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```


Image and Video Processing Assignment - 2

```
clc;
clear all;
close all;
```

Question 1: The Maar Edge Detector

```
% I will first create the functions which are needed for
 implementation in
% other parts of the code. Finally, the entire code will be written
% together to detect the edges.
```

Gaussian Blur Matrix

```
% Function to calculate the Gaussian matrix for a given value of
 standard
% deviation
```

```
function [blur] = gaussian_blur(sigma)

    % sigma: The std deviation of the gaussian kernel used

    % Find the filter dimension using the 6*sigma rule as the majority
 of
    % the gaussian is
    filter_dims = ceil(6*sigma);

    if mod(filter_dims,2)==0
        filter_dims = filter_dims + 1;
    end

    blur = zeros(filter_dims, filter_dims);
    centre_x = ceil(filter_dims/2);
    centre_y = ceil(filter_dims/2);

    for i=1:filter_dims
        for j=1:filter_dims
            x = i - centre_x;
            y = j - centre_y;
            blur(i,j) = exp(-1*(x^2 + y^2)/(2*sigma^2))/
(2*pi*sigma^2);
        end
    end
end
```

Laplacian of Gaussian Matrix

```
% Function to calculate the Laplacian of Gaussian matrix for a given
 value of standard
% deviation

function [blur] = LOG_filter(sigma)

    % sigma: The std deviation of the gaussian kernel used

    filter_dims = ceil(6*sigma);

    if filter_dims%2==0
        filter_dims = filter_dims + 1;
    end

    blur = zeros(filter_dims, filter_dims);
    centre_x = ceil(filter_dims/2);
    centre_y = ceil(filter_dims/2);

    for i=1:filter_dims
        for j=1:filter_dims
            x = i - centre_x;
            y = j - centre_y;
```

```
            blur(i,j) = exp(-1*(x^2 + y^2)/(2*sigma^2))*((x^2 + y^2 -
 2*sigma^2)/(2*pi*sigma^6));
        end
    end
end
```

Convolution of Matrices

```
% Function to convolve an image with a filter. This is done assuming
 that
% the filter size is odd.
function [oimg] = convolve(img, filter)
    % img: input image
    % filter: filter for convolution
    [frow, fcol] = size(filter);
    [irow, icol] = size(img);

    % The dimensions of the final image
    oimg = zeros(irow - frow + 1, icol - fcol + 1);
    for i=1 + floor(frow/2) : irow - floor(frow/2)
        for j=1 + floor(fcol/2) : icol - floor(fcol/2)

            % Calculating the image section on which the filter will
 be
            % multiplied
            x_start = i - floor(frow/2);
            y_start = j - floor(fcol/2);

            x_end = i + floor(frow/2);
            y_end = j + floor(fcol/2);

            img_section = img(x_start:x_end, y_start:y_end);
            oimg(i - floor(frow/2),j - floor(fcol/2)) =
 sum(sum(img_section.*filter));
        end
    end
end
```

Zero Crossing Detector

```
% Function to calculate the zero crossings based on the number of
 edges and
% the threshold
function [oimg] = zero_crossing(img, thresh)
    % img: input image

    oimg = zeros(size(img));
    [row, col] = size(img);
```

```
    for i=2:row-1
        for j=2:col-1
            % checking for vertical zero crossings
            count = 0;
            if(img(i-1,j) * img(i+1,j)<0 && abs(img(i-1,j) - img(i
+1,j))>thresh)
                count = count + 1;
            end

            % checking for horizontal zero crossings
            if(img(i,j-1) * img(i,j+1)<0 && abs(img(i,j-1) - img(i,j
+1))>thresh)
                count = count + 1;
            end

            % checking for positive diagonal zero crossings
            if(img(i-1,j-1) * img(i+1,j+1)<0 && abs(img(i-1,j-1) -
 img(i+1,j+1))>thresh)
                count = count + 1;
            end

            % checking for negative diagonal zero crossings
            if(img(i-1,j+1) * img(i+1,j-1)<0 && abs(img(i-1,j+1) -
 img(i+1,j-1))>thresh)
                count = count + 1;
            end

            if count>=2
                oimg(i,j) = 255;
            end

        end
    end
end
```

Maar Edge Detector

```
% Read the input image as a double
orig_img = imread('cameraman.tif');
img = double(orig_img);

% The std deviation of the LOG filter
std_dev = 0.9;
filter = LOG_filter(std_dev);

% We need to pad the image with zeros such that after convolution the
 size
% of the image is not reduced.
pad = size(filter,1) - 1;
padded_img = padding(img, pad, pad, 0);
```

```
% Convolve with the filter
out = convolve(padded_img, filter);

% To detect the edges we need to detect the zero crossings
edges0 = zero_crossing(out, 0);
edges4 = zero_crossing(out, 4);
edges6 = zero_crossing(out, 6);
edges10 = zero_crossing(out, 10);

figure('Name', 'Maar Edge Detector');
subplot(131)
imshow(orig_img);
title('Original Image');

subplot(132)
imshow(out);
title('Convolution with LOG filter (Std dev = 0.9)');

subplot(133)
imshow(edges0);
title('Threshold = 0');

figure('Name','Edges for different thresholds');
subplot(131)
imshow(edges4);
title('Threshold = 4');

subplot(132)
imshow(edges6);
title('Threshold = 6');

subplot(133)
imshow(edges10);
title('Threshold = 10');

% Repeating the same set with different std dev

% The std deviation of the LOG filter
std_dev = 2;
filter = LOG_filter(std_dev);

% We need to pad the image with zeros such that after convolution the
 size
% of the image is not reduced.
pad = size(filter,1) - 1;
padded_img = padding(img, pad, pad, 0);

% Convolve with the filter
out = convolve(padded_img, filter);

% To detect the edges we need to detect the zero crossings
edges0 = zero_crossing(out, 0);
edges4 = zero_crossing(out, 4);
edges6 = zero_crossing(out, 6);
```

```
edges10 = zero_crossing(out, 10);

figure('Name', 'Maar Edge Detector');
subplot(131)
imshow(orig_img);
title('Original Image');

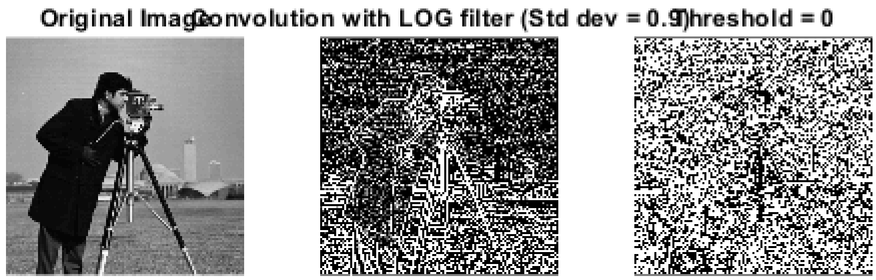
subplot(132)
imshow(out);
title('Convolution with LOG filter (Std dev = 2)');

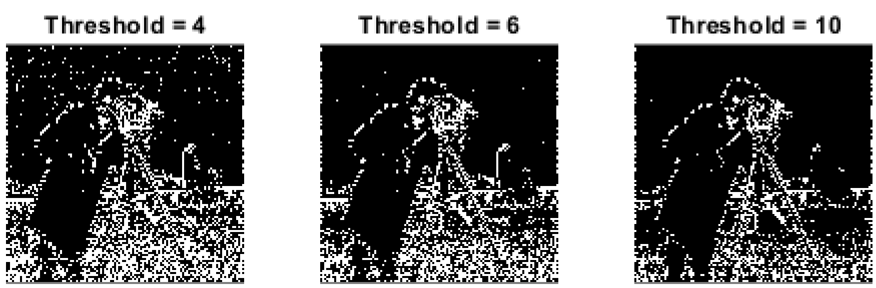
subplot(133)
imshow(edges0);
title('Threshold = 0');

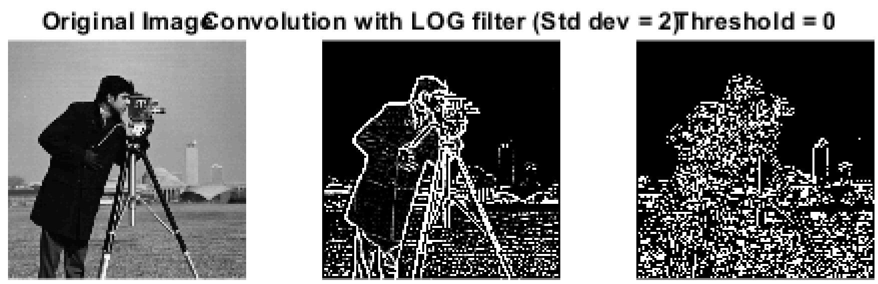
figure('Name','Edges for different thresholds');
subplot(131)
imshow(edges4);
title('Threshold = 4');

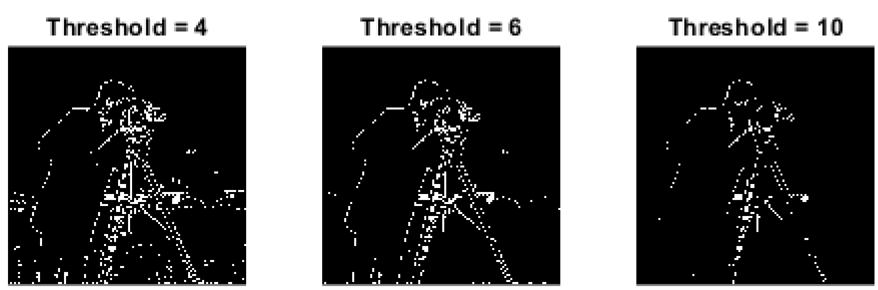
subplot(132)
imshow(edges6);
title('Threshold = 6');

subplot(133)
imshow(edges10);
title('Threshold = 10');
```


Original Image
Convolution with LOG filter (Std dev = 0.9)
Threshold = 0


Threshold = 4
Threshold = 6
Threshold = 10


Original Image
Convolution with LOG filter (Std dev = 2)
Threshold = 0


Threshold = 4
Threshold = 6
Threshold = 10

Question 2: Canny Edge Detection

```
% Creating other needed functions
```

Gradient of an image

```
% Returns the Sobel gradient kernel
function [grad_filter] = grad_filter(x_y)
    % dir: the direction in which gradient is to be calculated

    % Assuming the direction is X
    grad_filter = [-1,0,1;-2,0,2;-1,0,1];
    if (x_y=='Y')
        grad_filter = grad_filter';
    end

end
```

Nonmax supression

```
% Performs nonmax supression on an image given its gradient
function [supressed] = nonmax_supression(mag, angle)
    % mag: The magnitude of the image gradient
    % phase: The phase of the image gradient

    supressed = zeros(size(mag));
    [row, col] = size(mag);
    for i=2:row-1
        for j=2:col-1
            l = 255;
            m = 255;
            ang = angle(i,j);
            if ((ang<22.5) || (ang>157.5))
                l = mag(i,j-1);
                m = mag(i,j+1);
            elseif ((ang>=22.5) && (ang<67.5))
                l = mag(i-1,j-1);
                m = mag(i+1,j+1);
            elseif ((ang>=67.5) && (ang<112.5))
                l = mag(i-1,j);
                m = mag(i+1,j);
            elseif ((ang>=112.5) && (ang<157.5))
                l = mag(i-1,j+1);
                m = mag(i+1,j-1);
            end
            if (mag(i,j)>l && mag(i,j)>m)
                supressed(i,j) = mag(i,j);
```

```
                else
                    supressed(i,j) = 0;
                end
            end
        end

    end
```

Thresholding

```
    % Thresholding after nonmax supression
    function [output] = thresholding(img, thresh1)
        % img: The input image
        % thresh1: The higher threshold

        img(img>thresh1) = 255;
        img(img<thresh1) = 0;
        output = img;
    end
```

Canny Edge Detector

```
    function [final] = Canny_edge(img, std_dev,thresh)
        % std_dev: The standard deviation of Gaussian kernel
        % thresh1: Higher threshold for dual thresholding
        % thresh2: Lower threshold for dual thresholding

        filter = gaussian_blur(std_dev);

        % We need to pad the image with zeros such that after convolution
     the size
        % of the image is not reduced.
        pad = size(filter,1) - 1;
        padded_img = padding(img, pad, pad, 0);

        blurred = convolve(padded_img, filter);

        % Calculating gradients
        g_x = grad_filter('X');
        g_y = grad_filter('Y');

        % Pad the blurred image again
        blurred = padding(blurred,2,2,0);

        G_x = convolve(blurred, g_x);
        G_y = convolve(blurred, g_y);
```

```
    G = sqrt(G_x.^2 + G_y.^2);
    theta = atan2(G_y, G_x) * 180/pi;

    % Fixing the negative angles for ease of calculation
    theta(theta<0) = theta(theta<0)+180;

    % Performing Nonmax supression
    supressed = nonmax_supression(G,theta);

    % Performing hysteris thresholding
    final = thresholding(supressed, thresh);

end
```

Canny Edge Results

Read the input image Read the input image as a double

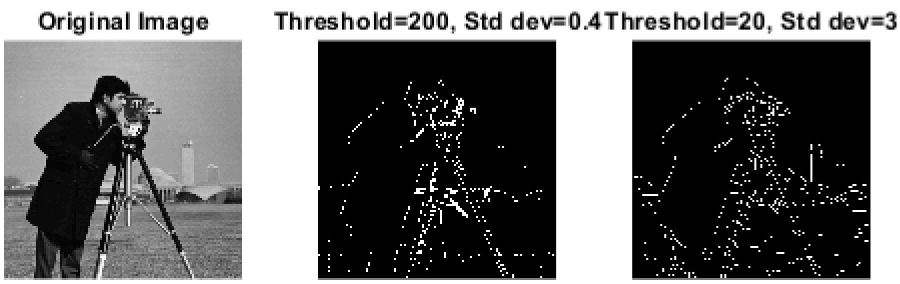
```
orig_img = imread('cameraman.tif');
img = double(orig_img);

output4 = Canny_edge(img, 0.4, 200);
output30 = Canny_edge(img, 3, 20);

figure('Name', 'Canny Edge Detector');
subplot(131)
imshow(orig_img);
title('Original Image');

subplot(132)
imshow(output4);
title('Threshold=200, Std dev=0.4');

subplot(133)
imshow(output30);
title('Threshold=20, Std dev=3');
```



Question 3: Phase only reconstruction

```
% Here, again we will write the dft and idft functions
```

Discrete Fourier Transform

```
% The function to calculate the Discrete Fourier Transform of an image
function [fourier2D] = dft2D(img)
    % img: The image for which fourier is to be calculated

    M = size(img,1);
    N = size(img,2);

    % Performing 2D fourier transform as two successive 1D transforms
 as once
    % over the rows and the other one over the columns

    % First, over rows. Creating a _N_*_N_ weight matrix as we are
 taking a
    % N-point DFT
    n = -(N-1)/2:1:(N-1)/2;
    k = -(N-1)/2:1:(N-1)/2;
    weight_row = n' * k;
    weight_row = (-2*pi*1i/N) .* weight_row;
```

```
    weight_row = exp(weight_row);

    % Secondly, now taking M-point DFT across the columns
    m = -(M-1)/2:1:(M-1)/2;
    k = -(M-1)/2:1:(M-1)/2;
    weight_col = m' * k;
    weight_col = (-2*pi*1i/M) .* weight_col;
    weight_col = exp(weight_col);

    % Taking M-point DFT of the previous N-point DFT
    fourier2D = weight_row * (img * weight_col);

end
```

Log Transformation

```
% Function to calculate the log transformation
function [log_transformed] = log_transformation(magn, scale)
    % magn: The magnitude of image whose log transform is to be
 calculated
    % scale: Scaling Factor

    log_transformed = log10(1 + magn) * scale;

end
```

Phase only reconstruction

Read the input image Read the input image as a double

```
orig_img = imread('cameraman.tif');
img = double(orig_img)/255;

fourier = dft2D(img);

magn = abs(fourier);
phase = atan2(imag(fourier), real(fourier));
phase_res = exp(1i * phase);

% Log transformed output
log_transformed = log_transformation(magn, 0.2);

% Original image reconstruction
orig = idft2D(fourier);

% Phase only reconstruction
phase_reconstruct = mat2gray(abs(idft2D(phase_res)))*30;
```

```
figure('Name', 'Fourier');
subplot(131)
imshow(orig_img);
title('Original Image');

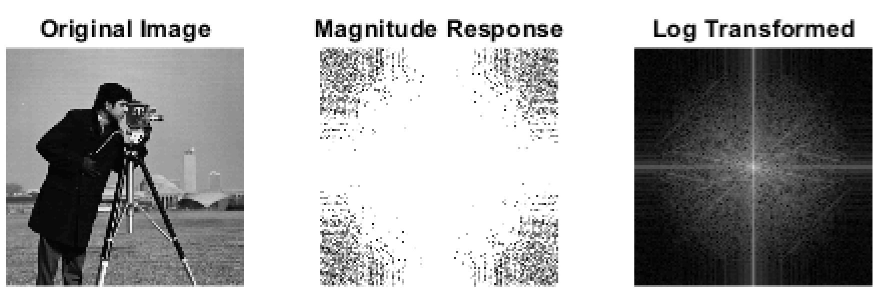
subplot(132)
imshow(magn);
title('Magnitude Response');

subplot(133)
imshow(log_transformed);
title('Log Transformed');

figure('Name', 'Reconstruction');
subplot(131)
imshow(phase);
title('Phase Response');

subplot(132)
imshow(abs(orig));
title('Original Image Reconstruction');

subplot(133)
imshow(phase_reconstruct);
title('Phase only Image Reconstruction');
```



Conclusion

Through this experiment it became clear that both Maar and Canny edge detectors are good and can be used for certain applications. It is evident that the Canny edge detector is better as because we get finer edges and only the edges which are of higher importance. Furthermore, we also implemented the 2D DFT and 2D IDFT to find the magnitude and phase spectrum of an image. We then used the phase spectrum to reconstruct the original image. It is quite surprising that the phase reconstruction is also able to detect edges, as the edge portions of an image get highlighted but clearly it is not a good method for edge detection.

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