Experiment No. 3	
To study Edge Detection with Canny	
Date of Performance:	
Date of Submission:	

Aim: To study Edge detection with Canny

Objective: Perform Canny Edge detector using Noise reduction using Gaussian filter ,Gradient calculation along the horizontal and vertical axis Non-Maximum suppression of false edges ,Double thresholding for segregating strong and weak edges ,Edge tracking by hysteresis

Theory: The Canny edge detector is an edge detection operator that uses a multi-stage algorithm to detect a wide range of edges in images. It was developed by John F. Canny in 1986. Canny also produced a computational theory of edge detection explaining why the technique works.

What are the three stages of the Canny edge detector

To fu1fi11 these objectives, the edge detection process included the following stages.

- Stage One - Image Smoothing.
- Stage Two - Differentiation.
- Stage Three - Non-maximum Suppression. The basic steps involved in this algorithm are:
  - Noise reduction using Gaussian filter
  - Gradient calculation along the horizontal and vertical axis
  - Non-Maximum suppression of false edges

- Double thresholding for segregating strong and weak edges
- Edge tracking by hysteresis

Now let us understand these concepts in detail:

1. Noise reduction using Gaussian filter

This step is of utmost importance in the Canny edge detection. It uses a Gaussian filter for the removal of noise from the image, it is because this noise can be assumed as edges due to sudden intensity change by the edge detector. The sum of the elements in the Gaussian kernel is 1, so the kernel should be normalized before applying convolution to the image. In this Experiment, we will use a kernel of size 5 X 5 and sigma = 1.4, which will blur the image and remove the noise from it. The equation for Gaussian filter kernel is

$$G_\sigma = \frac{1}{2\pi\sigma^2} e^{-\frac{(x^2+y^2)}{2\sigma^2}}$$

$$K_x = \begin{pmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{pmatrix}, K_y = \begin{pmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{pmatrix}.$$

after applying these kernel we can use the gradient magnitudes and the angle to further process this step. The magnitude and angle can be calculated as

$$|G| = \sqrt{I_x^2 + I_y^2},$$

$$\theta(x, y) = arctan\left(\frac{I_y}{I_x}\right)$$

Non-Maximum Suppression

This step aims at reducing the duplicate merging pixels along the edges to make them uneven. For each pixel find two neighbors in the positive and negative gradient directions, supposing that each neighbor occupies the angle of pi /4, and 0 is the direction straight to the right. If the magnitude of the current pixel is greater than the magnitude of the neighbors, nothing changes, otherwise, the magnitude of the current pixel is set to zero.

4. Double Thresholding

The gradient magnitudes are compared with two specified threshold values, the first one is lower than the second. The gradients that are smaller than the low threshold value are suppressed, the gradients higher than the high threshold value are marked as strong ones and the corresponding pixels are included in the final edge map. All the rest gradients are marked as weak ones and pixels corresponding to these gradients are considered in the next step.

5. Edge Tracking using Hysteresis

Since a weak edge pixel caused by true edges will be connected to a strong edge pixel, pixel W with weak gradient is marked as edge and included in the final edge map if and only if it is involved in the same connected component as some pixel S with strong gradient. In other words, there should be a chain of neighbor weak pixels connecting W and S (the neighbors are 8 pixels around the considered one). We will make up and implement an algorithm that finds all the connected components of the gradient map considering each pixel only once. After that, you can decide which pixels will be included in the final edge map. Below is the implementation.

```
import
numpy as np
import os

import cv2

import matp1ot1ib.pyp1ot as plt

# defining the canny detector function

# here weak_th and strong th are
thresholds for # double thresholding
step

def Canny detector(img, weak th = None, strong th = None):

# conversion of image to grayscale

img = cv2.cvtCo1or(img, cv2.COLOR BGR2GRAY)
```

Noise reduction step

img = cv2.GaussianB1ur(img, (5, 5), 1.4)

Calculating the gradients

gx = cv2.Sobe1(np.f1oat32(img), cv2.CV 64F, 1, 0, 3)

gy = cv2.Sobe1(np.f1oat32(img), cv2.CV 64F, 0, 1, 3)

Conversion of Cartesian coordinates to polar

mag, ang = cv2.cartToPo1ar(gx, gy, angleInDegrees = True)

setting the minimum and maximum thresholds # for double thresholding

mag max = np.max(mag)

if not weak th:weak th = mag max * 0.1 if not strong_th:strong th = mag max * 0.5

getting the dimensions of the input image height, width = img.shape

Looping through every pixel of the grayscale # image

for i x in range(width):

for ip in range(height):

grad ang = ang[i y, i x]

grad ang = abs(grad ang-180) if abs(grad ang)>180 else abs(grad ang)
# selecting the neighbours of the target pixel # according to the gradient direction
# In the x axis direction
if grad ang&1t;= 22.5:
neighb 1 x, neighb 1 y = i x-1, i y neighb 2 x, neighb 2 y = i x + 1, ip

top right (diagonal-1) direction

elif grad ang>22.5 and grad ang<=(22.5 + 45): neighb 1 x, neighb 1 y = i x-1, i y-1

neighb 2 x, neighb 2 y = i_x + 1, ip + 1

In y-axis direction

elif grad ang>(22.5 + 45) and grad ang&It;=(22.5 + 90): neighb 1 x, neighb l y = i x, i y-1

neighb 2 x, neighb 2 y = i x, i y + 1

top left (diagonal-2) direction
elif grad_ang>(22.5 + 90) and grad_ang&1t;=(22.5 + 135): neighb 1 x, neighb 1 y = i_x-1, i y + 1

neighb 2 x, neighb 2 y = i x + 1, ip-1

Now it restarts the cycle

elif grad ang>(22.5 + 135) and grad ang&1t;=(22.5 + 180):

neighb 1 x, neighb 1 y = i x-1, i y

neighb 2 x, neighb 2 y = i x + 1, ip

Non-maximum suppression step

if width>neighb 1 x>= 0 and 1 >= 0:
height>neighb

if mag[i y, i x]<mag[neighb Ip, neighb 1 x]:
mag[ip, i x]= 0

continue

if width>neighb 2 x>= 0 and 2
height>neighb if mag[i y, i x]<mag[neighb 2 >= 0:
, neighb 2 x]:

mag[ip, i x]= 0

weak ids = np.zeros like(img)
strong ids = np.zeros
like(img)

ids = np.zeros like(img)

double thresholding
step for i x in
range(width): for ip in
range(height): grad mag
= mag[i y, i x]

if grad mag&1t;weak th:

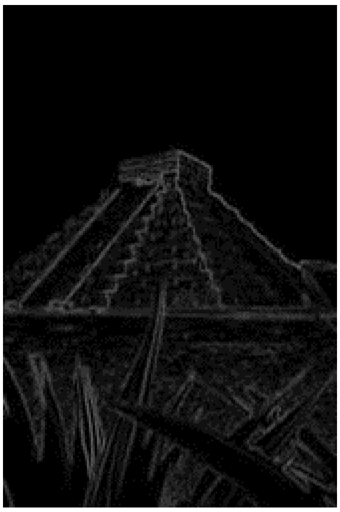
mag[ip, i x]= 0

elif strong th>grad mag>= weak th:
ids[ip, i x]= 1

```
else:

ids[ip, i x]= 2

# finally returning the magnitude of

# gradients of edges

return mag

frame = cv2.imread(&#39;food.jpeg&#39;)

# calling the designed function
for # finding edges

canny img = Canny detector(frame)

# Displaying the input and output image

plt.figure()

f, plots = plt.subp1ots(2,
1) plots[0].imshow(frame)
plots[1].imshow(canny
img)
```

Input:

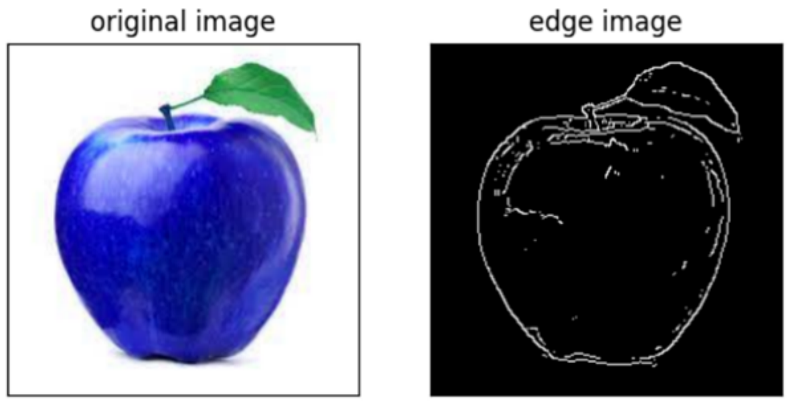
Output:



Code and Output: -

```
import cv2
import numpy as np
from matplotlib import pyplot as plt


img=cv2.imread('/content/download.jpeg')
edges=cv2.Canny(img,200,200)
plt.subplot(121), plt.imshow(img,cmap='gray')
plt.title('original image'),plt.xticks([]),plt.yticks([])
plt.subplot(122),plt.imshow(edges,cmap='gray')
plt.title('edge image'),plt.xticks([]),plt.yticks([])
plt.show
```

```
<function matplotlib.pyplot.show(close=None, block=None)>
```



Conclusion:

Canny edge detection is a widely-used technique for identifying edges in images. It involves multiple stages, including noise reduction, gradient calculation, non-maximum suppression, and hysteresis thresholding. Its strengths lie in accurately detecting edges in noisy images and handling thin and faint edges. However, tuning threshold values can be challenging, and it may struggle with complex textures or overlapping edges. Despite its limitations, Canny edge detection remains a fundamental tool in computer vision and image processing, with ongoing research aimed at refining and developing more advanced edge detection techniques.