EE 417 COMPUTER VISION

Lab #3: Edge Detection with First and Second Order Derivative Filters

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Introduction

Lab #3 focuses on implementing edge detection algorithms based on Sobel, Prewitt and Laplacion of Gaussian operators.

Prewitt Operator

Prewitt filtering is a discrete 2D derivative operation which can be applied with the following kernels

-1	0	1
-1	0	1
-1	0	1

X Filter

-1	-1	-1
0	0	0
1	1	1

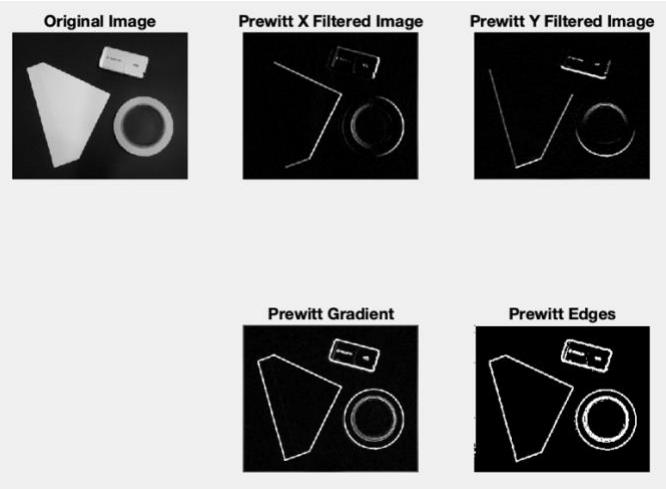
Y Filter

To detect edges in a grayscale image, the gradient image obtained by the horizontal and the vertical Prewitt operators is binarized by a threshold. The gradient image is calculated as

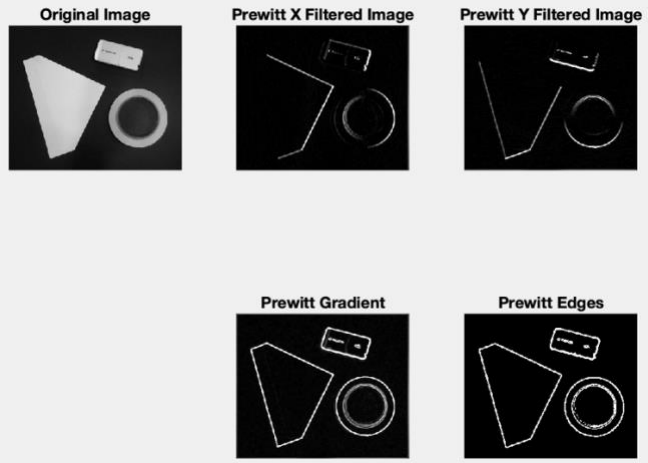
$$G(p) = \sqrt{G_x(p)^2 + G_y(p)^2}$$

Prewitt operator is a gradient-based operator. It computes the gradient approximation of image intensity function for image edge detection. At the pixels of an image, the Prewitt operator produces either the normal to a vector or the corresponding gradient vector. It uses two 3x3 kernels or masks shown above which are convolved with the input image to calculate approximations of the derivatives; one for horizontal changes, one for vertical.

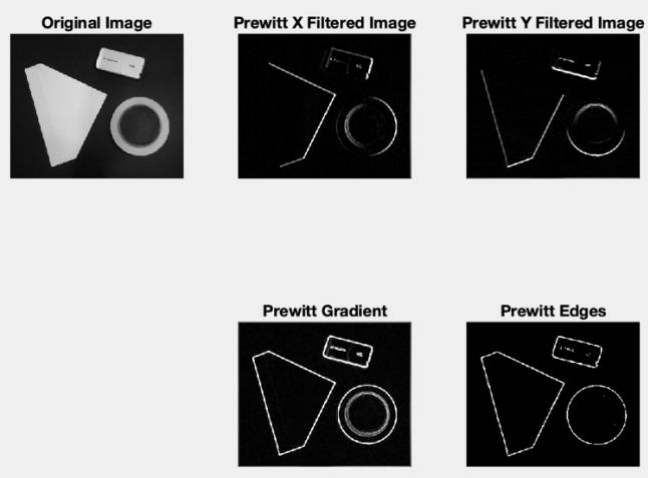
Results for lab3prewitt.m when the input is Object_contours.jpg and threshold is 50:



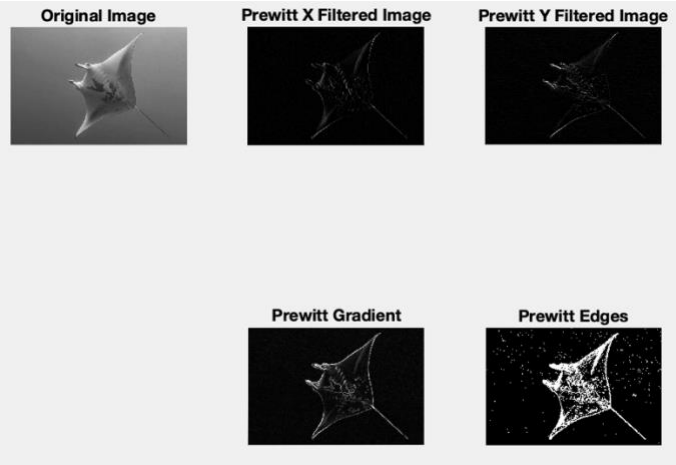
Results for lab3prewitt.m when the input is Object_contours.jpg and threshold is 100:



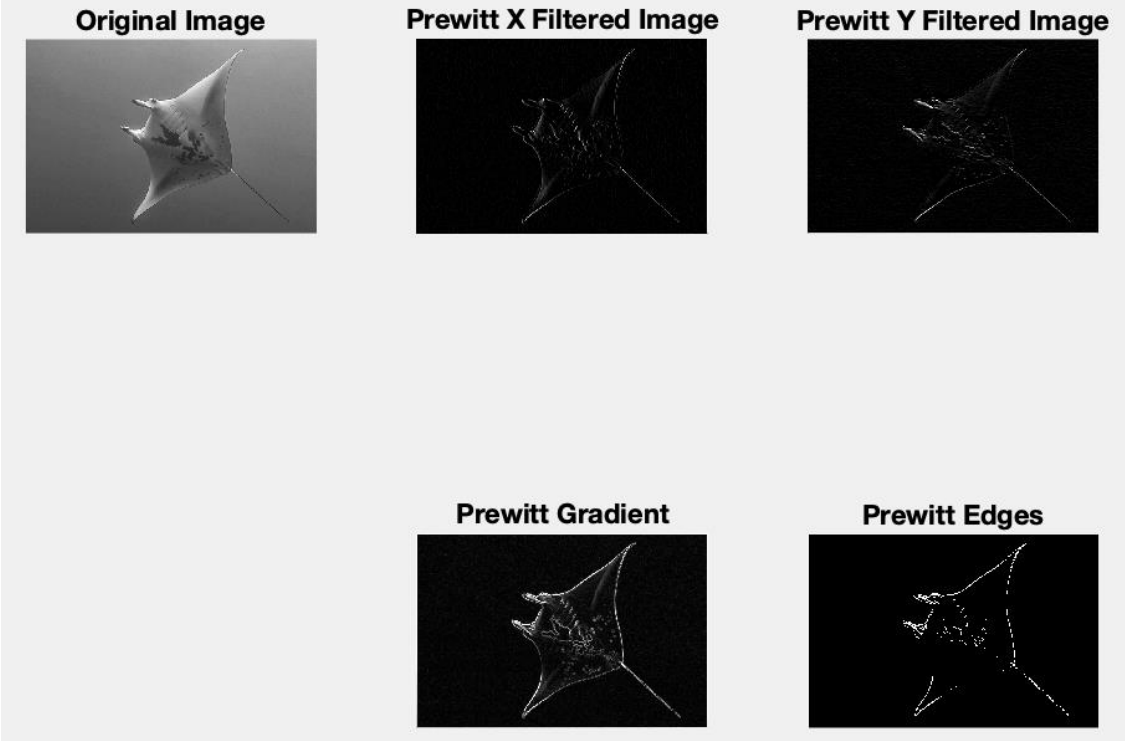
Results for lab3prewitt.m when the input is Object_contours.jpg and threshold is 250:



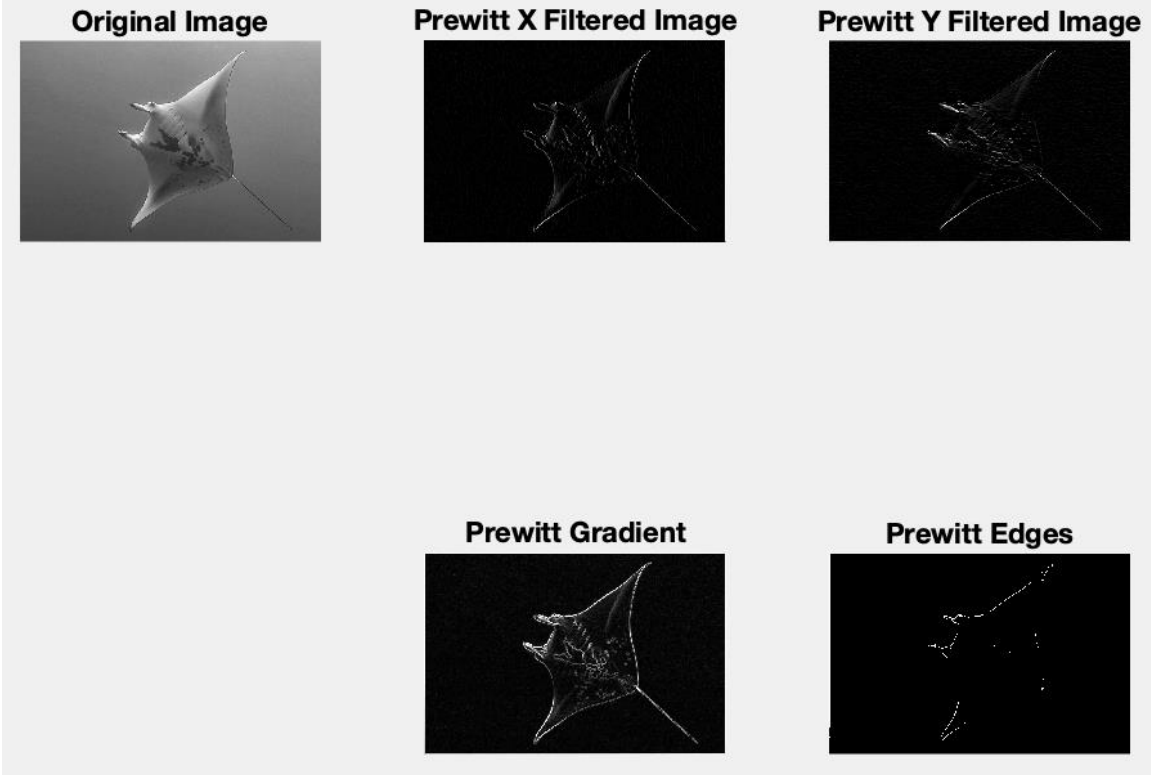
Results for lab3prewitt.m when the input is mantaRay.jpg and threshold is 20:



Results for lab3prewitt.m when the input is mantaRay.jpg and threshold is 120:



Results for lab3prewitt.m when the input is mantaRay.jpg and threshold is 220:



Prewitt Operator Conclusions

Prewitt filter approximates partial derivatives of the given image with the given kernels(convolution). The partial derivatives are discrete versions of gaussian convolutions of rows and columns. The local convolutions calculate partial derivatives(X-Y axis). Increasing the threshold value makes prewitt edges disappear. This can be easily observed from the mantaRay.jpg image results with different threshold values. Prewitt operator has great performance on detecting vertical & horizontal edges and orientation of an image. However the magnitutde of the coefficient is fixed and diagonal points are not preserved all the time.

Sobel Operator

Sobel filtering is a discrete 2D derivative operation which can be applied with the following kernels

-1	0	1
-2	0	2
-1	0	1

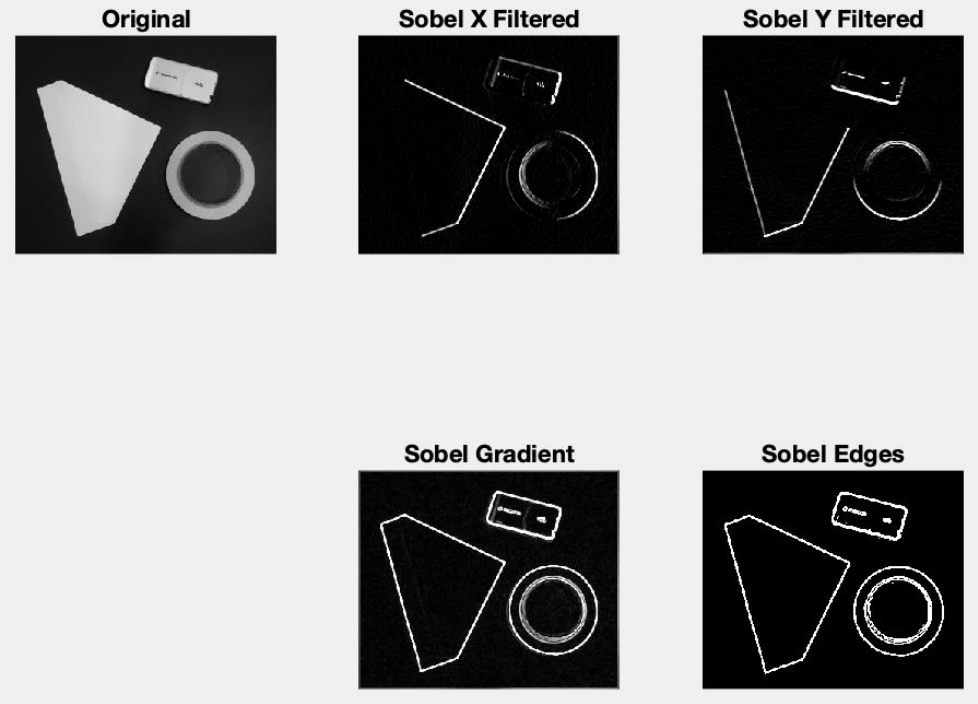
X Filter

-1	-2	-1
0	0	0
1	2	1

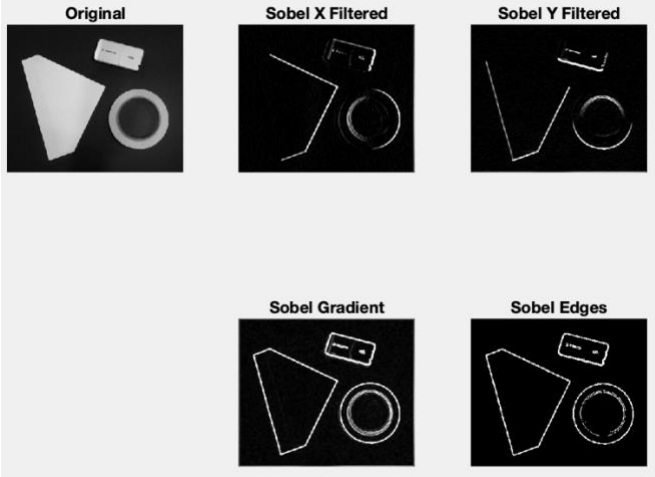
Y Filter

To detect edges in a grayscale image by employing Sobel operators, the same procedure is applied as Prewitt based edge detection except the kernels are changed.

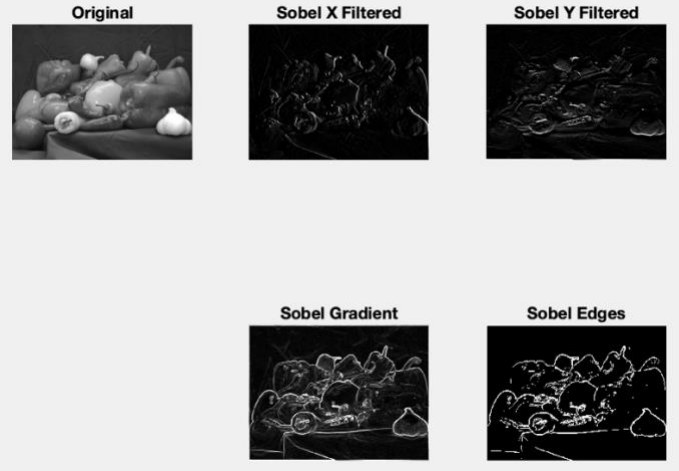
Results for lab3sobel.m when the input is Object_contours.jpg and threshold is 100:



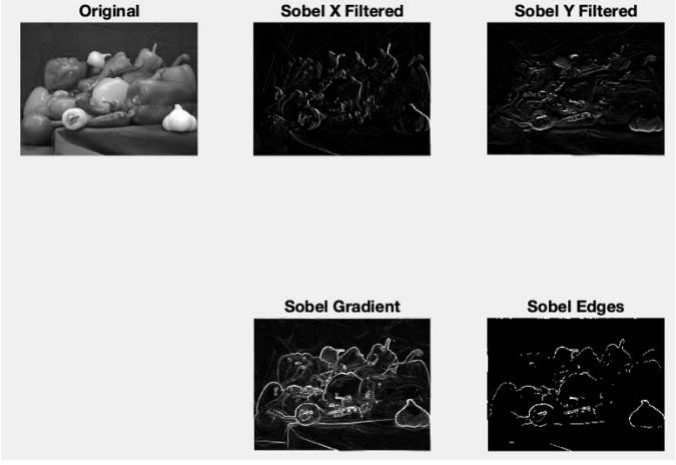
Results for lab3sobel.m when the input is Object_contours.jpg and threshold is 200:



Results for lab3sobel.m when the input is peppers.png and threshold is 100:



Results for lab3sobel.m when the input is peppers.png and threshold is 200:



Sobel Operator Conclusions

Sobel filter approximates partial derivatives of the given image with the given kernels(convolution). The partial derivatives are discrete versions of gaussian convolutions of rows and columns. The local convolutions calculate partial derivatives(X-Y axis). Increasing threshold makes Sobel edges disappear.

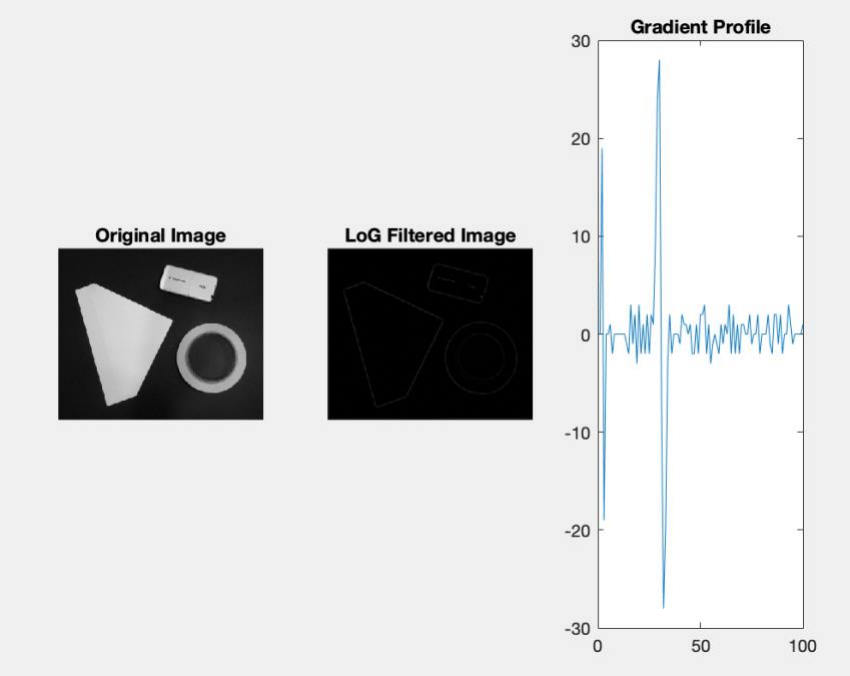
Laplacian of Gaussian Smoothed Image

As Laplace operator may detect edges as well as noise, it is des,rable to smooth the image first by a Gaussian filter. Applying the Laplacian for a Gauss-filtered image can be done in one step of convolution with the following kernel

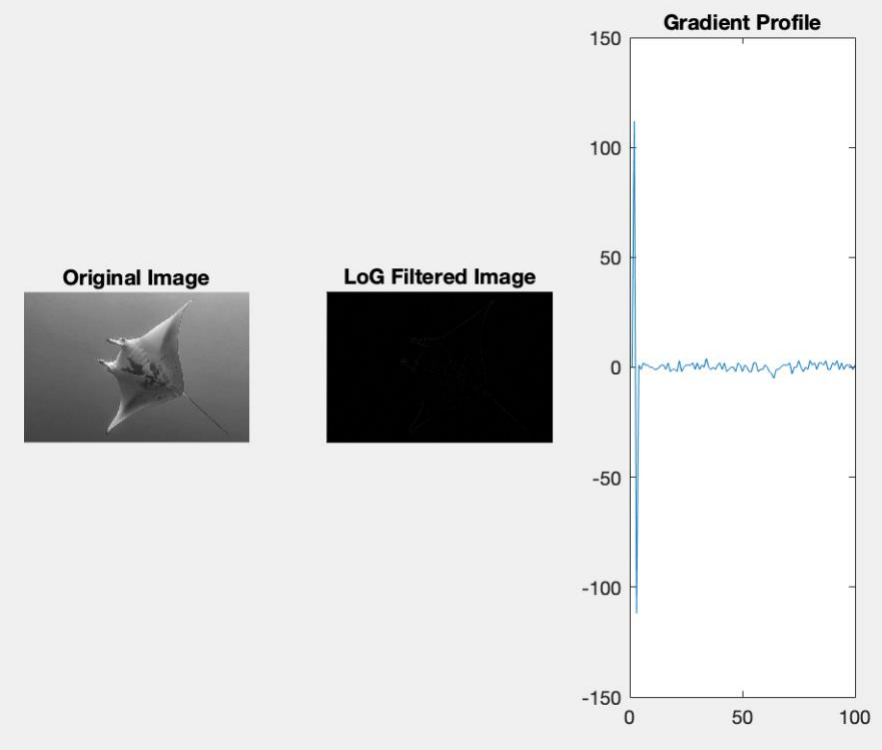
0	1	0
1	-4	1
0	1	0

Different from the Sobel and Prewitt based edge detection algorithms, zero crossing points represent the edge pixels.

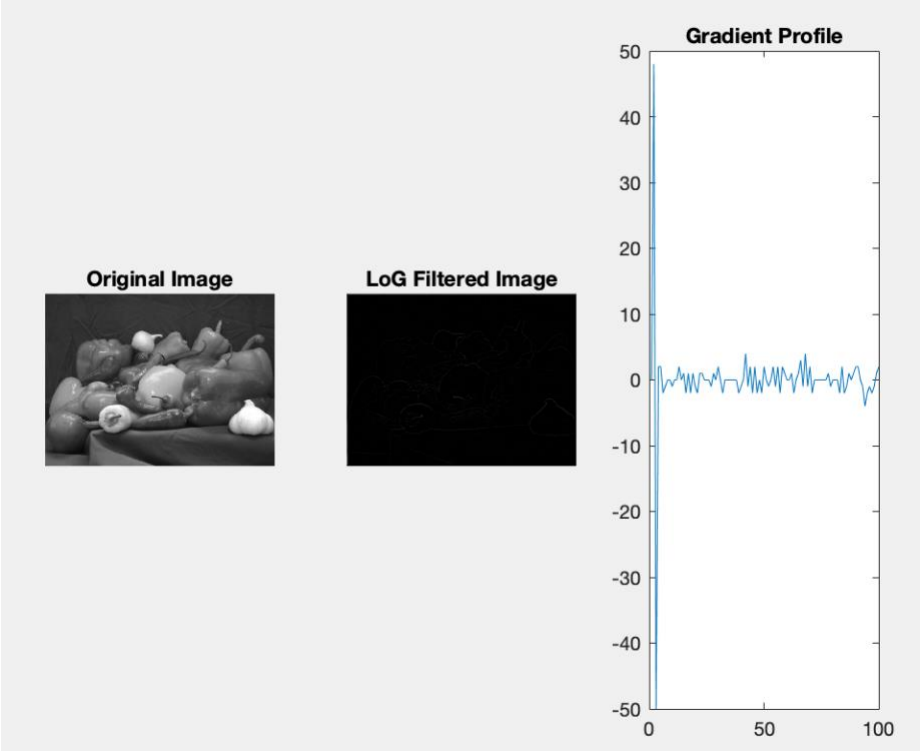
Results for lab3log.m when the input is Object_contours.jpg:



Results for lab3log.m when the input is mantaRay.jpg:



Results for lab3log.m when the input is peppers.png:



Laplacian of Gaussian Conclusions

LoG or Mexican Hat function is basically applying laplacian to the gaussian filtered image. Instead of the first derivative like Sobel and Prewitt, LoG is a second derivative function. The edges are detected by zero crossings.

I've used three different images therefore the graident values are different on plots(1st: -30 to 30, 2nd: -150 to 150, 3rd: -50 to 50).

Derivative filters are very sensitive to noise. This is why LoG first applies the Gaussian filter to smoothen the image, in other words reduce the noise.

When Gaussian's scale parameter is increased, larger scale edges can be detected. When decreased, finer features can be detected. However while eliminating noise by smoothening the image, fine details and image edges are lost. Therefore when applying the LoG, one should select what she/he is looking for!

Discussion on 1st Derivative and 2nd Derivative Edge Detection Algorithms

1st derivative filters such as Sobel and Prewitt are looking into the graph of the intensity values of the image. If the slope of the graph reaches a peak the algorithm declares that pixel as edges. However when there is noise, the algorithm detects that noise as edge as well(unexistent peak will occur). 2nd derivative filters such as LoG first smoothens the image and reduces the noise, then investigates the zero crossings. 2nd derivative graph of the intensity values of the image crosses zero when there is an edge. Therefore 2nd order filters are more advantegous because the error rate is lower thanks to smoothening.

According to Lindeberg blobs are detected as local extrema in space and scale, within the LoG scale-space volume. Therefore the LoG filter is also used for blob detection. LoG is also used in image coding(Laplacian Pyramid).

Note to TAs: Some Log Filtered images are hard to see but if you increase the brightness you can see the objects etc in the processed image and **the zero-crossings finding script is already in my lab3log.m file.**

APPENDIX

```
%% lAB3 edge detection
clear all; close all; clc;
%% sobel
clear all; close all; clc;

img=imread('peppers.png');
[row,col,ch]=size(img);
if (ch==3)
    img=rgb2gray(img);
end

[sobel_X, sobel_Y, sob_Grad, sob_Edge]=lab3sobel(img,200);

figure
subplot(2,3,1);
imshow(img);
title('Original');

subplot(2,3,2);
imshow(sobel_X);
title('Sobel X Filtered');

subplot(2,3,3);
imshow(sobel_Y);
title('Sobel Y Filtered');

subplot(2,3,5);
imshow(sob_Grad);
title('Sobel Gradient');

subplot(2,3,6);
imshow(sob_Edge);
title('Sobel Edges');
%% prewitt
clear all; close all; clc;
im=imread('mantaRay.jpg');

[row,col,chNum]=size(im);

if (chNum==3)
    im=rgb2gray(im);
end

[prewX, prewY, prewGrad, prewEdge]=lab3prewitt(im,220);

figure
subplot(2,3,1);
imshow(im);
title('Original Image');

subplot(2,3,2);
imshow(prewX);
title('Prewitt X Filtered Image');

subplot(2,3,3);
imshow(prewY);
title('Prewitt Y Filtered Image');

subplot(2,3,5);
imshow(prewGrad);
title('Prewitt Gradient');

subplot(2,3,6);
imshow(prewEdge);
title('Prewitt Edges');

%% Log
clear all; close all; clc;

img=imread('peppers.png');
Th1=10;
Th2=210;
[E]=lab3log(img,Th1,Th2);
```

main.m

```
function [x_img,y_img,sob_Grad,sob_Edge] = lab3sobel(img,thold)

[row,col,ch]=size(img);

if (ch==3)
    img=rgb2gray(img);
end

img=double(img);

xfilter=[-1 0 1;-2 0 2;-1 0 1];
yfilter=[-1 -2 -1;0 0 0;1 2 1];

x_img=conv2(img, xfilter);
y_img=conv2(img, yfilter);

sob_Grad=sqrt(x_img.^2+y_img.^2);
sob_Edge=zeros(size(img));

for i=1:1:row
    for j=1:1:col
        if sob_Grad(i,j)<=thold
            sob_Edge(i,j)=0;
        else
            sob_Edge(i,j)=255;
        end
    end
end

x_img=uint8(x_img);
y_img=uint8(y_img);
sob_Grad=uint8(sob_Grad);
sob_Edge=uint8(sob_Edge);

end
```

lab3sobel.m

```
function [x_img,y_img,prewGrad,prewEdge] = lab3prewitt(img,thold)

[row,col,chNum]=size(img);

if (chNum==3)
    img=rgb2gray(img);
end

img=double(img);

xfilter=[-1 0 1;-1 0 1;-1 0 1];
yfilter=[-1 -1 -1;0 0 0;1 1 1];

x_img=conv2(img, xfilter);
y_img=conv2(img, yfilter);

prewGrad=sqrt(x_img.^2+y_img.^2);
prewEdge=zeros(size(img));
for i=1:1:row

    for j=1:1:col

        if prewGrad(i,j)<=thold
        prewEdge(i,j)=0;


        else
            prewEdge(i,j)=255;
        end

    end

end
x_img=uint8(x_img);
y_img=uint8(y_img);
prewGrad=uint8(prewGrad);
prewEdge=uint8(prewEdge);
end
```

lab3prewitt.m

```
function[E] = lab3log(img,Th1,Th2)

[row,col,chNum]=size(img);

if (chNum==3)
    img=rgb2gray(img);
end

img=double(img);

J=lab2gaussfilt(img);
kernel=[0 1 0; 1 -4 1; 0 1 0];
E=zeros(size(img));
G = zeros(size(img));
G=conv2(J,kernel,'same');

k=1
% for i = k+1:1:row-k-1
%    for j = k+1:1:col-k-1
%     Window = J(i-k:i+k,j-k:j+k);
%     value = sum(dot(Window,kernel));
%     G(i,j) = value;
%    end
% end

for i=k+1:1:row-k-1
    for j=k+1:1:col-k-1

       if (abs(G(i,j))>=Th1)
           if ( (G(i,j)*G(i+1,j)<0) || (G(i,j)*G(i-1,j))<0) ||
(G(i,j)*G(i,j+1)<0) || (G(i,j)*G(i,j-1)<0 )
               if( (abs(G(i+1,j)-G(i,j))>=Th2) || (abs(G(i-1,j)-G(i,j))>=Th2)
|| (abs(G(i,j+1)-G(i,j))>=Th2) || (abs(G(i,j-1)-G(i,j))>=Th2))
                   E(i,j)=255;
               end
           end

       else
           if ( (G(i+1,j)*G(i-1,j)<0) || (G(i,j+1)*G(i,j-1)<0) )
               if( (abs(G(i+1,j)-G(i-1,j))/2>=Th2) || (abs(G(i,j+1)-G(i,j-
1))/2>=Th2) )
                   E(i,j)=255;
               end
           end
       end

    end
end

for(x=1:1:100)
   gp(x) = G(80,x) ;
```

```
end

img=uint8(img);
G=uint8(G);
E=uint8(E);

figure
subplot(1,3,1);
imshow(img);
title('Original Image');

subplot(1,3,2);
imshow(G);
title('LoG Filtered Image');

subplot(1,3,3);
plot(gp);
title('Gradient Profile');


end
```

lab3log.m

```
function [Filtered_img] = lab2gaussfilt(img)

    [row,col,ch]=size(img);

    if (ch==3)
        img = rgb2gray(img);
    end

    Gaussian_matrix = (1/273)*[    1   4   7   4    1  ;
                                   4   16  26  16   4  ;
                                   7   26  41  26   7  ;
                                   4   16  26  16   4  ;
                                   1   4   7   4    1  ];

    Filtered_img = zeros(size(img));
    img = double(img);
    k = 2;

    for i = k+1:1:row-k-1

       for j = k+1:1:col-k-1

           Window = img(i-k:i+k,j-k:j+k);

           value = sum(sum(Window.*Gaussian_matrix));

           Filtered_img(i,j) = value;

       end
```

```
    end

    %method 2
%     Filtered_img = conv2(img,Gaussian_matrix,'full');
%
    img = uint8(img);
    Filtered_img = uint8(Filtered_img);
end
```

lab2gaussfilt.m