Session 6

Image Derivatives and Edge Detection

OBJECTIVE:

The objective of this lab is to understand & implement

1. To learn about different edge detection operators
2. Use of second derivative for image enhancement: the Laplacian
3. Use of first derivative for image enhancement: the Gradient
4. To implement Image segmentation using edge detection technique.

IMAGE SEGMENTATION:

Image segmentation can be achieved in two ways.

1. Segmentation based on discontinuity of intensity
2. segmentation based on similarities based on intensity edge detection from an important part

An edge can be defined as a set of disconnected pixels that form a boundary between two disjoin regions

EDGE DETECTION MASK:

Edge detection is performed using various masks/operators. An edge detection mask is usually a $n \times n$ matrix which is used as a sliding window on an image and the dot product of the maks and image window is placed on the edge-derived image's corresponding window's center pixel. In Table 6.1, we have shown a 3×3 image pixel window. Different edge detection operators can be applied here.

z_1	z_2	z_3
z_4	z_5	z_6
z_7	z_8	z_9

Table 6.1: A 3×3 image used for mask illustration

ALGORITHM:

1. Construct an empty image with same dimensions as input image
2. Choose an edge detection mask and use it as sliding window over the image
3. With each input image pixel as center, calculate the dot product of the mask and the corresponding image window
4. Place the result in the corresponding image pixel (center) of the empty image
5. At the end, return the new image

ROBERT'S MASK:

Equation: $\nabla f \approx |z_5 - z_9| + |z_6 - z_8|$
Masks along x-axis, y-axis and the sum of masks are:

$\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$, $\begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$ and $\begin{bmatrix} 1 & 1 \\ -1 & -1 \end{bmatrix}$ respectively.

PREWITT OPERATOR:

Equation: $\nabla f \approx |z_1 - z_7 + z_2 - z_8 + z_3 - z_9| + |z_3 - z_1 + z_6 - z_4 + z_9 - z_7|$
Masks along vertical axis and horizontal axis are:
$\begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}$, $\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$
respectively.

SOBEL OPERATOR:

Equation: $\nabla f \approx |z_1 - z_7 + 2z_2 - 2z_8 + z_3 - z_9| + |z_3 - z_1 + 2z_6 - 2z_4 + z_9 - z_7|$
Masks along vertical axis and horizontal axis are:

$\begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$, $\begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$
respectively.

LAPLACIAN OPERATOR:

Equation:
$\nabla f \approx |z_9 - z_5| + |z_8 - z_6|$
$\nabla^2 f = [f(x+1, y) + f(x-1, y) + f(x, y+1) + f(x, y-1)] - 4f(x, y)$

$$g(x,y) = \begin{cases} f(x,y) - \nabla^2 f(x,y) & \text{If the center coefficient of the Laplacian Mask is negative} \\ f(x,y) - \nabla^2 f(x,y) & \text{If the center coefficient of the Laplacian Mask is positive} \end{cases}$$

Laplacian Mask Operator:

$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 4 & -1 \\ 0 & -1 & 0 \end{bmatrix}$

CODE OF PREWITT EDGE DETECTION:

Program-code 6.1 shows a sample code of prewitt edge detection and Figure 6.1 shows the output.

```
function prewittEdge()

S = im2double(rgb2gray(imread('coins.jpg')));

%% defining filters
hx = [-1 0 1;
      -1 0 1;
      -1 0 1];

```

```
hy = [ 1   1   1;
       0   0   0;
      -1  -1  -1];

%% applying filters

Rx = imfilter(S, hx);
Ry = imfilter(S, hy);


figure;
subplot(1,3,1);
imshow(S);
title('input');

subplot(1,3,2);
imshow(Rx);
title('edges along x');

subplot(1,3,3);
imshow(Ry);
title('edges along y');

end
```

Program 6.1: Prewitt Edge Detection

SAMPLE INPUT/OUTPUT:

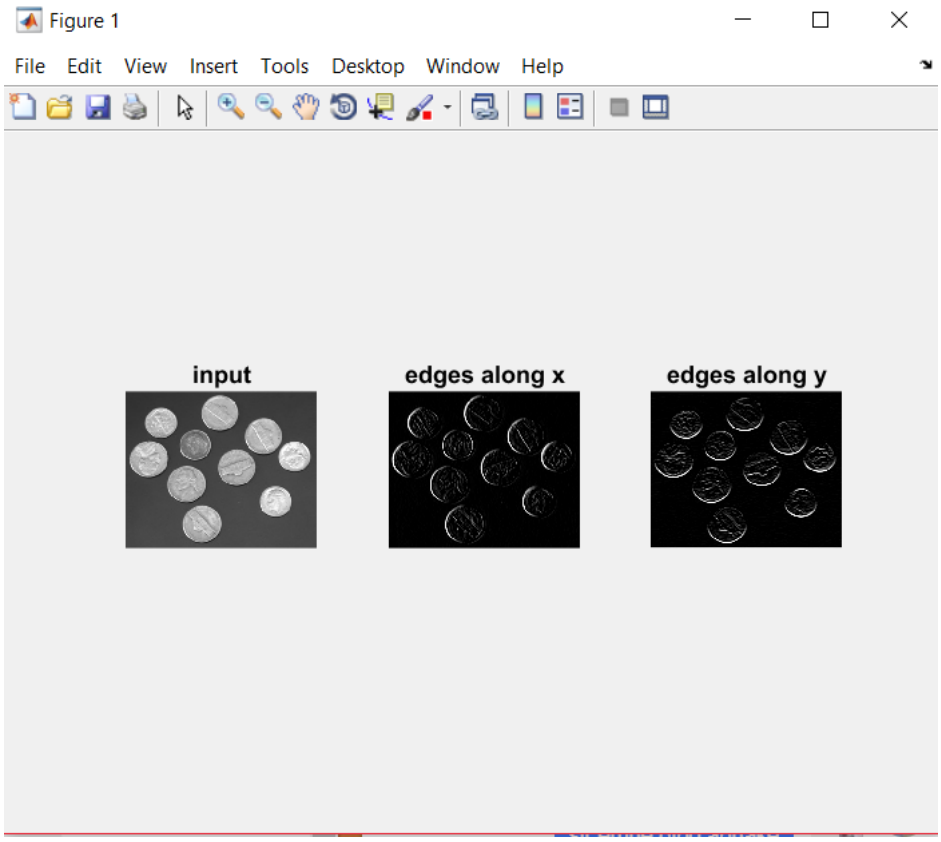

Figure 6.1: Original image and Edge Detected Image using Prewitt Operators in two directions.

CONCLUSION:

Prewitt is simpler to implement but sobel gives the better result. Laplacian is more sensitive to noise.

Question 1. Give the difference between first order derivative filter and second order derivative filter.

Question 2. What is compass gradient mask?

Task 1. Write a program to implement “Robert Cross Gradient Operator” and observe the changes on image.

Task 2. Write a program to implement “Sobel Gradient Operator” and observe the changes on image.

Task 3. Write a program to implement “Prewitt Operator” and observe the changes on image.

Task 4. Write a program to implement “Laplacian Operator” and observe the changes on image.

Task 5. Write a program to implement which will take an input image and an edge detection mask. It should return the edge-detected image.

Task 6. Write a program which will take the input image and return the output image as shown in Figure 6.2.

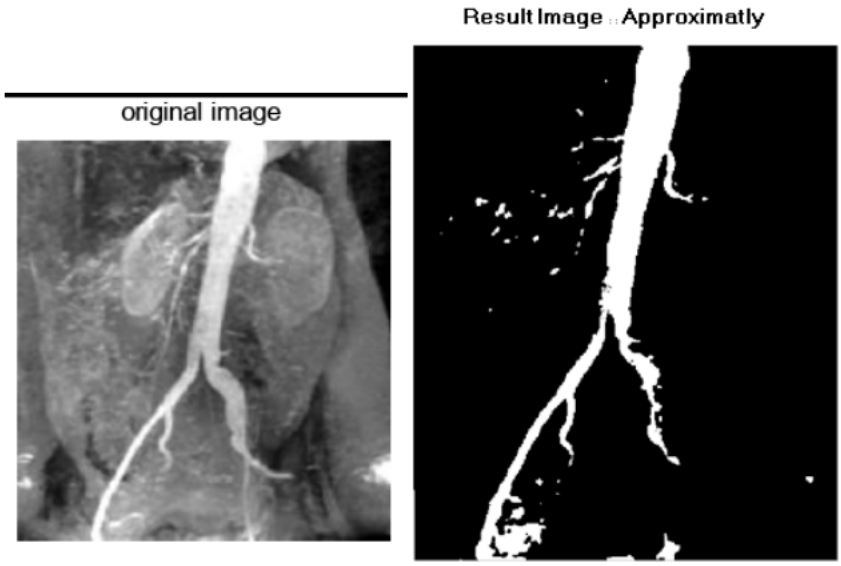

Figure 6.2: Original image and approximated binary edge directed image

MID TERM EXAMINATION

There will be a 40-minutes written mid-term examination. Different types of questions will be included such as MCQ, mathematics, writing code fragments etc.

FINAL TERM EXAMINATION

There will be a one-hour written examination. Different types of questions will be included such as MCQ, mathematics, write a program etc.