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IVP Assignment 2

```
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```

Creating a new environment.

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

Functions Created for the Assignment: add_padding

```
% Function that pads a specific value to the image. The value us user
% entered. The filter_dim is assumed to be odd and the filter is
 assumed to
% be a square filter.

function [img] = add_padding(image, filter_dim, value)
    img = image;
```

```
   [~, cols] = size(image);
   n = uint8(floor(filter_dim/2));
   % Horizontal padding is to be added on the top and bottom of the
image
   horizontal_padding = zeros(n, cols) + value;
   img = [horizontal_padding; img; horizontal_padding];
   [row, ~] = size(img);
   % Vertical padding is to be added on the left and the right. The
2*n
   % additional rows is for the horizontal padding added on the top
and
   % bottom.
   vertical_padding = zeros(row, n) + value;
   img = [vertical_padding img vertical_padding];
```

Functions Created for the Assignment: log_filter

```
% Function that returns the laplacian of a gaussian blur for a given
% filter_dim.

function [log] = log_filter(filter_dim, sigma)
    log = double(zeros(filter_dim, filter_dim));
    n = double(ceil(filter_dim/2));
    for i=1:filter_dim
        for j=1:filter_dim
            x = double(i-n);
            y = double(j-n);
            log(i,j) = double((x^2+y^2-sigma^2)*...
                exp(-(x^2 + y^2)/(2*sigma^2))/sigma^4);
        end
    end

   % The problem with this is that the sum of all the coefficients is
not
   % zero. This causes an issue when we have to find the zero
   % crossings. Causing us to renormalize it in the end. Moreover,
what
   % happens is that since the total is a positive number, it
basically
   % enhances values that are similar in nature. For example,
brighter
   % spots become brighter and darker spots become brighter because
of
   % the fact that the total is positive. Instead, lets normalise
this
   % filter itself such that the total sum is 0.

   log = log - mean(mean(log));
```

Functions Created for the Assignment: correlation

```
% Function that convolves an image with a filter. The assumption is
 that
% the filter is a square and has odd dimensions. If it is required
 that the
% image does not loose its dimentsions due to the convolution process
 it is
% required that the image should be padded.

function [img] = correlation(image, filter)
[f_row, f_col] = size(filter);
[i_row, i_col] = size(image);
image = double(image);
img=double(zeros(i_row-f_row+1, i_col-f_col+1));
for i=1:(i_row-f_row+1)
    for j=1:(i_col-f_col+1)
        img(i,j) = sum(sum(image(i:i+f_row-1,j:j+f_col-1).*filter));
    end
end
```

Functions Created for the Assignment: zero_crossing_enhanced_image

```
% Function that uses zero crossing to enhance the log (Laplacian of
% Gaussian) image. Whereever there is a zero crossig, thats the point
 where
% the edge is present. A threshold is added so that we can control
 what
% edges we want to preserve and what edges we don't. Zeros crossing
 can be
% found out taking a 3x3 square and then checking the opposite pixels.

function [img] = zero_crossing_enhanced_image(image, thresh)
    [row, col] = size(image);
    image = add_padding(image, 3, 0);
    % Vertical filter is used to the center top and bottom pixels.
    vert_filter = zeros(3,3);
    vert_filter(1,2) = 1;
    vert_filter(3,2) = 1;
    % Horizontal filter is used to the horizontal middle pixels.
    horz_filter = zeros(3,3);
    horz_filter(2,1) = 1;
    horz_filter(2,3) = 1;
    % Positive 45 degree filter is used to the pixels on the positive
    % diagonal barring the center.
```

```
    pos_45_deg_filter = zeros(3,3);
    pos_45_deg_filter(3,1) = 1;
    pos_45_deg_filter(1,3) = 1;
    % Negative 45 degree filter is used to the pixels on the negative
    % diagonal barring the center.
    neg_45_deg_filter = zeros(3,3);
    neg_45_deg_filter(1,1) = 1;
    neg_45_deg_filter(3,3) = 1;
    img = double(zeros(row, col));
    for i=1:(row)
        for j=1:(row)
            v = image(i:i+2,j:j+2) .* vert_filter;
            h = image(i:i+2,j:j+2) .* horz_filter;
            pos_45 = image(i:i+2,j:j+2) .* pos_45_deg_filter;
            neg_45 = image(i:i+2,j:j+2) .* neg_45_deg_filter;
            check = 0;
            if (v(1,2)*v(3,2)<-1 && abs(v(1,2)-v(3,2))>thresh)
                check = 1;
            elseif (h(2,1)*h(2,3)<-1 && abs(h(2,1)-v(2,3))>thresh)
                check = 1;
            elseif (pos_45(3,1)*pos_45(1,3)<-1 && abs(pos_45(3,1)-
pos_45(1,3))>thresh)
                check = 1;
            elseif (neg_45(1,1)*neg_45(3,3)<-1 && abs(neg_45(3,1)-
neg_45(1,3))>thresh)
                check = 1;
            end

            if (check == 1)
                img(i,j) = 255;
            else
                img(i,j) = 0;
            end
        end
    end
```

Functions Created for the Assignment: gaussian_blur

```
% Function that returns the gaussian blur, for nxn dimensions.

function [gauss_blur] = gaussian_blur(filter_dim, sigma)
    gauss_blur = double(zeros(filter_dim, filter_dim));
    n = double(ceil(filter_dim/2));
    for i=1:filter_dim
        for j=1:filter_dim
            x = double(i-n);
            y = double(j-n);
            gauss_blur(i,j) = exp(-(x^2 + y^2)/(2*sigma^2));
        end
```

```
    end

    % For getting a zero mean signal.
    gauss_blur = gauss_blur - mean(mean(gauss_blur));
```

Functions Created for the Assignment: non_maxima_supression_with_thresh

```
% Function that returns a non_maxima_supressed image. The inputs are
 the
% image, the gradient of the image in x, the gradient of the image in
 y,
% and the threshold above which pixels would be considered.

function [img] = non_maxima_supression_with_thresh(image, grad_x,
 grad_y, thresh)
    image = double(image);
    mag = sqrt(grad_x.^2 + grad_y.^2);
    angle = atan2(grad_y, grad_x) * 180/pi;
    angle = angle + (angle>180)*(-180) + (angle<0)*(180);
    [row, col] = size(image);
    image = add_padding(image, 3, 0);
    % Vertical filter is used to the center top and bottom pixels.
    vert_filter = zeros(3,3);
    vert_filter(1,2) = 1;
    vert_filter(3,2) = 1;
    % Horizontal filter is used to the horizontal middle pixels.
    horz_filter = zeros(3,3);
    horz_filter(2,1) = 1;
    horz_filter(2,3) = 1;
    % Positive 45 degree filter is used to the pixels on the positive
    % diagonal barring the center.
    pos_45_deg_filter = zeros(3,3);
    pos_45_deg_filter(3,1) = 1;
    pos_45_deg_filter(1,3) = 1;
    % Negative 45 degree filter is used to the pixels on the negative
    % diagonal barring the center.
    neg_45_deg_filter = zeros(3,3);
    neg_45_deg_filter(1,1) = 1;
    neg_45_deg_filter(3,3) = 1;
    img = double(zeros(row, col));
    for i=1:(row)
        for j=1:(col)
            v = image(i:i+2,j:j+2) .* vert_filter;
            h = image(i:i+2,j:j+2) .* horz_filter;
            pos_45 = image(i:i+2,j:j+2) .* pos_45_deg_filter;
            neg_45 = image(i:i+2,j:j+2) .* neg_45_deg_filter;
            ang = angle(i, j);
            sector = 0;
```

```
                % Checking which bucket the angle lies in.
                if ((ang>0 && ang<22.5) || (ang>157.5 && ang<180))
                    sector = 1;
                elseif (ang>22.5 && ang<67.5)
                    sector = 2;
                elseif (ang>67.5 && ang<112.5)
                    sector = 3;
                elseif (ang>112.5 && ang<157.5)
                    sector = 4;
                end

                value = 0;

                % Assigning a value to the corresponsing pixel depending
 on
                % the internsity of the original image.
                switch sector
                    case 1
                        if (h(2,1)>mag(i,j) && h(2,3)>mag(i,j))
                            value = mag(i,j);
                        end
                    case 2
                        if (pos_45(3,1)>mag(i,j) && pos_45(1,3)>mag(i,j))
                            value = mag(i,j);
                        end
                    case 3
                        if (v(1,2)>mag(i,j) && v(3,2)>mag(i,j))
                            value = mag(i,j);
                        end
                    case 4
                        if (neg_45(1,1)>mag(i,j) && neg_45(1,1)>mag(i,j))
                            value = mag(i,j);
                        end
                end

                img(i,j)=value;

            end
        end

        img = img.*(img>thresh);
```

Functions Created for the Assignment: grad_filter

```
% Function that returns the 3x3 grad filter for a given x or y
 direction.

function [grad_filt] = grad_filter(x_or_y)
    grad_filt = double(zeros(3,3));
```

```
    if (x_or_y == 'x')
        grad_filt(2,1) = 1;
        grad_filt(2,2) = -2;
        grad_filt(2,3) = 1;
    else
        grad_filt(1,2) = 1;
        grad_filt(2,2) = -2;
        grad_filt(3,2) = 1;
    end
```

Functions Created for the Assignment: inv_dft2d

```
% Function that returns the inverse of the 2D DFT

function [inv_fft] = inv_dft2d(image)
    image = double(image);
    [M, N] = size(image);

    % m, n should go from -pi to pi for better interpretation.
    m = -(M-1)/2:1:(M-1)/2;
    n = -(N-1)/2:1:(N-1)/2;

    % Creates the X exponentials required to compute the DFT.
    exponential_x = m' * m;
    exponential_x = exp(-2 * pi * 1i / M .* exponential_x);

    % Creates the Y exponentials required to compute the DFT.
    exponential_y = n' * n;
    exponential_y = exp(-2 * pi * 1i / N .* exponential_y);

    % Final FFT Computation.
    inv_fft = inv(exponential_x) * image * inv(exponential_y);
```

Functions Created for the Assignment: log_transform

```
% Function that computes the log transform for an image.

function [log_trans] = log_transform(image, c)
    log_trans = double(image);
    [~, dim] = size(size(image));

    % If conditional is used to check whether the image is 2D or 3D.
    if dim == 2
        [row, col] = size(image);
```

```
        for i = 1:row
            for j = 1:col
                log_trans(i, j) = c * log( 1+ (log_trans(i, j)));
            end
        end
    else
        [row, col, channels] = size(image);
        for i = 1:row
            for j = 1:col
                for k = 1: channels
                    log_trans(i, j, k) = c * log(1 + (log_trans(i, j,
k)));
                end
            end
        end
    end
```

Functions Created for the Assignment: dft_2d

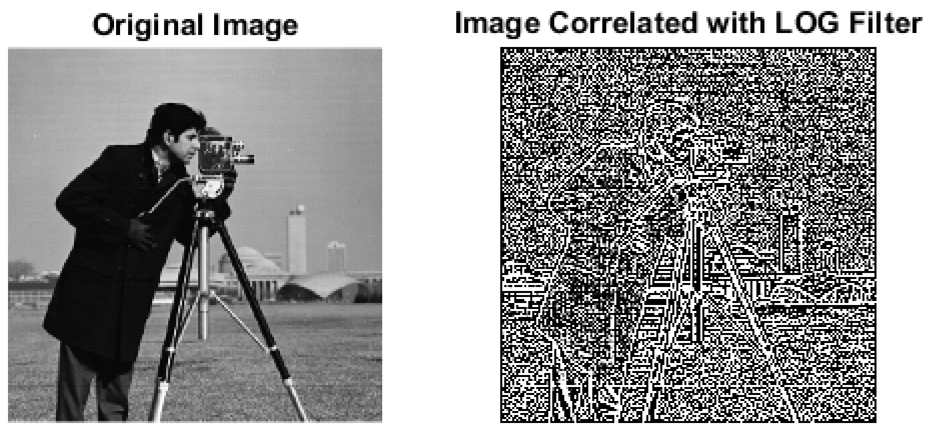
```
% Function that computes the 2D-DFT for an image.

function [dft2d] = dft_2d(image)
    image = double(image);
    [M, N] = size(image);

    % m, n should go from -pi to pi for better interpretation.
    m = -(M-1)/2:1:(M-1)/2;
    n = -(N-1)/2:1:(N-1)/2;

    % Creates the X exponentials required to compute the DFT.
    exponential_x = m' * m;
    exponential_x = exp(-2 * pi * 1i / M .* exponential_x);

    % Creates the Y exponentials required to compute the DFT.
    exponential_y = n' * n;
    exponential_y = exp(-2 * pi * 1i / N .* exponential_y);

    % Final FFT Computation.
    dft2d = exponential_x * image * exponential_y;
```

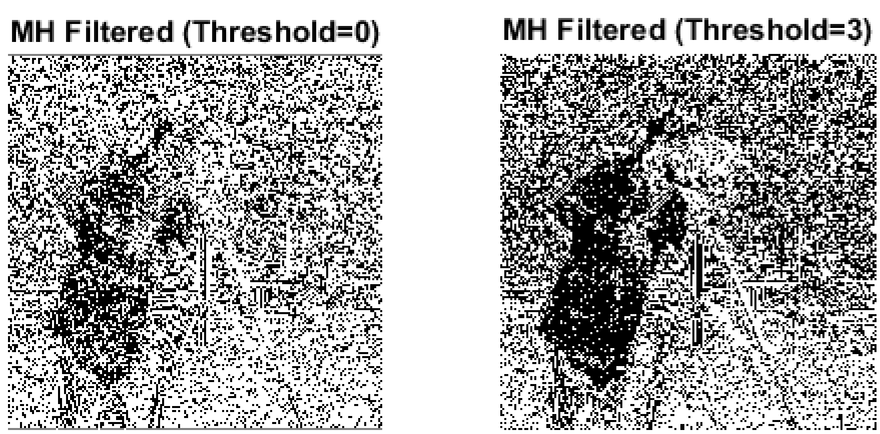
Image Imports

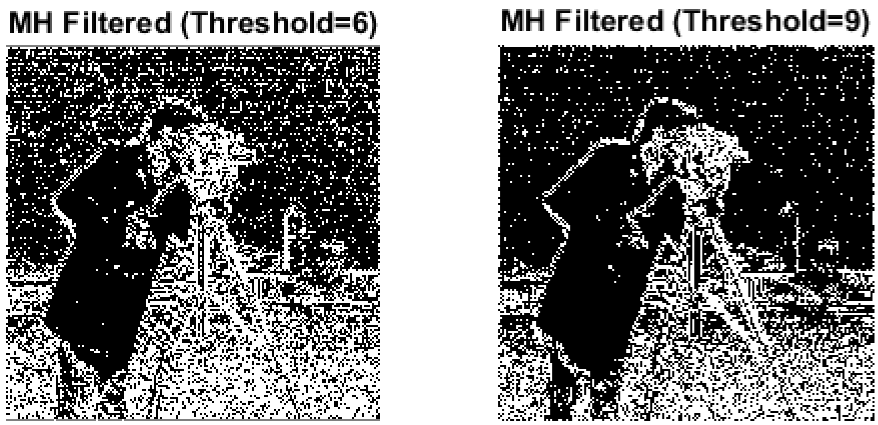
```
cameraman = imread('C:\Chanakya\Projects\ivp-assignments
\Assignment-1\images\cameraman.tif');
lena_color = imread('C:\Chanakya\Projects\ivp-assignments
\Assignment-1\images\lena_color_256.tif');
```

Question 1: Use the Marr-Hilderith filter to obtain the edges of the image.

```
% Padding the image so that the correlation does not reduce the
 dimensions.
mh_image = add_padding(cameraman, 5, 0);

% Generating the LOG Filter
log_filt = log_filter(5, 1);

% Correlation of the image and the LOG filter.
correlated_image = correlation(mh_image, log_filt);

% Enhancing the zero crossings.
mh_final_image_0 = zero_crossing_enhanced_image(correlated_image, 0);
mh_final_image_3 = zero_crossing_enhanced_image(correlated_image, 3);
mh_final_image_6 = zero_crossing_enhanced_image(correlated_image, 6);
mh_final_image_9 = zero_crossing_enhanced_image(correlated_image, 9);

%Plotting the images.
figure('Name', 'Maar-Hilderith Edge Detection 1');
subplot(1,2,1);
imshow(cameraman);
title('Original Image');

subplot(1,2,2);
imshow(correlated_image);
title('Image Correlated with LOG Filter');

figure('Name', 'Maar-Hilderith Edge Detection 2');
subplot(1,2,1);
imshow(mh_final_image_0);
title('MH Filtered (Threshold=0)');

subplot(1,2,2);
imshow(mh_final_image_3);
title('MH Filtered (Threshold=3)');

figure('Name', 'Maar-Hilderith Edge Detection 3');
subplot(1,2,1);
imshow(mh_final_image_6);
title('MH Filtered (Threshold=6)');

subplot(1,2,2);
imshow(mh_final_image_9);
title('MH Filtered (Threshold=9)');
```


Original Image
Image Correlated with LOG Filter


MH Filtered (Threshold=0)
MH Filtered (Threshold=3)



Question 2: Use the Canny Edge Detection Technique to obtain the edges of the image.

```
% Padding the image so that the correlation does not reduce the
 dimensions.
ce_image = add_padding(cameraman, 5, 0);

% Getting the Gaussian Blur Kernel
gaus_blur = gaussian_blur(5, 1);

% Correlation of the blur and the padded image.
gaussing_blurred_image = correlation(ce_image, gaus_blur);

% Getting the gradient filters
g_x = grad_filter('x');
g_y = grad_filter('y');

% Padding the image so that the correlation does not reduce the
 dimensions.
gaussing_blurred_image_padded = add_padding(gaussing_blurred_image, 3,
 0);

% Getting the gradients of the gaussian blurred image.
grad_x = correlation(gaussing_blurred_image_padded , g_x);
```

```
grad_y = correlation(gaussing_blurred_image_padded , g_y);

% Performing Non Maxima Supression.
nms_1 = non_maxima_supression_with_thresh(gaussing_blurred_image,
 grad_x, grad_y, 0.1);
nms_2 = non_maxima_supression_with_thresh(gaussing_blurred_image,
 grad_x, grad_y, 2);

%Plotting the images.
figure('Name', 'Canny Edge Detection 1');
subplot(1,2,1);
imshow(gaussing_blurred_image);
title('Image Corr with the Gaussian Blur');

subplot(1,2,2);
imshow(grad_x);
title('Grad of the Gauss Blur in X');

figure('Name', 'Canny Edge Detection 2');
subplot(1,2,1);
imshow((grad_y));
title('Grad of the Gauss Blur in Y');

subplot(1,2,2);
imshow((nms_1));
title('Nonmax Supress (Thresh=0.1)');

figure('Name', 'Canny Edge Detection 3');
subplot(1,2,1);
imshow(abs(nms_2));
title('Nonmax Supress (Thresh=2)');

subplot(1,2,2);
imshow(abs(nms_2-nms_1));
title('Diff of the Nonmax Suppressions');

figure('Name', 'Final Image');
subplot(1,2,1);
imshow(cameraman);
title('Original Image');

subplot(1,2,2);
imshow(mat2gray(nms_2- abs(nms_2-nms_1)));
title('Final Edges');
```

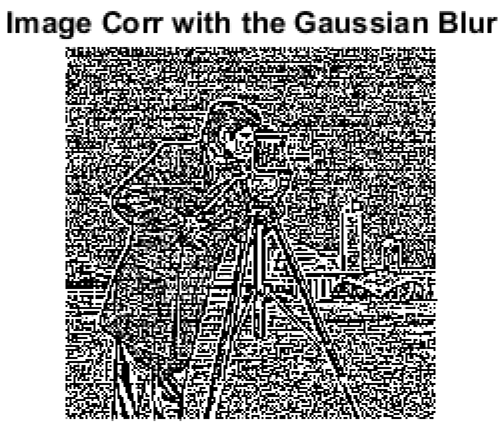
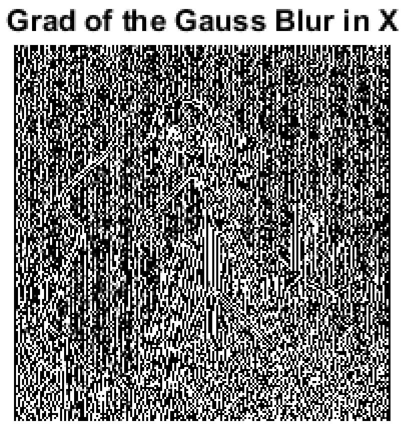
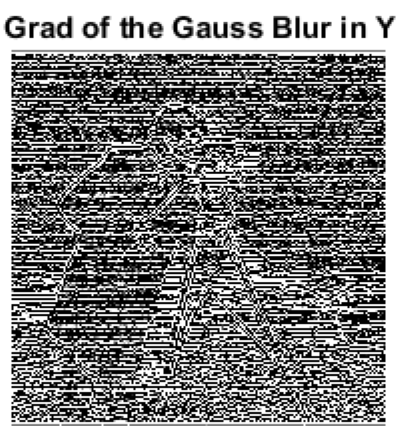
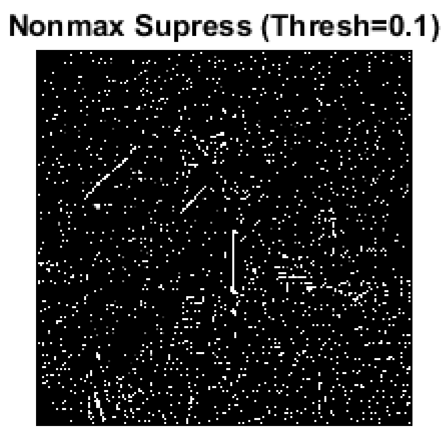
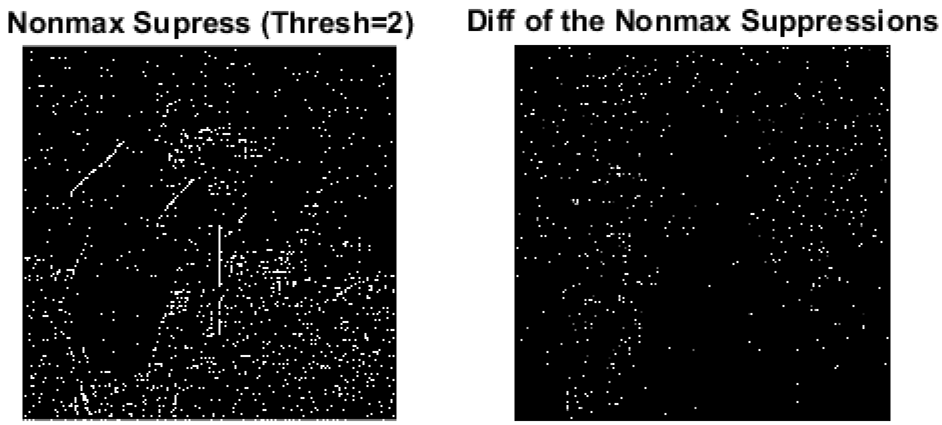


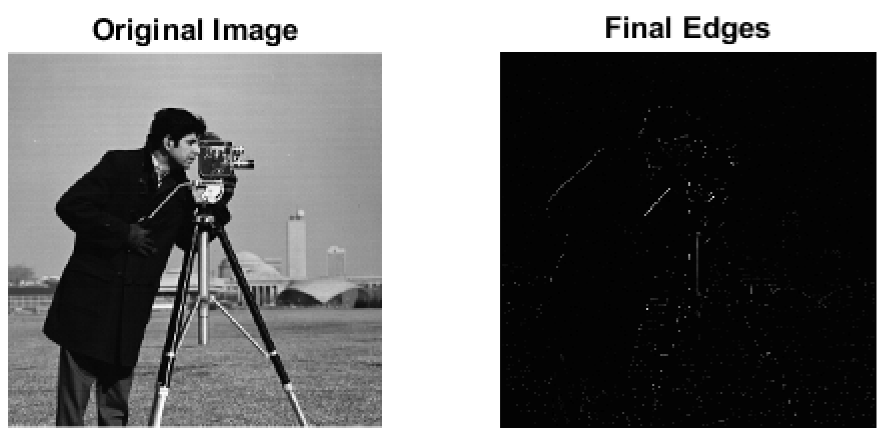
Image Corr with the Gaussian Blur


Grad of the Gauss Blur in X


Grad of the Gauss Blur in Y

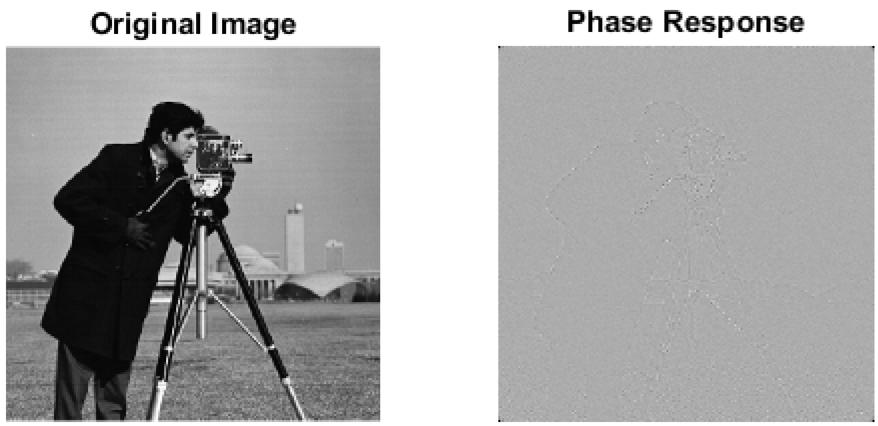

Nonmax Supress (Thresh=0.1)


Nonmax Supress (Thresh=2)
Diff of the Nonmax Suppressions


Original Image
Final Edges

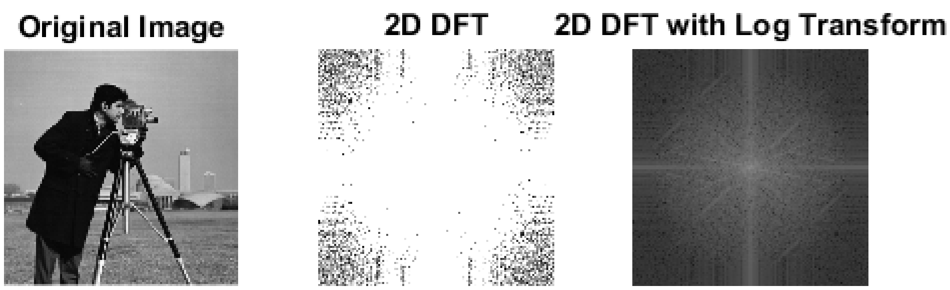
Question 3: Phase only reconstruction of the image from the Fourier Domain.

```
% Computing the DFT of the image.

% Computing the DFT.
dft2d = dft_2d(cameraman);

% Getting the magnitude and phase.
mag = abs(dft2d);
phase = atan2(imag(dft2d), real(dft2d));
phase_response = exp(1i*phase);

figure('Name', '2D DFT Reconstruction Phase Response');
subplot(1,2,1);
imshow(cameraman);
title('Original Image');

subplot(1,2,2);
imshow((im2uint8(mat2gray(real(inv_dft2d(phase_response)))))*3);
title('Phase Response');
```



Question 4: Phase only reconstruction of the image from the Fourier Domain.

```
% Comparing the image, the 2D-DFT and the log transform of the 2D DFT.
figure('Name', 'Computing the 2D-DFT of the image.');
subplot(1,3,1);
imshow(cameraman);
title('Original Image');

subplot(1,3,2);
imshow(uint8(abs(dft2d)));
title('2D DFT');

subplot(1,3,3)
imshow(uint8(log_transform(abs(dft2d), 10)));
title('2D DFT with Log Transform');
```



Conclusion

From the assignment we can observe that the Maar-Hildereth Filter can be used for edge detection and we can also use the Canny Edge Detection method to get the edges. The main observation was that the Canny Edge Detection is a much better method than Maar-Hilderith as the edges are finer. In addition to that we can also observe that phase reconstruction of the 2D DFT gives the edges of the image. We can also observe that magnitude of the 2D-DFT image is correlated to the edges of the image. Moreover, we can also notice that the magnitude of the 2D-DFT has to be enhanced using the log transform as the magnitude of the 2D-DFT is feeble and corresponds to low pixel intensities.

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