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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 + 90;
    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

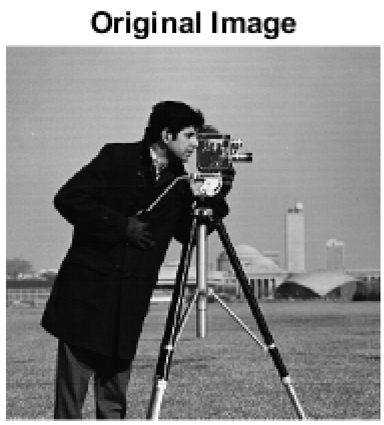
```
% Function that computes the 2D-DFT for an image.

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

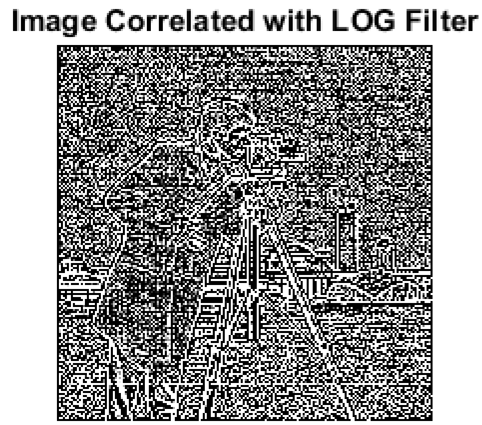
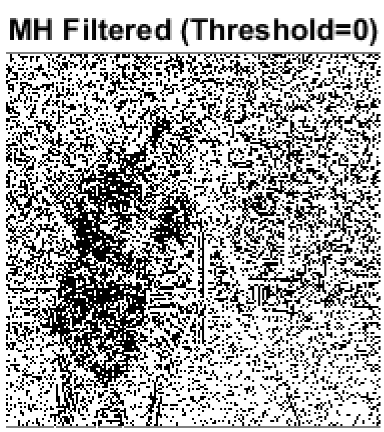


Image Correlated with LOG Filter


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');
```

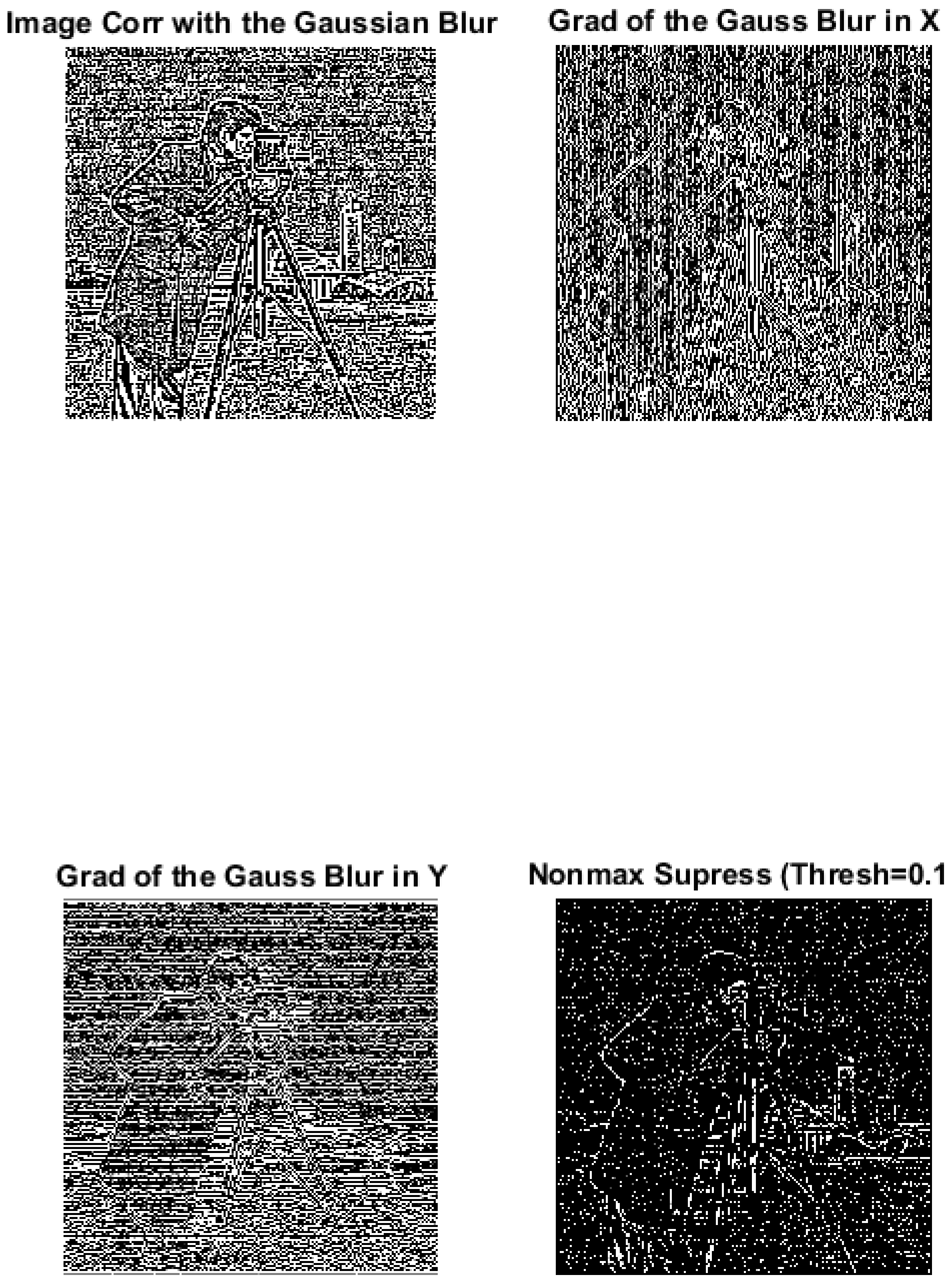
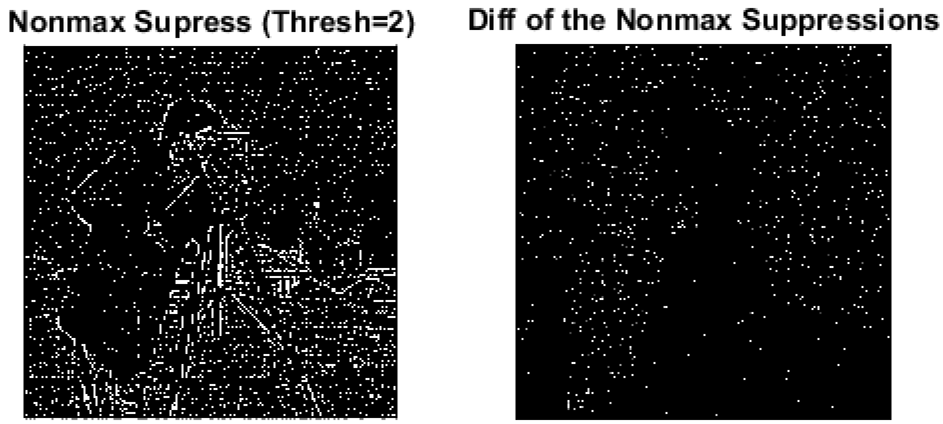
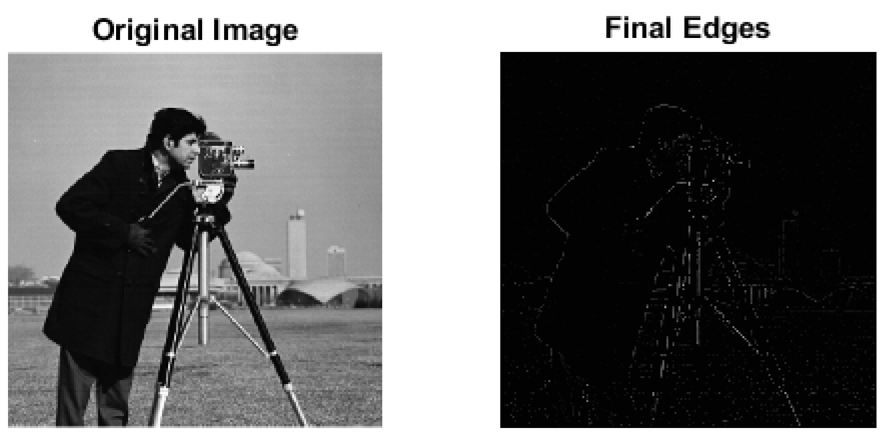


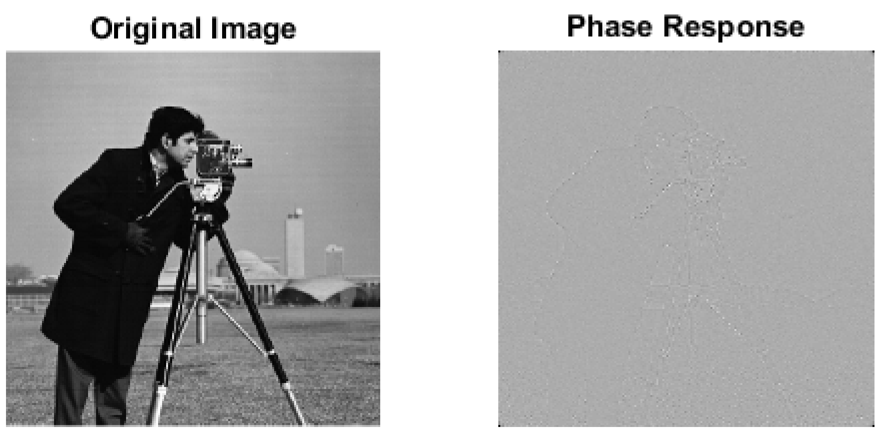
Image Corr with the Gaussian Blur
Grad of the Gauss Blur in X
Grad of the Gauss Blur in Y
Nonmax Supress (Thresh=0.1)


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


Original Image
Final Edges

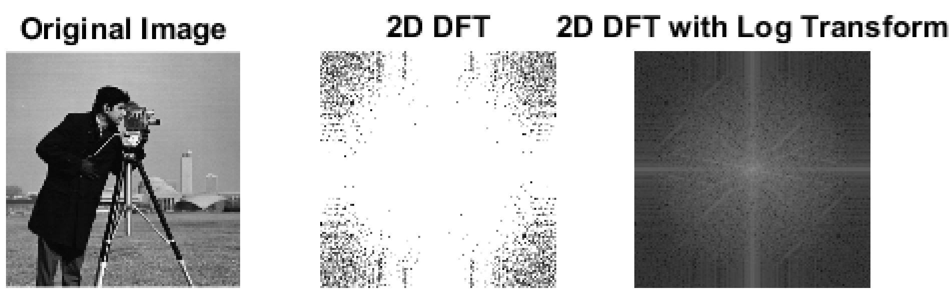
Question 3: Phase only reconstruction of the image from the Fourier Domain.

```
% 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');
```



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