COMPUTER VISION
PROJECT

<u>CANNY EDGE DETECTOR</u>

Name: Shweta Shrivastava
NetId: sas1472

1. File name of your source code - CannyEdgeDetector_sas1472.ipynb

2. Instructions on how to run your program and instructions on how to compile your program if your program requires compilation.
    a. Open Jupyter notebook using “jupyter notebook”.
    b. Insert path of test images and threshold value under “path” in the “runProject(" ",)” function.
    For example:

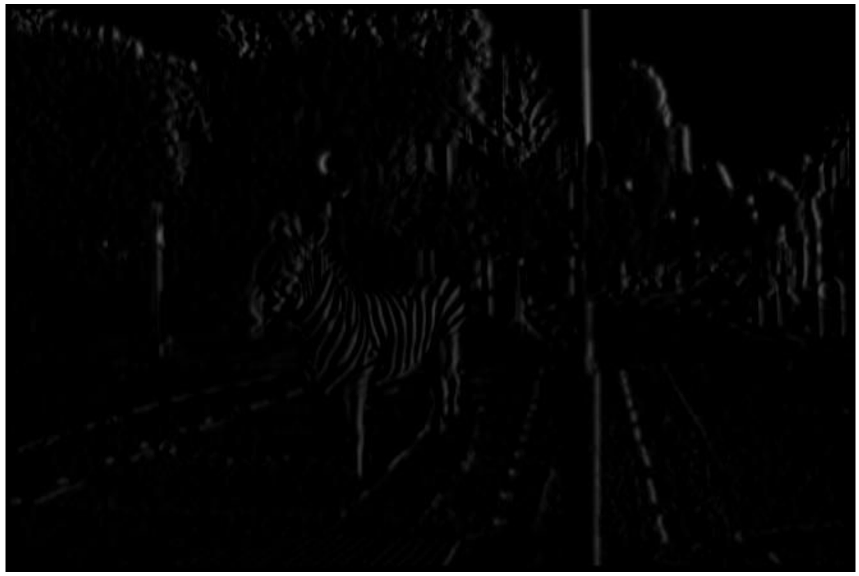
runProject("/Users/shwetasrivastava/Documents/CV/Zebra-crossing-1.bmp",9)

    c. Run Jupyter notebook.

3. Output image results (1) to (5) for all test images.
    a. Normalized image result after Gaussian smoothing.
        i. Zebra-crossing-1_GaussianSmoothing.jpg

        ii. Houses-225_GaussianSmoothing.jpg

b. Normalized horizontal and vertical gradient responses (two separate images.)
    i. Normalized horizontal gradient response
        1. Zebra-crossing-1_GradientX.jpg

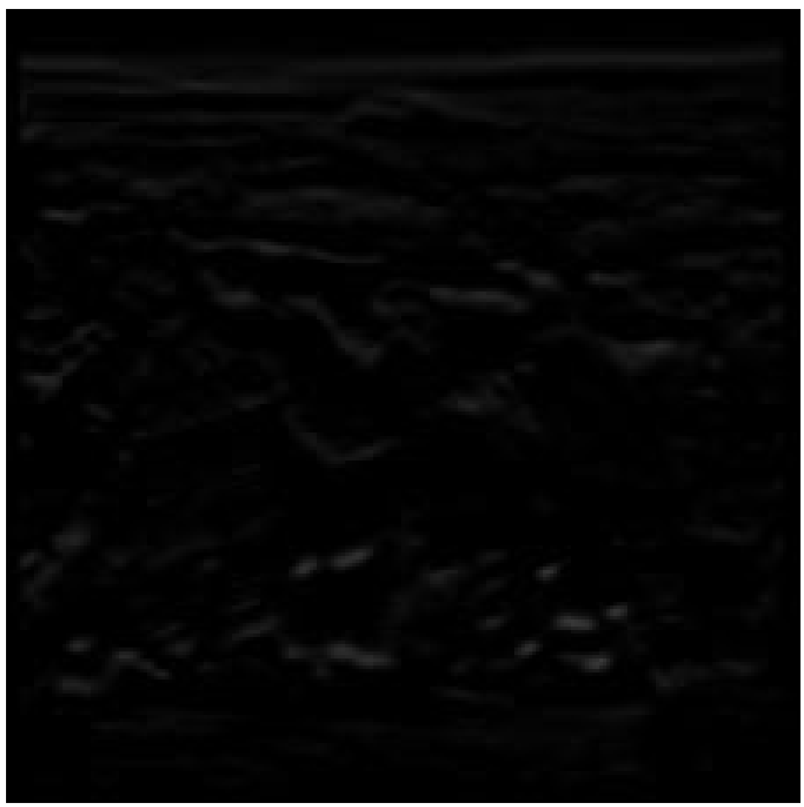


        2. Houses-225_GradientX.jpg

ii. Normalized vertical gradient response

1. Zebra-crossing-1_GradientY.jpg

2. Houses-225_GradientY.jpg



c. Normalized gradient magnitude image

i. Zebra-crossing-1_GradientMagnitude.jpg

ii. Houses-225_GradientMagnitude.jpg

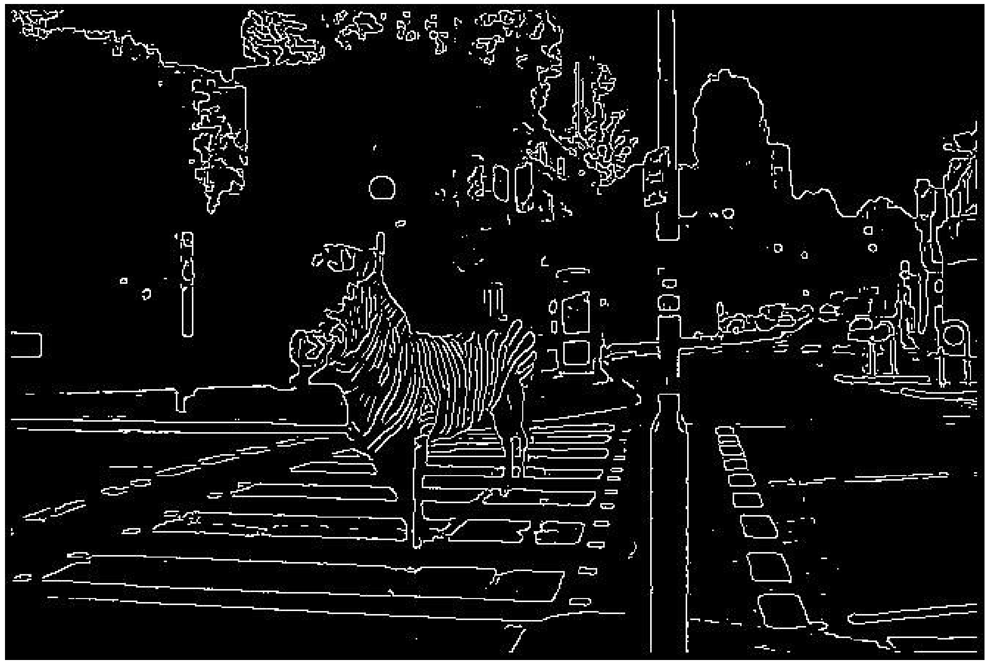
d. Normalized gradient magnitude image after non-maxima suppression.

i. Houses-225_nonMaximaSuppressed.jpg

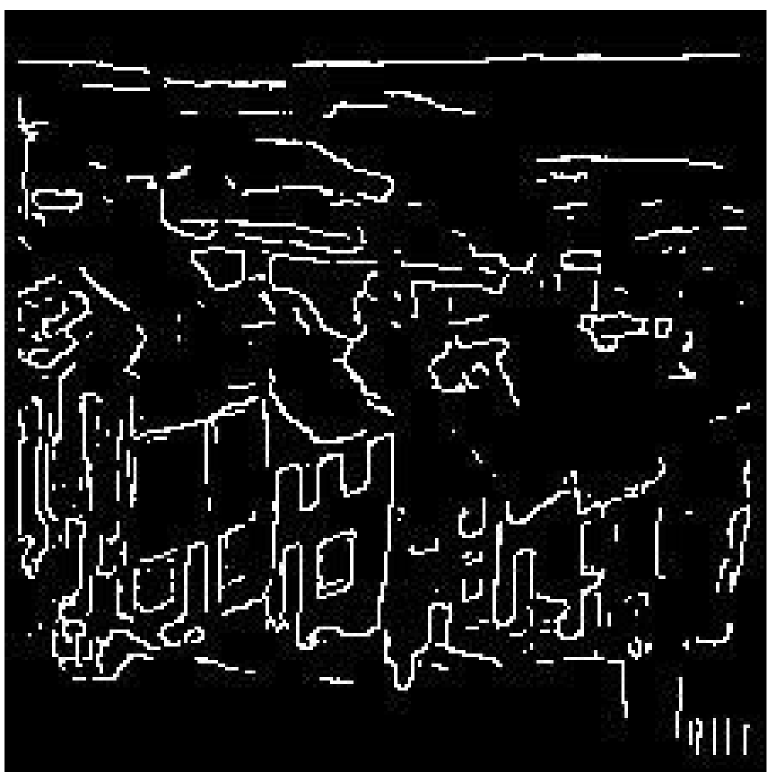
ii. Zebra-crossing-1_nonMaximaSuppressed.jpg

e. Binary edge map using double thresholding

i. Zebra-crossing-1_DoubleThreshold.jpg (T1=9, T2=18)



ii. Houses-225_DoubleThreshold.jpg (T1=8,T2=16)



(v) The source code of your program.

```
import numpy as np
import PIL.Image
import matplotlib.pyplot as plt
import math

np.warnings.filterwarnings('ignore')

def loadImage(path):
    '''
    Reads an image and return an array containing pixel intensity values
    Input : type - String
            value - Path to the image

    Returns : type - 2D numpy array
            value - Pixel Intensity Values at each pixelmpy array of image
    '''

    print("-----Loading Image-----")

    # Open a grayscale image
    image = PIL.Image.open(path).convert('L')

    #make numpy array of the image
    image = np.array(image)

    #print shapes of the image arrays
    print("image shape[0]",image.shape[0])
    print("image shape[0]",image.shape[1])
    return image

def gaussianSmoothing(image):
    '''
    Reads an array of of pixel intensity values and applies 7x7 gaussian smoothening

    Input: type - numpy array
                value - Pixel Intensity values

    Returns: type - numpy array
                values - Pixel Intensity values after gaussian smoothening
    '''
    print("-----Gaussian Smoothing-----")
```

```
    #declare the convolution mask
    convolutionMask =
np.array([[1,1,2,2,2,1,1],[1,2,2,4,2,2,1],[2,2,4,8,4,2,2],[2,4,8,16,8,4,2],[2,2,4,8,4,2,2],[1,2,2,4,2,2,
1],[1,1,2,2,2,1,1]])

    #declare the output array
    output = np.zeros((image.shape[0]-6, image.shape[1]-6))
    print("output shape[0]",image.shape[0]-6)
    print("output shape[1]",image.shape[1]-6)

    #apply convolution mask after looping through every pixel
    for x in range(image.shape[0]-6):
        for y in range(image.shape[1]-6):
            # Applying the convolution filter
            output[x,y]=round(float(((convolutionMask*image[x:x+7,y:y+7]).sum())/140),2)

    # Assig the calculated pixel values to outputImage
    outputImage = np.zeros((image.shape[0], image.shape[1]))
    outputImage[3:-3, 3:-3] = output
    print("Image after Gaussian Smoothing")
    plt.imshow(outputImage, cmap='gray')
    plt.show()

    return outputImage

def gradientOperator(image):
    '''
    Reads an array of of pixel intensity values and applies prewitt's gradient operator

    Input: tyoe - numpy array
                value - Pixel Intensity values

    Returns: type - 4 numpy arrays
                values - return 1 : Gradient about X-axis
                         return 2 :  Gradient about Y-axis
                            return 3 :  Gradient Magnitude
                               return 4 :  Gradient Angle
    '''
    print("-----Gradient Operator-----")

    #print shapes of the image arrays
    print("image shape[0]",image.shape[0])
```

```
    print("image shape[0]",image.shape[1])

    #declare Sobel's operator
    gradX = np.array([[-1,0,1],[-2,0,2],[-1,0,1]])
    gradY = np.array([[1,2,1],[0,0,0],[-1,-2,-1]])

    #declare output arrays
    outputX = np.zeros((image.shape[0] - 8, image.shape[1] - 8))
    outputY = np.zeros((image.shape[0] - 8, image.shape[1] - 8))
    outputImageX = np.zeros((image.shape[0], image.shape[1]))
    outputImageY = np.zeros((image.shape[0], image.shape[1]))

    #apply the operator
    for x in range(3, image.shape[0]-6):
        for y in range(3, image.shape[1]-6):
            outputX[x-3,y-3]=((gradX*image[x:x+3,y:y+3]).sum())
            outputY[x-3,y-3]=((gradY*image[x:x+3,y:y+3]).sum())

    #normalizing image values
    outputX = outputX/4
    outputY = outputY/4

    #assign calculted pixels to outImage
    outputImageX[4:-4,4:-4] = outputX
    outputImageY[4:-4,4:-4] = outputY

    #calculate gradient magnitude
    gradientMagnitude = np.around(np.sqrt((outputImageX * outputImageX) + (outputImageY *
outputImageY)))

    #calculate gradient angle in radians
    gradientAngle = np.arctan(np.true_divide(outputImageX, outputImageY))

    #convert gradient angle in radians to degrees
    gradientAngle = gradientAngle * (180 / np.pi)

    #plot normalized horizontal gradient response
    print("Normalized horizontal gradient response")
    plt.imshow(outputImageX, cmap='gray')
    plt.show()

    #plot normalized vertical gradient response
    print("Normalized vertical gradient response")
```

```
    plt.imshow(outputImageY, cmap='gray')
    plt.show()

    return outputImageX, outputImageY, gradientMagnitude, gradientAngle

def nonMaximaSuppression(gradientMagnitude, gradientAngle):
    '''
    Reads two arrays of gradient magnitude and gradient angle and performs non maxima
suppression

    Input: type - two numpy arrays
                value - gradient magnitude and gradient angle at every pixel

    Returns: type - numpy array
             values - non maxima suppressed image array
    '''
    print("-----Non Maxima Suppression-----")


    output = np.zeros((gradientMagnitude.shape[0], gradientMagnitude.shape[1]))

    # Loop over every pixel of the image
    for x in range(1, gradientMagnitude.shape[0]-1):
        for y in range(1, gradientMagnitude.shape[1]-1):
            currAngle = gradientAngle[x,y]
            currMagnitude = gradientMagnitude[x,y]

            # No need of else statement (in nested if conditions) as entire matrix is initially set to
zero

            if -22.5 <= currAngle <= 22.5 or currAngle <= -157.5 or currAngle >= 157.5: # Case 0
                if currMagnitude >= np.amax([currMagnitude, gradientMagnitude[x+1,y],
gradientMagnitude[x-1,y]]):
                    output[x,y] = currMagnitude

            elif 22.5 <= currAngle <= 67.5 or -112.5 >= currAngle >= -157.5: # Case 1
                if currMagnitude >= np.amax([currMagnitude, gradientMagnitude[x+1,y-1],
gradientMagnitude[x-1,y+1]]):
                    output[x,y] = currMagnitude

            elif 67.5 <= currAngle <= 112.5 or -67.5 >= currAngle >= -112.5: # Case 2
                if currMagnitude >= np.amax([currMagnitude, gradientMagnitude[x,y-1],
gradientMagnitude[x,y+1]]):
```

```
                output[x,y] = currMagnitude

          elif 112.5 <= currAngle <= 157.5 or -22.5 >= currAngle >= -67.5: # Case 3
             if currMagnitude >= np.amax([currMagnitude, gradientMagnitude[x-1,y-1],
gradientMagnitude[x+1,y+1]]):
                output[x,y] = currMagnitude

   #plot non maxima suppressed image
   print("Image after Non Maxima Suppression")
   plt.imshow(output,cmap='gray')
   plt.show()

   return output

def thresholding(T1,image,gradientMagnitude,gradientAngle):
   '''
   Reads three arrays of image,gradient magnitude and gradient angle and performs double
thresholding
   based on threshold T1

   Input: type - three numpy arrays, one integer
                value - Pixel Intensity values, gradient magnitude and gradient angle at every pixel,
threshold value

   Returns: type - numpy array
             values - final image after double thresholding
   '''

   #calculate T2
   T2=2*T1

   #loop through every pixel
   for x in range(0, image.shape[0]):
      for y in range(0, image.shape[1]):
          #if N[i,j]<T1, then E[i,j]=0
          if (image[x,y] < T1):
             image[x,y] = 0
          #if N[i,j]>T1, then E[i,j]=255
          elif (image[x,y] > T2):
             image[x,y] = 255
          #if pixel N(I,j) has an 8-connected neighbor N(i′,j′) with gradient magnitude N(i′,j′) > T2
          ## AND the gradient angles of N(i,j) and N(i′,j′) differ by 45° or less, then E[i,j]=255,
otherwise, then E[i,j]=0
```

```
        elif (T1 <= image[x,y] <= T2) :
            for i in range(-1,1):
                for j in range(-1,1):
                    if((gradientMagnitude[x+i,y+j]>T2) and
(abs(gradientMagnitude[x+i,+j]-gradientMagnitude[x,y])<=45)):
                        image[x,y] = 255
                    else:
                        image[x,y] = 0

    return image

def runProject(path,T1):
    '''
    Reads path and thresholding value to perform Canny Edge Detection

    Input: type - string, integer
                value - path where image is stored, threshold value

    Returns: type - plot
            values - final image
    '''

    #Loading image
    image=loadImage(path)

    #Gaussian Smoothing
    gaussianImage = gaussianSmoothing(image)
    saveImage = PIL.Image.fromarray(gaussianImage).convert("RGB")
    saveImage.save(path[:-4] + "_GaussianSmoothing" + ".jpg")

    #Apply Gradient Operator
    gradientX, gradientY,gradientMagnitude,gradientAngle = gradientOperator(gaussianImage)
        ##saving normalized vertical gradient response
    saveImage = PIL.Image.fromarray(gradientX).convert("RGB")
    saveImage.save(path[:-4] + "_GradientX" + ".jpg")
        ##saving normalized vertical gradient response
    saveImage = PIL.Image.fromarray(gradientY).convert("RGB")
    saveImage.save(path[:-4] + "_GradientY" + ".jpg")
        ##saving normalized gradient magnitude image
    saveImage = PIL.Image.fromarray(gradientMagnitude).convert("RGB")
    saveImage.save(path[:-4] + "_GradientMagnitude" + ".jpg")

    #Non-Maxima Suppression
```

```
    nonMaximaImage=nonMaximaSuppression(gradientMagnitude, gradientAngle)
    saveImage = PIL.Image.fromarray(nonMaximaImage).convert("RGB")
    saveImage.save(path[:-4] + "_nonMaximaSuppressed" + ".jpg")

    #Double thresholding
    thresholdedImage=thresholding(T1,nonMaximaImage,gradientMagnitude,gradientAngle)
    saveImage = PIL.Image.fromarray(thresholdedImage).convert("RGB")
    saveImage.save(path[:-4] + "_DoubleThreshold" + ".jpg")

    #Plot final output image
    plt.imshow(thresholdedImage, cmap='gray')
    plt.show()

runProject("/Users/shwetasrivastava/Documents/CV/Houses-225.bmp",8)
runProject("/Users/shwetasrivastava/Documents/CV/Zebra-crossing-1.bmp",9)
```