq(g_plane, g_plane_count)
b_plane_count = intensity_count(b_plane)
eq_b_plane = histogram_eq(b_plane, b_plane_count)
new_image = cv.merge((eq_r_plane,eq_g_plane,eq_b_plane))
```



Question 06

Part a,b,c

```
h_plane, s_plane, v_plane = cv.split(image6_hsv)
th_val, binary_image = cv.threshold(s_plane, 11, 255, cv.THRESH_BINARY)
result = cv.bitwise_and(image6, image6, mask = binary_image)
```

Part d

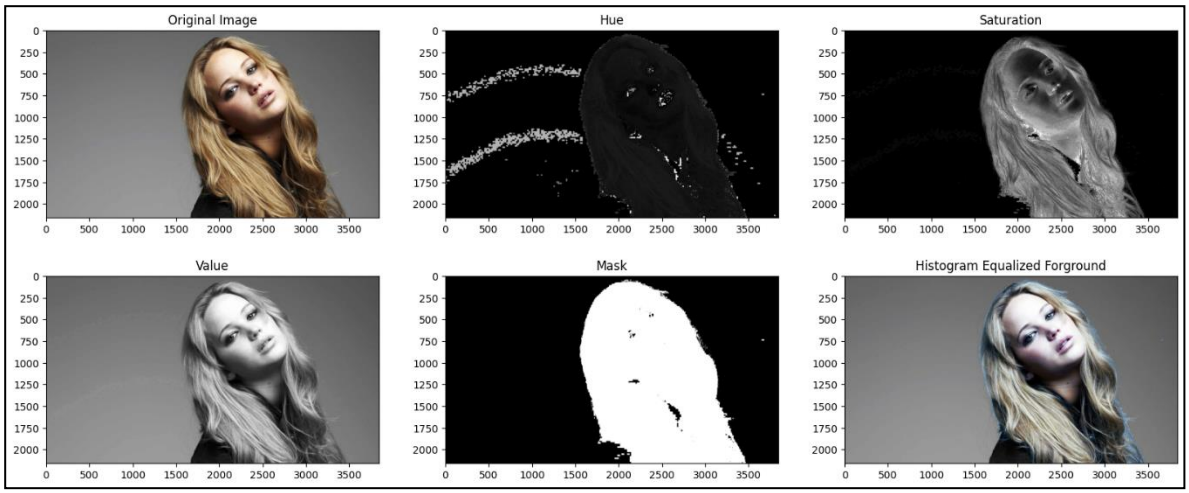
```
hist, bins = np.histogram(result.ravel(),256,[0,256])
cdf = hist.cumsum()
cdf_normalized = cdf * hist.max() / cdf.max()
```

Part e

```
result_r , result_g, result_b = cv.split(result)
equ_r, equ_g, equ_b = cv.equalizeHist(result_r), cv.equalizeHist(result_g), cv.equalizeHist(result_b)
```

Part f

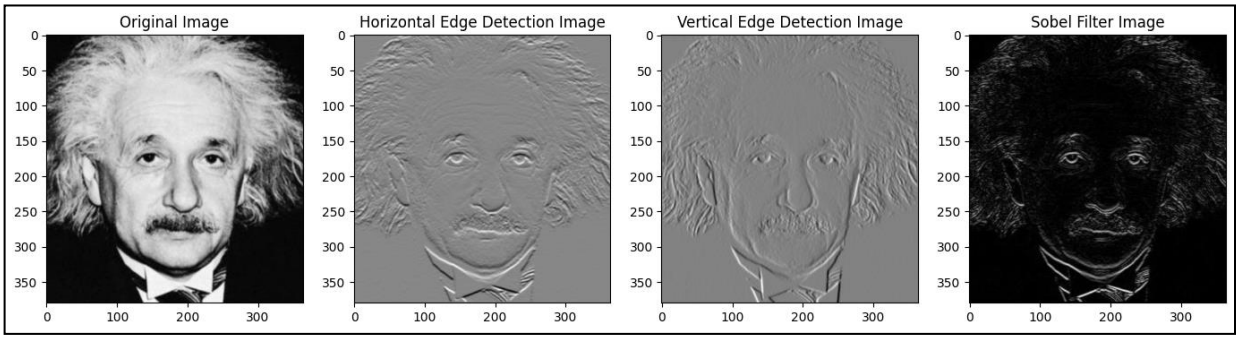
```
equalized_result = cv.merge((equ_r, equ_g, equ_b))
backgnd_mask = cv.bitwise_not(binary_image)
backgnd = cv.bitwise_and(image6, image6, mask = backgnd_mask)
final = cv.add(equalized_result, backgnd)
```



Question 07

Part a

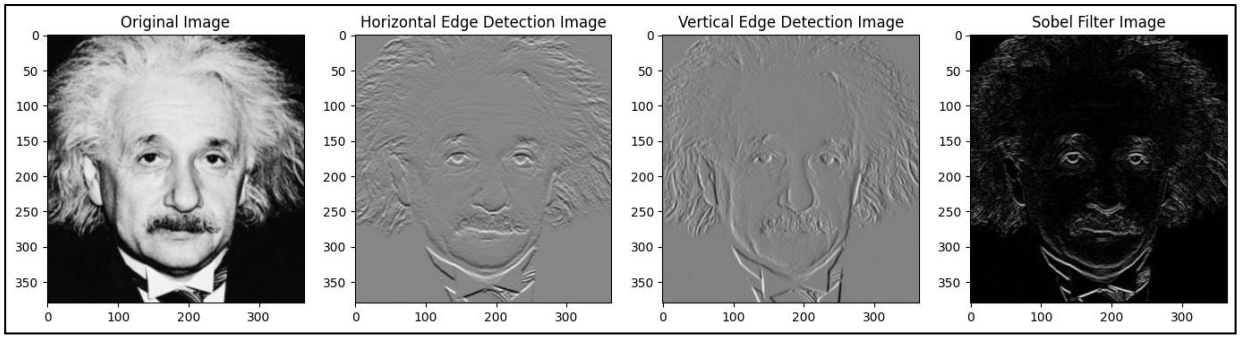
```
image7 = cv.imread('einstein.png', cv.IMREAD_GRAYSCALE).astype(np.float32)
vertical_sobel = np.array([[-1,-2,-1],[0,0,0],[1,2,1]], dtype = np.float32)
horizontel_sobel = np.array([[-1,0,1],[-2,0,2],[-1,0,1]], dtype = np.float32)
img_horizontal = cv.filter2D(image7, -1, vertical_sobel)
img_vertical = cv.filter2D(image7, -1, horizontel_sobel)
final_image = np.sqrt(img_horizontal**2, img_vertical**2)
```



Part b

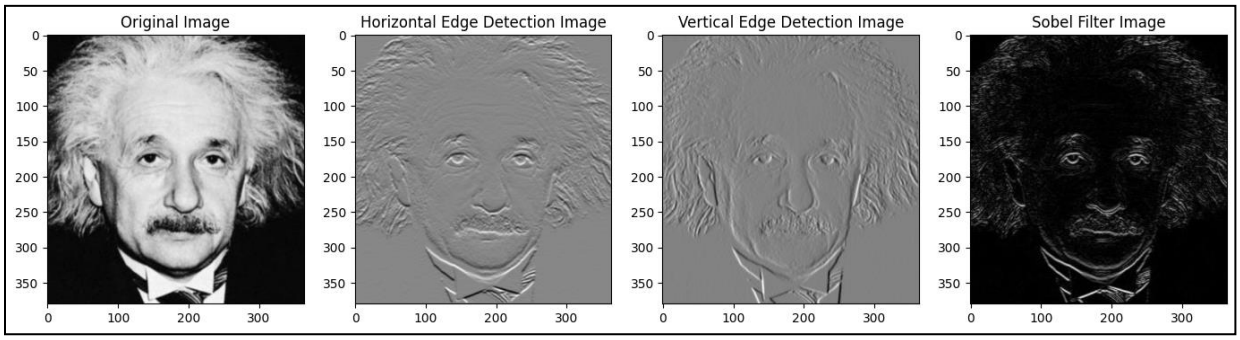
```
def sobel_fiter(image, kernel):

  h_im, w_im = image.shape[0] , image.shape[1]
  h_ke, w_ke = kernel.shape[0] , kernel.shape[1]
  h_ke_half, w_ke_half = h_ke // 2, w_ke // 2
  result_h=np.zeros(image.shape,dtype=np.float32)
  image = cv.normalize(image.astype('float'), None, 0.0, 1.0, cv.NORM_MINMAX)

  for i in range(h_ke, h_im - h_ke):
    for j in range(w_ke, w_im - w_ke):
   # indentify the image window to get the 2D convolution with kernal, then convolution
      image_window = image[i - h_ke_half : i + h_ke_half + 1, j - w_ke_half : j + w_ke_half + 1]
      result_h[i, j] = np.sum(image_window * kernel)
  result_h = (result_h - np.min(result_h)) / (np.max(result_h) - np.min(result_h)) * 255
  return result_h
```

```
img_h = sobel_fiter(image7, vertical_sobel)
img_v = sobel_fiter(image7, horizontel_sobel)
final_image = np.sqrt(img_horizontal**2, img_vertical**2)
```



Part C

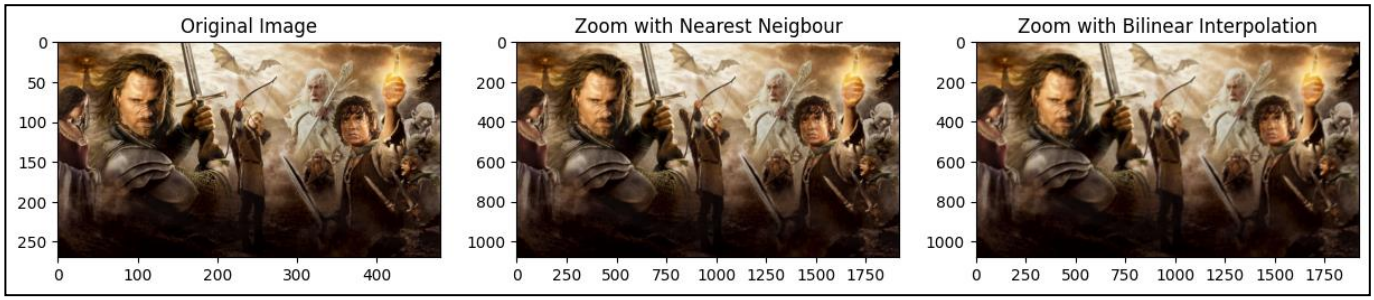
```
kernal_vertical  = np.array([-1,0,1],dtype=np.float32)
kernal_horizontal  = np.array([1,2,1],dtype=np.float32)
img_vertical = cv.sepFilter2D(image7, -1, kernal_vertical, kernal_horizontal)
img_horizontal = cv.sepFilter2D(image7, -1, kernal_horizontal, kernal_vertical)
final_image = np.sqrt(img_horizontal**2, img_vertical**2)
```

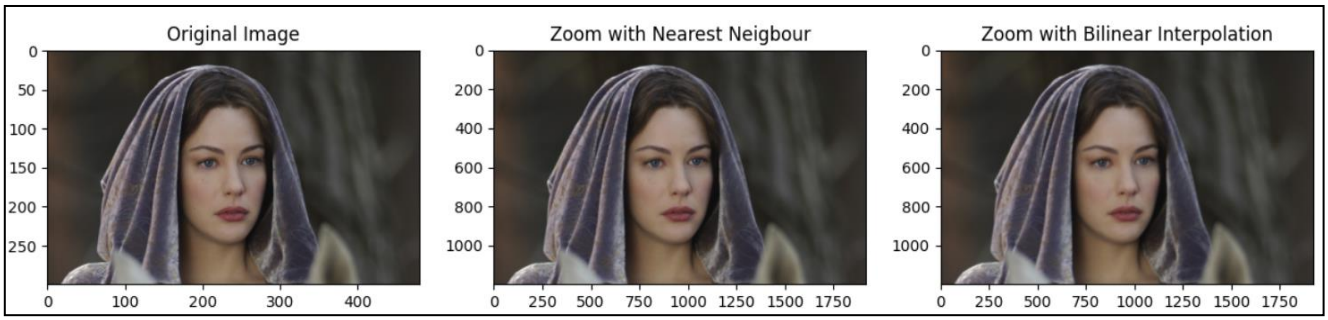


Question 08

```
def zoom(image, scale, method) :
    h_image , w_image , channels = image.shape
    h_zoomed = h_image*scale
    w_zoomed = w_image*scale
    zoomed_image = np.zeros((h_zoomed, w_zoomed, channels), dtype = np.float32)
    if method == 'nearest neighbour' :
        for i in range(h_zoomed) :
            for j in range(w_zoomed) :
                zoomed_image[i,j] = image[i // scale, j // scale]

    if method == 'bilinear interpolation' :
        for i in range(h_zoomed) :
            for j in range(w_zoomed) :
                x_image , y_image = (i / scale) , (j / scale )
                x1 , y1 = int(x_image) , int(y_image)
                x2 , y2 = x1+1, y1+1
```

```
            if x2 >= h_image : x2 = x1
            if y2 >= w_image : y2 = y1
            dx, dy = x_image - x1 , y_image - y1
            w1,w2,w3,w4 =(1 - dx)*(1 – dy),dx*(1 - dy),(1 - dx)*dy, dx*dy
            zoomed_image[i,j] = w1*image[x1,y1] + w2*image[x1,y2] + w3*image[x2,y1] + w4*image[x2,y2]
    return zoomed_image.astype(np.uint8)

zoomed_nn = zoom(image8, 4, 'nearest neighbour')
zoomed_bi = zoom(image8, 4, 'bilinear interpolation')
```





Discussion

Nearest neighbour method gives a sharp zoomed images while bilinear interpolation gives a smooth zoomed images. It happens because, interpolation method is taking the weighted sum of the four nearest pixel values. Therefore sharp edges will smooth when zooming images using bilinear interpolation.

Question 08 algorithm testing (for image 01)

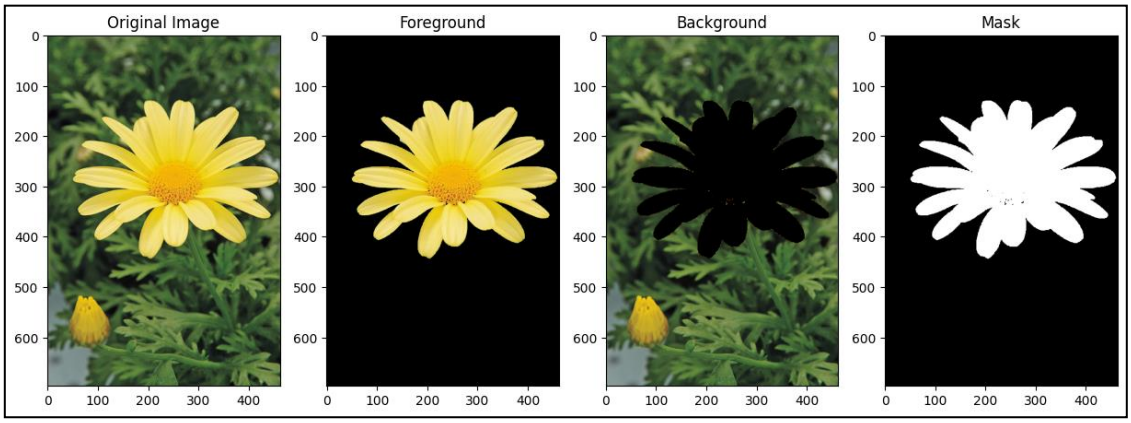
```
zoomed_image = cv.imread('zooming/im01.png')
resized = cv.resize(image8, (1920, 1080), interpolation=cv.INTER_LINEAR)
squared_diff1 = np.sum(np.square(zoomed_image - zoomed_nn))
squared_diff2 = np.sum(np.square(zoomed_image - zoomed_bi))
squared_diff3 = np.sum(np.square(zoomed_image - resized))
```

Squared Difference of zoomed image by Nearest Neighbour : 522633462
Squared Difference of zoomed image by the Bilinear interpolation : 543747100
Squared Difference of zoomed image by the resize Function : 522553013

Question 09

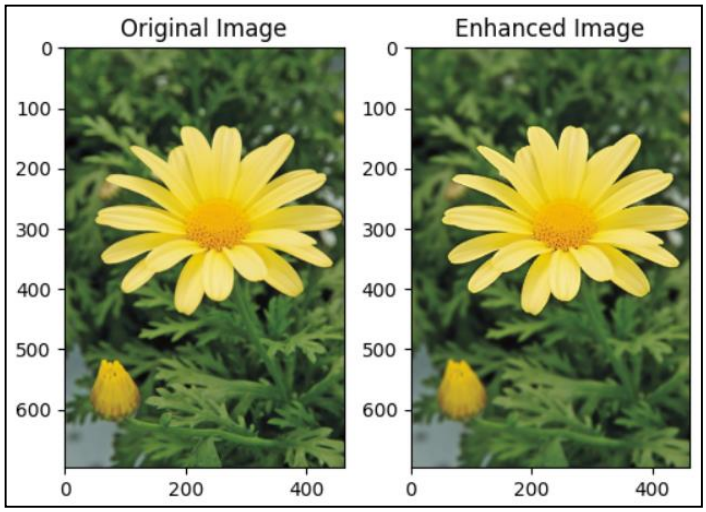
```
h, w, _ = image9.shape
mask = np.zeros((h, w), dtype = np.uint8)
bgdModel = np.zeros((1,65),np.float64)
```

```
fgdModel = np.zeros((1,65),np.float64)
rectangle = (0,0,h,w)
mask, bg_model, fg_model = cv.grabCut(image9, mask, rectangle, bgdModel, fgdModel, 5,
cv.GC_INIT_WITH_RECT)

new_mask = np.where((mask == 0) | (mask == 2), 0, 1).astype(np.uint8)
foreground = image9 * new_mask[:, :, np.newaxis]
background = image9 * (1 - new_mask[:, :, np.newaxis])
```



Part B

```
blur_bg = cv.GaussianBlur(background, (11,11), 0,0)
final_image = cv.add(foreground, blur_bg)
```



Part C

- Blurring the background decreases contrast and edge details. Deformations near the foreground edge can lead to darker appearances there.
- Using GrabCut for segmentation might misclassify edge pixels between foreground and background, leading to dark appearances near the foreground edge.

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