CSE 5524 HW 3 Utkarsh Pratap Singh Jadon

Question 1

Import necessary libraries

In [526…

```
import matplotlib.pyplot as plt
import matplotlib.image as mpimg
from skimage.color import rgb2gray
import cv2 as cv
import numpy as np
import math
from PIL import Image
import glob
import os
from os import listdir
from os.path import join, isfile
from skimage import morphology
from skimage import measure,color
```

Read and resize input RGB image

In [481…

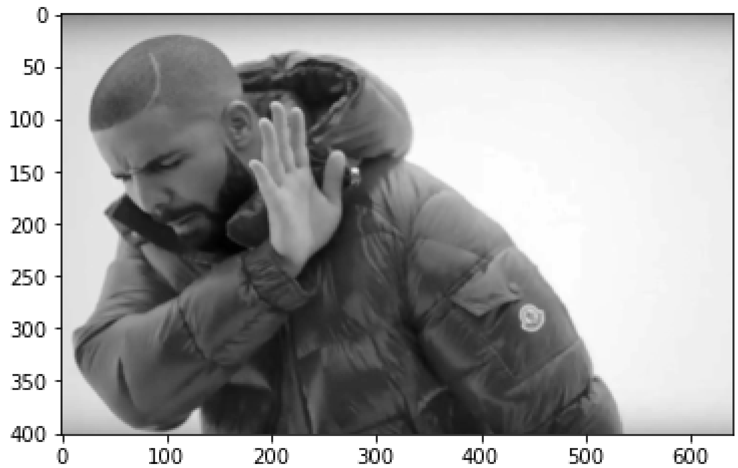
```
image1 = Image.open('Q1_Input Image.png') #Creates image object of original inp

# R = (Mr * 2^N) + 1
# C = (Mc * 2^N) + 1

# Here, N=3, and by taking Mr=80 & Mc=50, we get R=641 & C=401

inputImageResized = image1.resize((641, 401)) #Resizes original input RGB image
inputImageResized.save('Input RGB Image Resized.png') #Saves resized input RGB

plt.imshow(inputImageResized) #Displays resized input RGB image
print(inputImageResized.size) #Prints size of resized input RGB image
```

```
(641, 401)
```

Convert resized RGB image to single channel grayscale image

In [482…
```
image2 = cv.imread('Input RGB Image Resized.png') #Creates image object of resi
inputImageResizedGray = cv.cvtColor(image2, cv.COLOR_BGR2GRAY) #Convert resized
plt.imshow(inputImageResizedGray, cmap='gray') #Displays resized grayscale imag

# print(image2.shape) #Prints shape of resized RGB image
print(inputImageResizedGray.shape) #Print shape of resized single channel grays
```

```
(401, 641)
```



Create two separable Gaussian mask kernels: Wm and Wn

In [483…
```
#G(m,n) = w(m) * w(n) where w = [0.25-0.5*a 0.25 a 0.25 0.25-0.5a]
#Here a=0.4, hence w = [0.05 0.25 0.4 0.25 0.05]

wm = np.array([[0.05,0.25,0.4,0.25,0.05]])
wn = wm.transpose()

print(wm)
print(wn)
```

```
[[0.05 0.25 0.4  0.25 0.05]]
[[0.05]
 [0.25]
 [0.4 ]
 [0.25]
 [0.05]]
```

Create 1D Gaussian Blur function across columns using Wm kernel

In [487…
```
def gaussianBlurColumn(inputImageResizedGray):

    a,b = inputImageResizedGray.shape #Gets number of rows (or height) (a) and
    wmImage = np.zeros((a,b))         #Creates a vector with 'a' rows and 'b' co
    i=0
    j=0
    while(i<a):
        while(j<b-4):
            wmImage[i][j+2] = wm[0][0]*inputImageResizedGray[i][j] + wm[0][1]*i
            j+=1
```

```
        i+=1
        j=0

    return wmImage
```

1D Gaussian Blur across row using Wn kernel for Level 1

In [489…
```
def gaussianBlurRow(wmImage):

    c,d = wmImage.shape #Gets number of rows (or height) (x) and number of colu
    wnImage = np.zeros((c,d))
    i=0
    j=0
    while(j<d):
        while(i<c-4):
            wnImage[i+2][j] = wn[0][0]*wmImage[i][j] + wn[1][0]*wmImage[i+1][j]
            i+=1
        j+=1
        i=0

    return wnImage
```

Create interpolation function

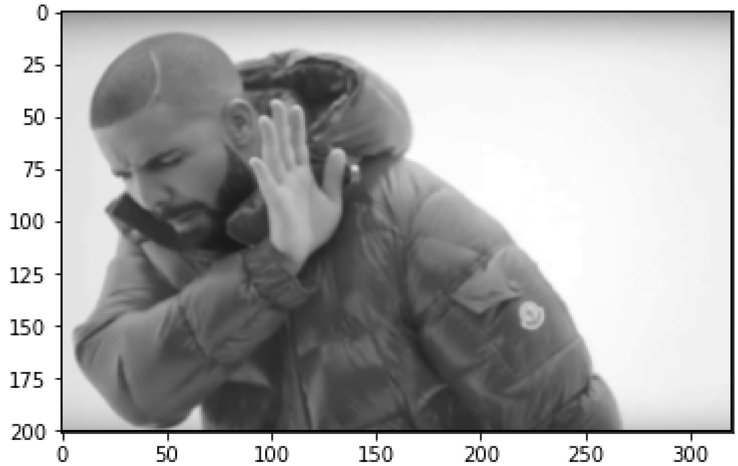
In [490…
```
def interpolation(input_img):

    a,b = input_img.shape                                #Gives rows (height) (a) and
    output_img = np.zeros((2*a - 1,2*b - 1))               #Creates blank image (=0) c

    i=0
    j=0

    while(i< (2*a - 1)):
        while(j< (2*b - 1)):
            if(j%2==0):
                output_img[i][j] = input_img[math.floor(i/2)][math.floor(j/2)]
            else:
                output_img[i][j] = (input_img[math.floor(i/2)][math.floor(j/2)]
            j+=1
        i+=1
        j=0

    i=1
    while(i< (2*a - 1)):
        output_img[i] = (output_img[i-1] + output_img[i+1]) / 2
        i+=2

    return output_img
```

Perform gaussian blurring and downsampling to get Level 1

In [491…
```
blurredColumn1 = gaussianBlurColumn(inputImageResizedGray)
blurredRow1 = gaussianBlurRow(blurredColumn1)
```

```
gaussianPyramidLevel1 = blurredRow1[0::2,0::2]
plt.imshow(gaussianPyramidLevel1, cmap='gray')
```

Out[491]: <matplotlib.image.AxesImage at 0x7febd227b370>



Perform gaussian blurring and downsampling to get Level 2

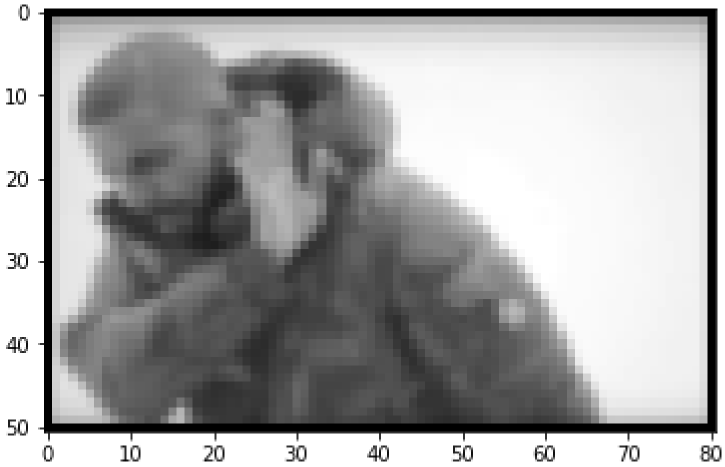
In [492…
```
blurredColumn2 = gaussianBlurColumn(gaussianPyramidLevel1)
blurredRow2 = gaussianBlurRow(blurredColumn2)
gaussianPyramidLevel2 = blurredRow2[0::2,0::2]
plt.imshow(gaussianPyramidLevel2, cmap='gray')
```

Out[492]: <matplotlib.image.AxesImage at 0x7febd26bc280>

Perform gaussian blurring and downsampling to get Level 3

In [493…
```
blurredColumn3 = gaussianBlurColumn(gaussianPyramidLevel2)
blurredRow3 = gaussianBlurRow(blurredColumn3)
gaussianPyramidLevel3 = blurredRow3[0::2,0::2]
plt.imshow(gaussianPyramidLevel3, cmap='gray')
```

Out[493]: <matplotlib.image.AxesImage at 0x7febd2772400>



Get interpolation estimates for N=2, N=1, and N=0 levels

In [494…

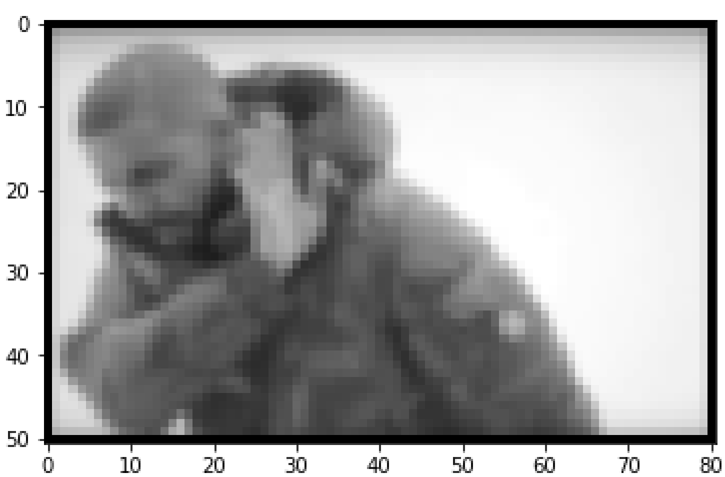
```
#Following section is to get interpolation estimates for N=2 from Gaussian pyra

interpolationLevel2 = interpolation(gaussianPyramidLevel3)
#plt.imshow(interpolationLevel2, cmap='gray')

#Following section is to get interpolation estimates for N=1 from Gaussian pyra

interpolationLevel1 = interpolation(gaussianPyramidLevel2)
#plt.imshow(interpolationLevel1, cmap='gray')

#Following section is to get interpolation estimates for N=0 from Gaussian pyra

interpolationLevel0 = interpolation(gaussianPyramidLevel1)
#plt.imshow(interpolationLevel0, cmap='gray')
```

Get Laplacian pyramid for N=3

In [495…

```
laplacianPyramidLevel3 = gaussianPyramidLevel3
plt.imshow(laplacianPyramidLevel3, cmap='gray')
```

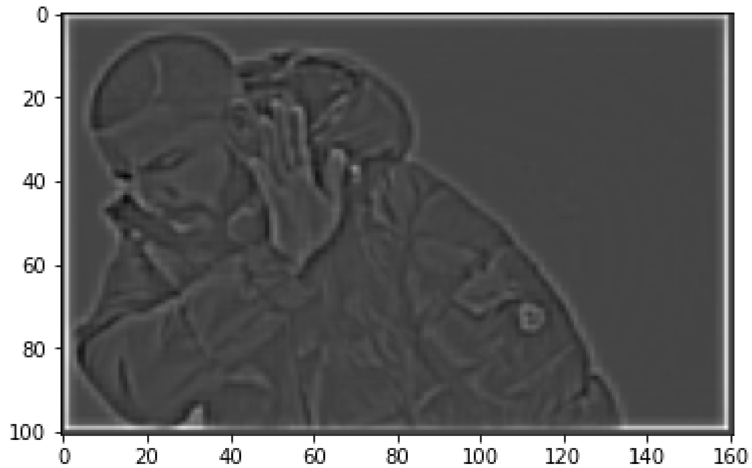
Out[495]: <matplotlib.image.AxesImage at 0x7febd28e76d0>



Get Laplacian pyramid for N=2

In [496…
```
laplacianPyramidLevel2 = gaussianPyramidLevel2 - interpolationLevel2
plt.imshow(laplacianPyramidLevel2, cmap='gray')
```

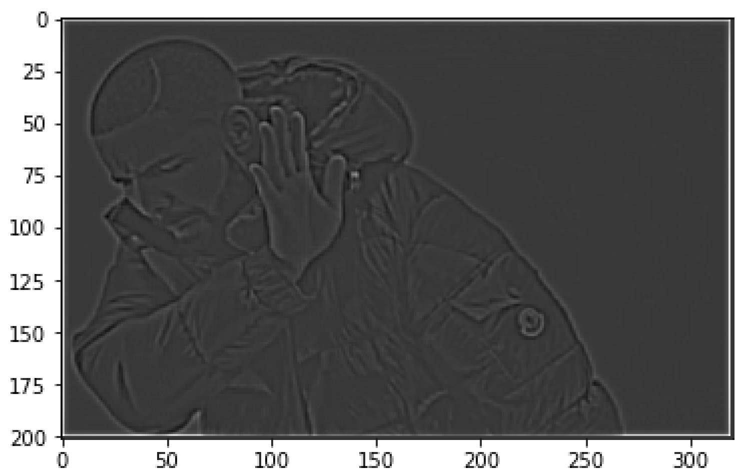
Out[496]: <matplotlib.image.AxesImage at 0x7fe63ba0d4f0>



Get Laplacian pyramid for N=1

In [497…
```
laplacianPyramidLevel1 = gaussianPyramidLevel1 - interpolationLevel1
plt.imshow(laplacianPyramidLevel1, cmap='gray')
```

Out[497]: <matplotlib.image.AxesImage at 0x7fec7008b520>



Get Laplacian pyramid for N=0

In [498…
```
laplacianPyramidLevel0 = inputImageResizedGray - interpolationLevel0
plt.imshow(laplacianPyramidLevel0, cmap='gray')
```

Out[498]: <matplotlib.image.AxesImage at 0x7febd2d98b50>

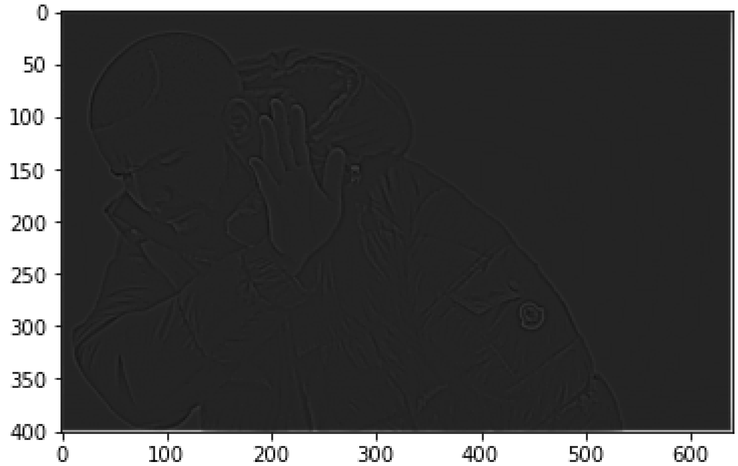


Image reconstruction for N=3

In [499…
```
reconstructedImageLevel3 = laplacianPyramidLevel3
plt.imshow(reconstructedImageLevel3, cmap='gray')
```

Out[499]: <matplotlib.image.AxesImage at 0x7fec75b3aa30>

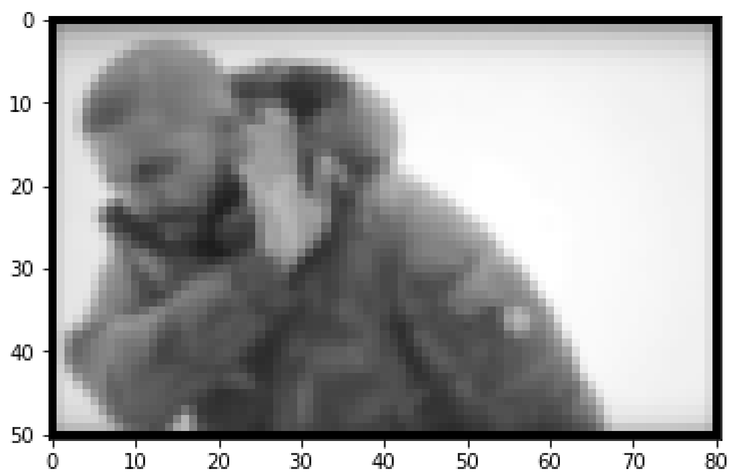


Image reconstruction for N=2

In [500…
```
reconstructedImageLevel2 = laplacianPyramidLevel2 + interpolationLevel2
plt.imshow(reconstructedImageLevel2, cmap='gray')
```

Out[500]: <matplotlib.image.AxesImage at 0x7febd2d6d610>

Image reconstruction for N=1

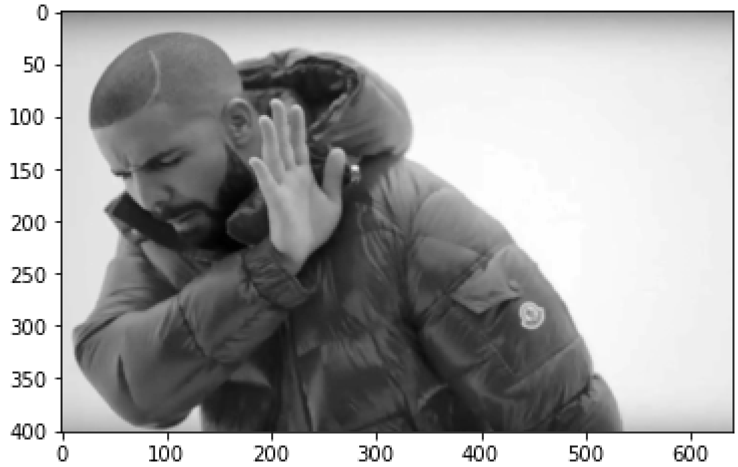
In [501…
```
reconstructedImageLevel1 = laplacianPyramidLevel1 + interpolationLevel1
plt.imshow(reconstructedImageLevel1, cmap='gray')
```

Out[501]: <matplotlib.image.AxesImage at 0x7fecc2eb94c0>

Image reconstruction for N=0

In [248…
```
reconstructedImageLevel0 = laplacianPyramidLevel0 + interpolationLevel0
plt.imshow(reconstructedImageLevel0, cmap='gray')
```

Out[248]: <matplotlib.image.AxesImage at 0x7fec8130a4c0>



Discussion

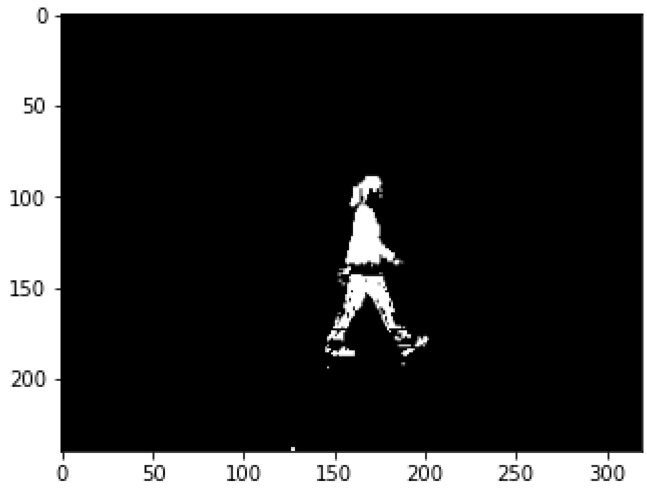
Original images require a lot of computation to send/receive. With the use of a Laplacia pyramid, we can send and resconstruct the original image with much less time and more efficiency.

Question 2

In [507…

```
background000 = cv.imread('bg000.bmp')                                  #Reads input
background000 = np.asarray(background000,dtype=np.float64)              #Converts in
foreground = cv.imread('walk.bmp')                                      #Reads foreg
foreground = np.asarray(foreground,dtype=np.float64)                    #Converts fo

a,b,c = background000.shape         #Gets rows(a), columns(b), and channels(c)

outputImage = np.zeros((a,b,c))     #Creates a zero image with same dimensions a

i=0
j=0
k=0
T=80            #Set threshhold value

while(k<c):
    while(i<a):
        while(j<b):
            if(abs(background000[i][j][k] - foreground[i][j][k]) > T):
                outputImage[i][j][k] = 1
            j+=1
        i+=1
        j=0
    k+=1
    i=0
    j=0

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

Out[507]: <matplotlib.image.AxesImage at 0x7febd34530a0>



Discussion

For lower threshhold values, we see that along with foreground, more than required sections of background are also retained. And for higher values of threshhold, less than required sections of foreground are retained. Hence, values around T=60 gives an acceptable background subtraction for type 1

Question 3

In [509…

```
#Following section reads multiple background images

backgroundImages = [cv.imread(file) for file in glob.glob("bg images/*.bmp")]

a,b,c = backgroundImages[0].shape    #Gets rows, columns, and channels in backg
i=0      #For rows
j=0      #For columns
k=0      #For channel
l=0      #To access images for average
m=0      #To access images for variance
add=0
square=0
pixelAverage = np.zeros((a,b,c))
pixelAverage = np.asarray(pixelAverage,dtype=np.float64)
pixelVariance = np.zeros((a,b,c))
pixelVariance = np.asarray(pixelVariance,dtype=np.float64)

#Following section generates matrix with average values of pixels in time domai

for k in range(c):
    for i in range(a):
        for j in range(b):

            for l in range(30):
                add += backgroundImages[l][i][j][k]
            pixelAverage[i][j][k] = add/30
            add = 0

            for m in range(30):
                square += ((backgroundImages[m][i][j][k] - pixelAverage[i][j][k
```

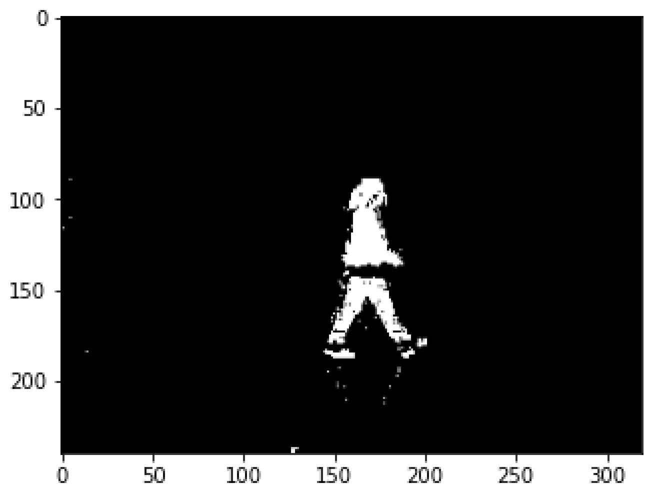
```
            pixelVariance[i][j][k] = square/30
            square = 0
```

In [510…

```
T=15      #Set threshhold value

outputImage = np.zeros((a,b,c))
outputImage = ((foreground - pixelAverage)**2) / (pixelVariance) > T**2
outputImage = np.asarray(outputImage,dtype=np.float64)
plt.imshow(outputImage,cmap='gray')
```

```
/var/folders/_z/7q8tzcpd3s7cr5lz406qzczw0000gn/T/ipykernel_2393/1705601871.py:
4: RuntimeWarning: divide by zero encountered in true_divide
  outputImage = ((foreground - pixelAverage)**2) / (pixelVariance) > T**2
/var/folders/_z/7q8tzcpd3s7cr5lz406qzczw0000gn/T/ipykernel_2393/1705601871.py:
4: RuntimeWarning: invalid value encountered in true_divide
  outputImage = ((foreground - pixelAverage)**2) / (pixelVariance) > T**2
```

Out[510]: <matplotlib.image.AxesImage at 0x7fecc2eff2b0>



Discussion

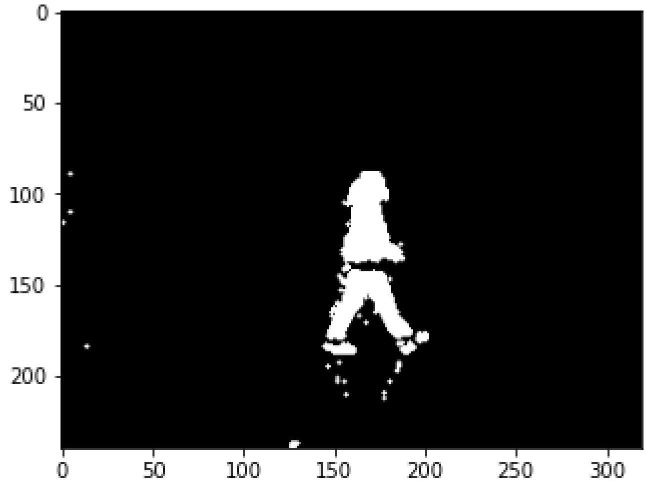
We see that a much more recognizable subtraction is done using this method. Also, the threshhold value required for this technique (15) is much lower than what was required in background subtraction 1 (60) to get acceptable output

Question 4

In [459…

```
dilatedImage = morphology.dilation(outputImage)
plt.imshow(dilatedImage,cmap='gray')
```

Out[459]: <matplotlib.image.AxesImage at 0x7febd1fbe220>



Discussion

Dilation adds pixels to the boundary of object in an image. Here, we see that the object has more white pixels than the original binary image.

Question 5

In [531…

```
L,num = measure.label(dilatedImage,connectivity=2,return_num=True)
print('Number of regions is',num)
```

```
Number of regions is 18
```

In [ ]: