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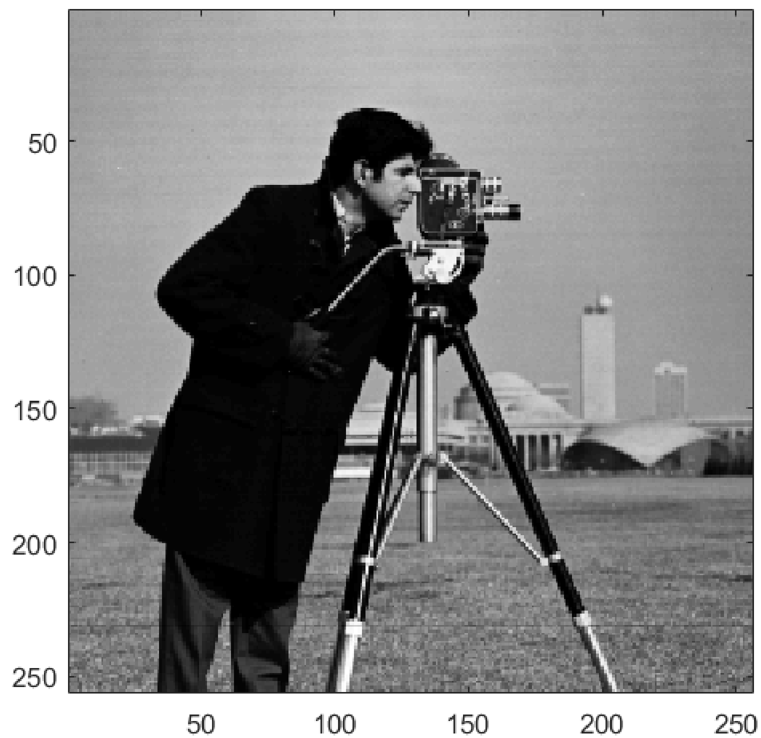
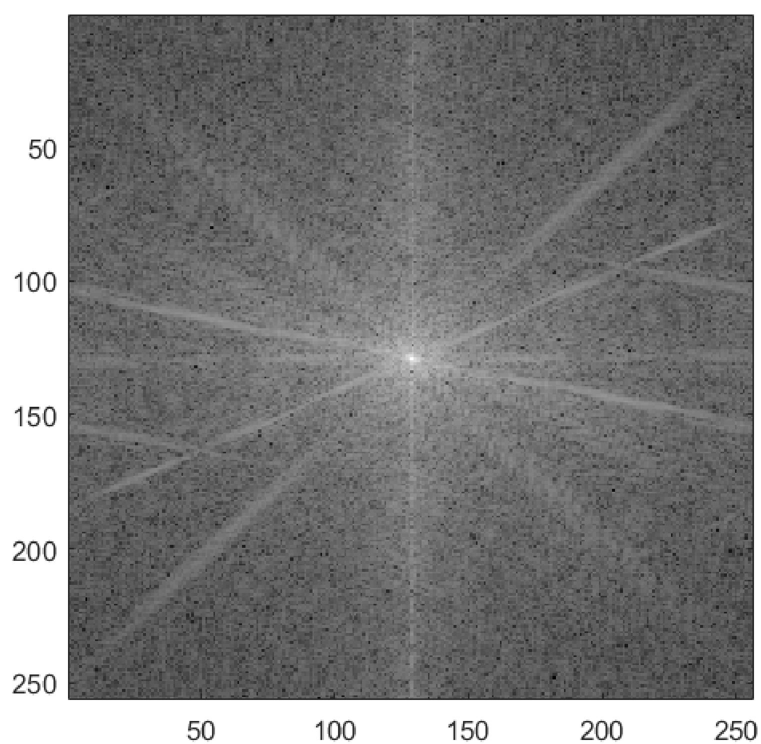
Lab 8 Image processing and compression 4/30/2017

3.1 Image analysis using 2D DFT

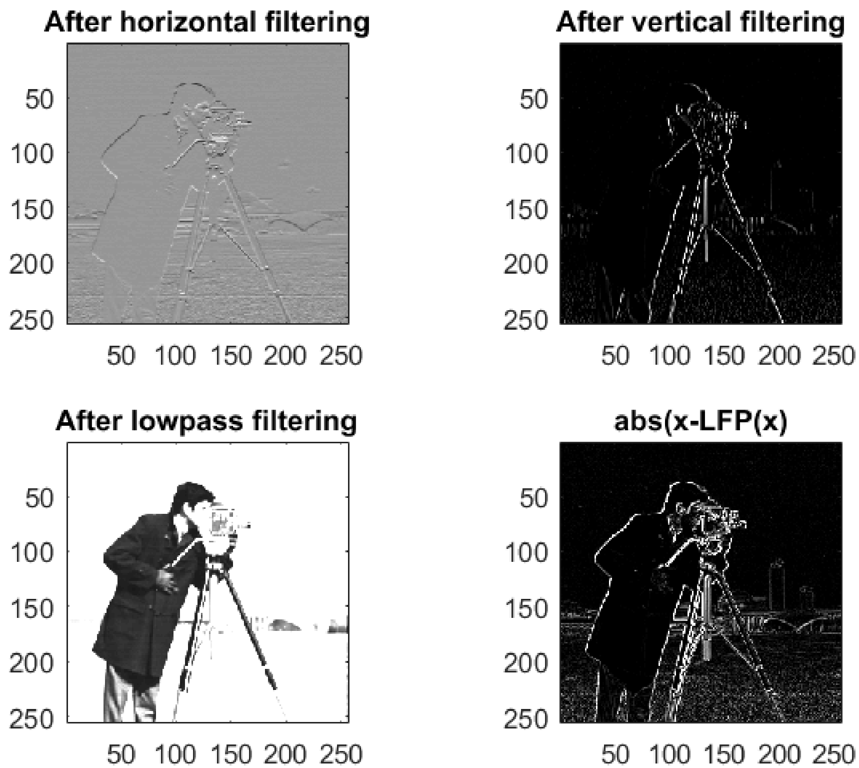
```
clear all
close all

load cameraman.mat
figure(1)
imagesc(x)
colormap(gray)
axis('square')
figure(2)
spec_x = fft2(x);
imagesc(fftshift(log10(abs(spec_x))));
colormap(gray)
axis('square')

% <= enter matlab code here
```


50
100
150
200
250
50
100
150
200
250


50
100
150
200
250
50
100
150
200
250

3.2 Image filtering

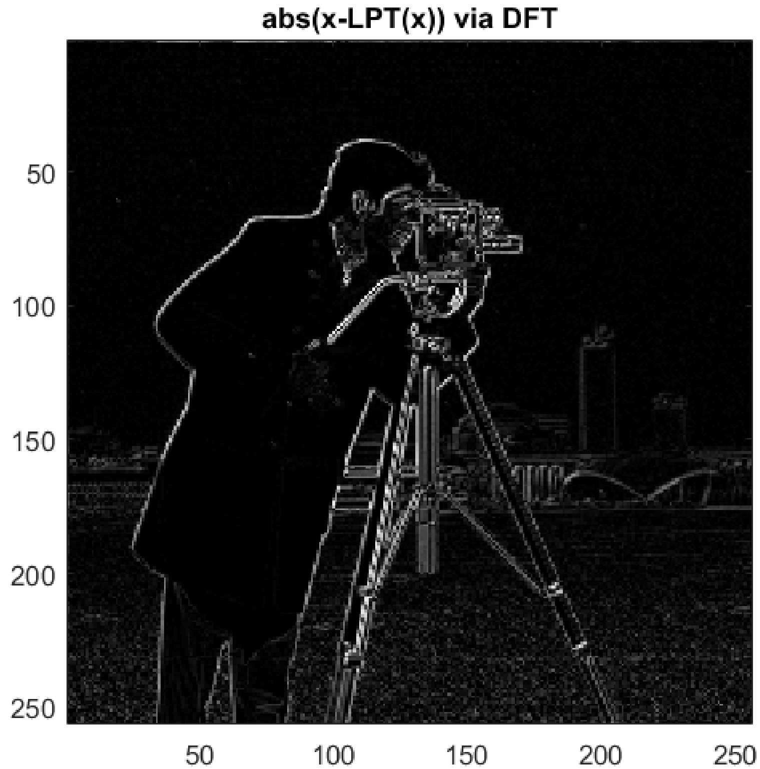
```
% you should turn in 4 figures. the first one will use the title
 'after
% horizontal filtering' the second with title 'after vertical
 filtering'.
% The third one with title 'after lowpass filtering' The fourth one
 with
% title 'abs(x-LPF(x))'

h_h = [1/4 1/4; -1/4 -1/4];
h_v = [1/4 -1/4; 1/4 -1/4];
h_lp = [1/4 1/4; 1/4 1/4];

y_h = conv2(x, h_h, 'same');
figure,
subplot(2,2,1), imagesc(y_h); colormap('gray'); axis square
title('After horizontal filtering');

y_v = conv2(x, h_v, 'same');
subplot(2,2,2), image(y_v); colormap('gray'); axis square
title('After vertical filtering');

y_lp = conv2(x, h_lp, 'same');
subplot(2,2,3), image(y_lp); colormap('gray'); axis square
title('After lowpass filtering');

diff1 = abs(x-y_lp);
subplot(2,2,4), image(diff1); colormap('gray'); axis square
title('abs(x-LFP(x)');

% <= enter matlab code here
```



3.3 Image filter using the DFT

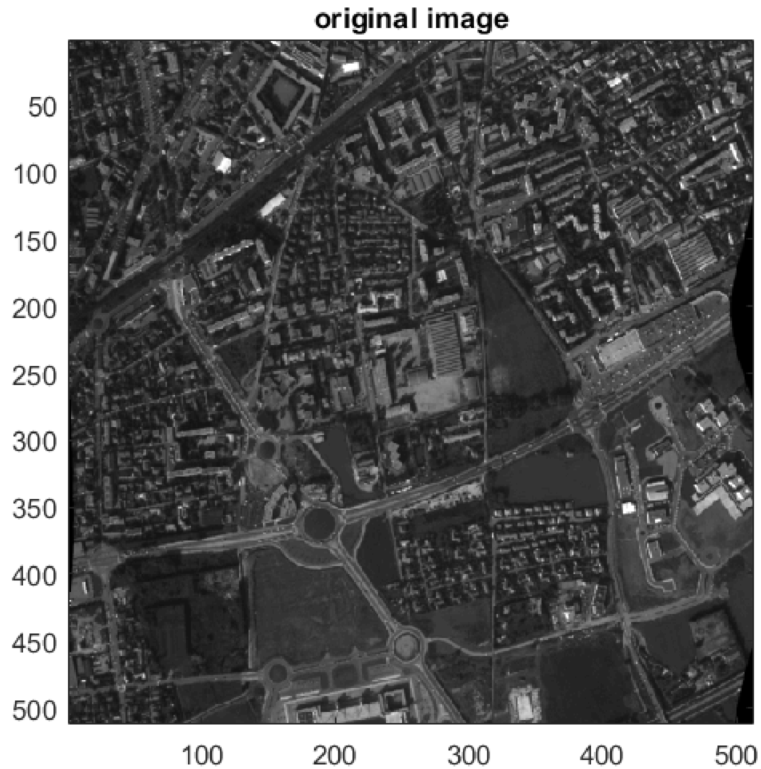
you should submit 1 figure with title 'abs(x-LPT(x)) via DFT'

```
fftx = fft2(x);
fft_hlp = fft2(h_lp, 256,256);
filtered_image = fftx.*fft_hlp;
LPT_DFT = ifft2(filtered_image);

diff2 = abs(x - LPT_DFT);
figure,
imagesc(diff2); colormap(gray); axis square
title('abs(x-LPT(x)) via DFT');

% <= enter matlab code here
```



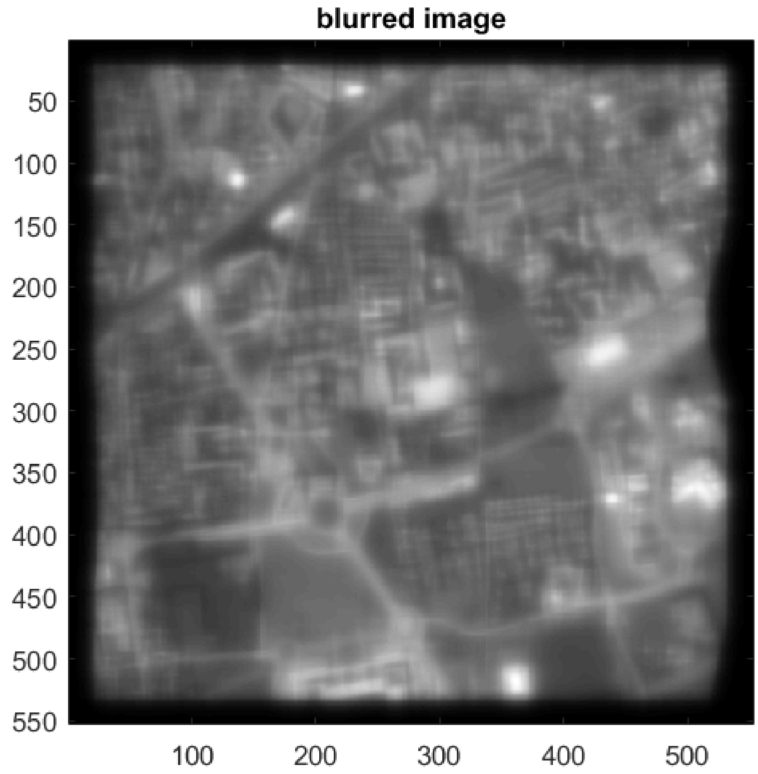
4.1 Image restoration

```
% load blur.mat and display it with title 'original image'

clear all

load blur.mat
load nimes_france.mat
figure,
imagesc(x); colormap('gray'); axis square
title('original image');

% <= enter matlab code here
```



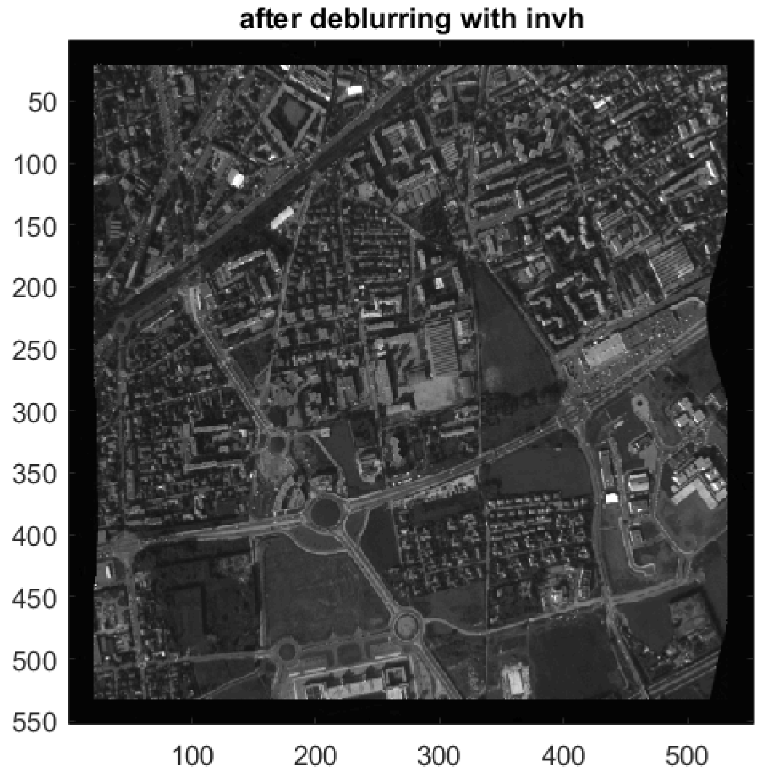
4.1a generate blurred image

```
% display the blurred image with title 'blurred image'

blurred_image = conv2(h,x);

figure,
imagesc(blurred_image); colormap('gray'); axis square
title('blurred image');

% <= enter matlab code here
```



4.1b deblurring using inverse filtering

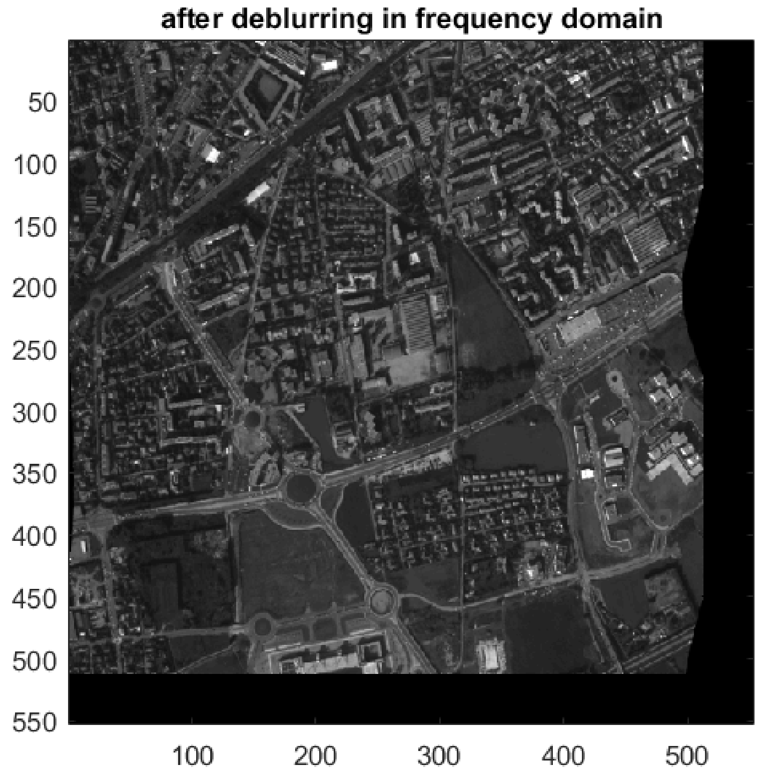
```
% remember to use 'same' in conv2 to ensure the image afater
 convolution
% has the same size.
% submit 1 figure with title 'after deblurring with invh'

load blurinv.mat

tic
deblurred_image = conv2(blurred_image, invh, 'same');
toc

figure,
imagesc(deblurred_image); colormap('gray'); axis square
title('after deblurring with invh');

% <= enter matlab code here

Elapsed time is 0.042919 seconds.
```



4.1c deblurring in frequency domain

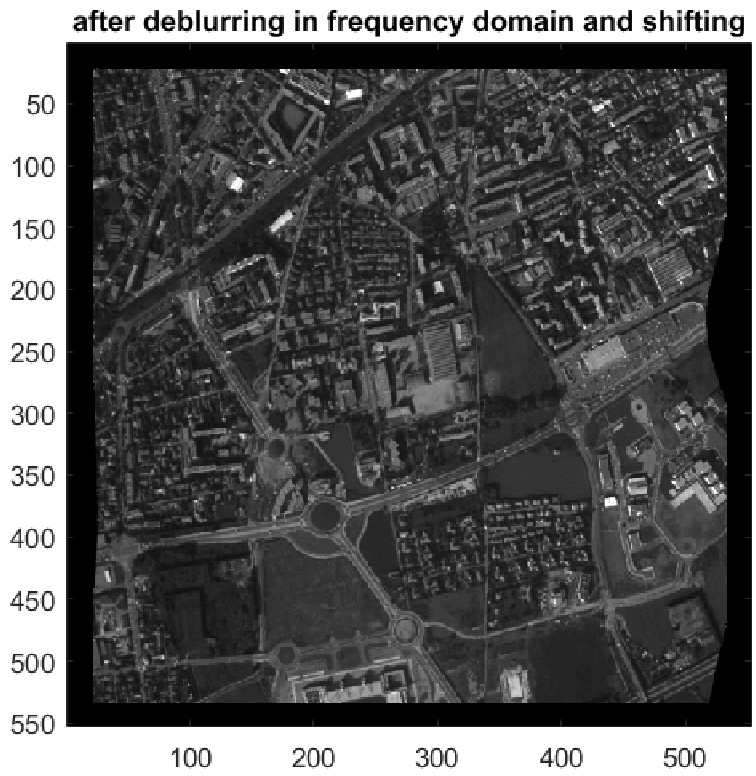
```
% the division is performed element by element using ./ operator.
% denote the recovered image Xrecovery
% submit 1 figure with title 'after deblurring in frequency domain'
% print elapse time and compare it against that in 4.1b (longer?
 shorter?)

fft_blurred = fft2(blurred_image);
fft_blurring = fft2(h, 553, 553);

tic
deblurred_DFT = fft_blurred./fft_blurring;
Xrecovery = ifft2(deblurred_DFT);
toc

%Using the frequency domain method is faster than the convolution
 method

figure,
imagesc(Xrecovery); colormap('gray'); axis square
title('after deblurring in frequency domain');

% <= enter matlab code here
```

Elapsed time is 0.032033 seconds.



4.1d deblurring in frequency domain (improved)

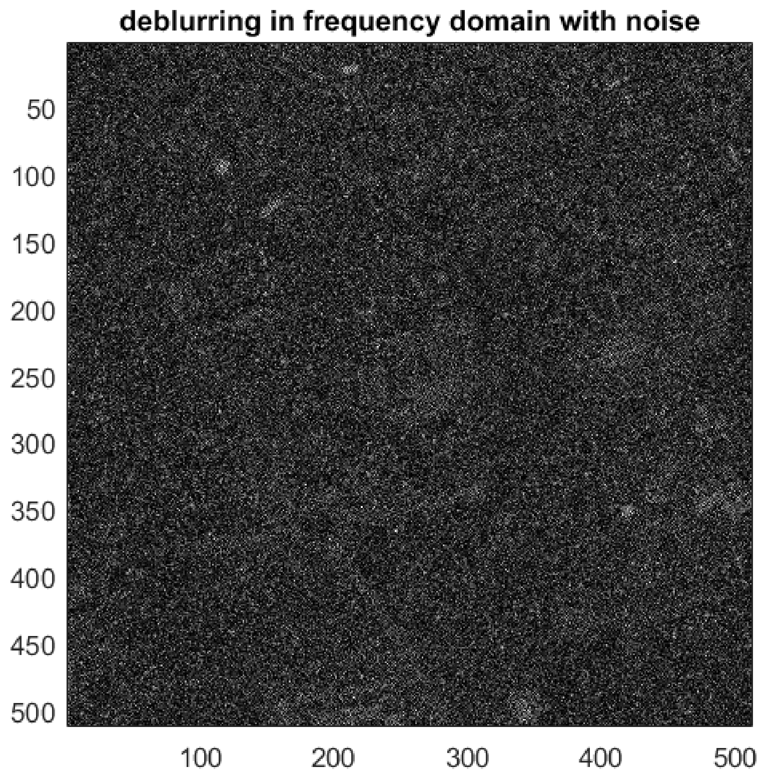
```
% submit 1 figure with title 'after deblurring in frequency domain and
% shifting'
% Image name to be used: Xrecovery1
N = length(Xrecovery);

shift = exp(-j*2*pi*21/N*(0:N-1)')*exp(-j*2*pi*21/N*(0:N-1));
Xrecovery1 = real(ifft2(fft2(Xrecovery).*shift));

figure,
imagesc(Xrecovery1); colormap('gray'); axis square
title('after deblurring in frequency domain and shifting');

% <= enter matlab code here
```

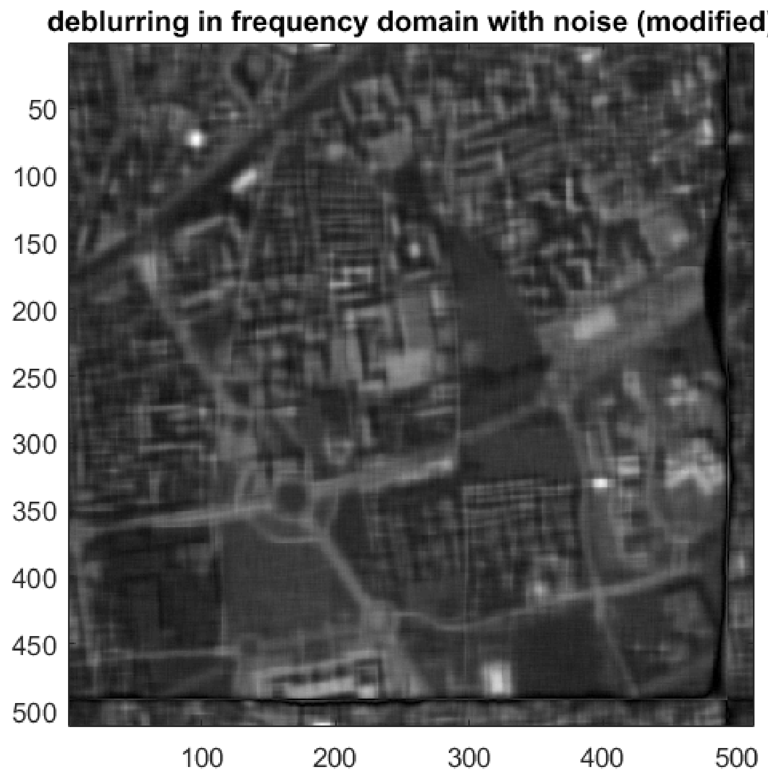


4.1e deblurring noisy blurred image

```
% generate the blurred image plus noise as instructed in the handout.
% part I. apply deblurring method in 4.1d. submit the result with
 title
% 'deblurring in frequency domain with noise'
% Also comment on the result.

y = conv2(x,h, 'same') + randn(size(x));

N = length(y);

fft_blurred = fft2(y);
fft_blurring = fft2(h, 512, 512);
deblurred_DFT = fft_blurred./fft_blurring;
Xrecovery2 = ifft2(deblurred_DFT);

shift = exp(-j*2*pi*21/N*(0:N-1)')*exp(-j*2*pi*21/N*(0:N-1));
Xrecovery3 = real(ifft2(fft2(Xrecovery2).*shift));

figure,
imagesc(abs(Xrecovery3)); colormap('gray'); axis square
title('deblurring in frequency domain with noise');
```

```
%This image looks much more blurry and hsa more static than the
 previously
%deblurred image using the DFT.

% <= enter matlab code here

% Part II. repeat part I but with suggested improvement in handout.
 submit
% the result with title 'deblurring in frequency domain with noise
% (modified)'

Xrecovery4 = fft_blurred.*conj(fft_blurring)./(abs(fft_blurring).^2 +
 0.01);
figure,
imagesc(abs(ifft2(Xrecovery4))); colormap('gray'); axis square
title('deblurring in frequency domain with noise (modified)');

% <= enter matlab code here
```

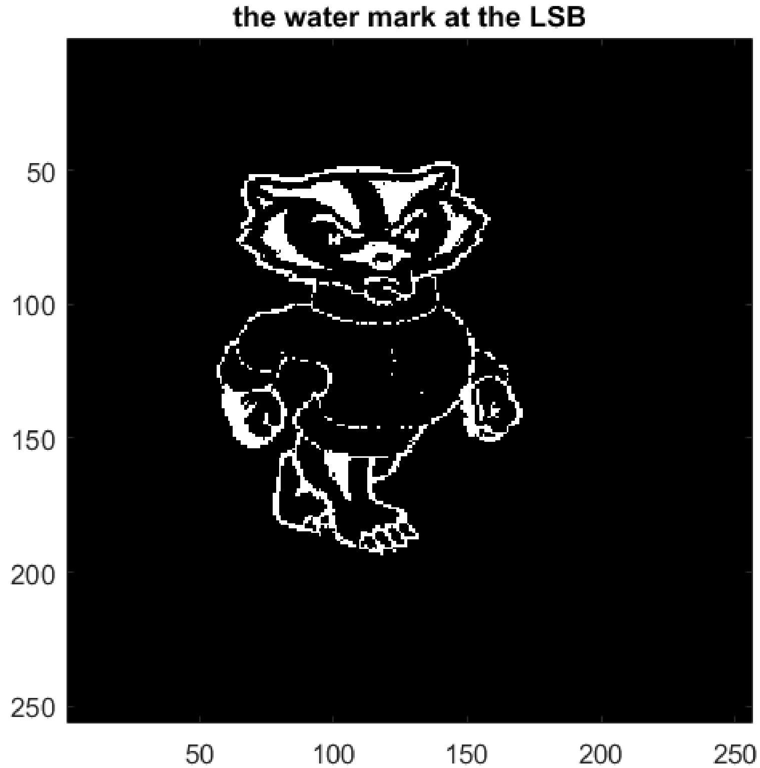




4.2a extract the LSB bit plane of an image

```
% load cam_wm.mat in which an image called y.
% to extract least significant bit, note that each pixel is an integer
 with
% value between 0 to 255 (2^8 -1). The LSB determines if the value is
 an
% odd number (LSB = 1) or an even number (LSB=0).
% if y is an even number, then y - 2*floor(y/2) = 0 where floor(x) is
 the
% largest integer smaller than x. If y is an odd number,
 y-2*floor(y/2) = 1
% to check, if y = 4, 4-2*floor(4/2)=0. If y = 5, 5-2*floor(5/2) =
 5-2*2 =
% 1. Use this method you can find the LSB for each pixel of the image.
 the
% matrix of the LSB value form a binary image (contains 0 or 1).
% submit 1 figure of the LSB image with title 'the water mark at the
 LSB'

load cam_wm.mat
water_mark = y - 2*floor(y/2);
figure,
imagesc(water_mark); colormap('gray'); axis square
title('the water mark at the LSB');
```

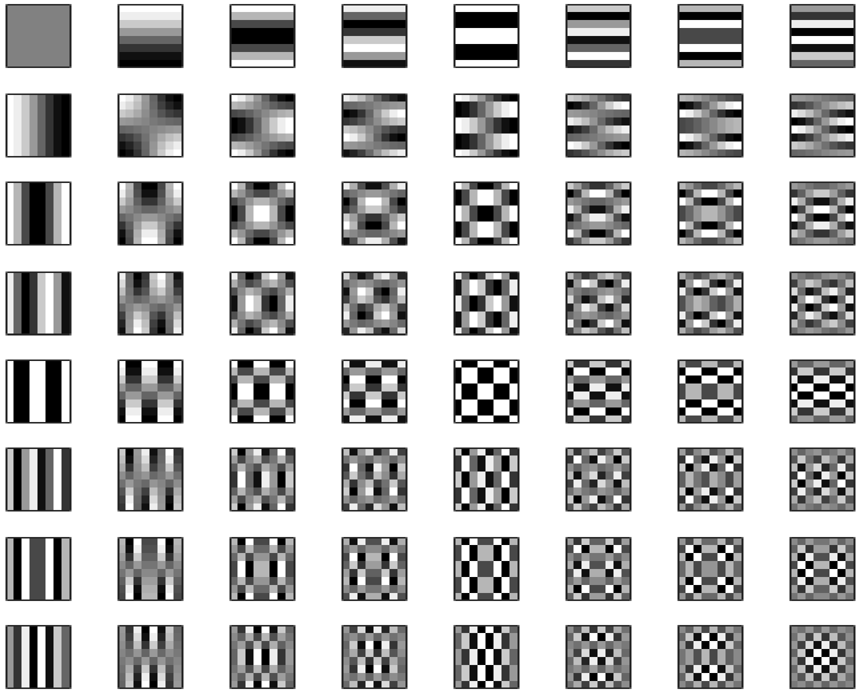
```
% <= enter matlab code here
```



4.3a 2D DCT

display DCT basis. follow the instruction in the handout. Watch out for the quotation marks for text strings. submit 1 figure title '2D DCT Basis function'

```
figure,
N=8;
for m=1:N
    for n=1:N
        e=zeros(N,N);
        e(m,n)=1;
        b = idct2(e);
        subplot(8,8,m+(n-1)*N)
        imagesc(b)
        colormap(gray)
        set(gca,'Xtick',[])
        set(gca,'Ytick',[])
        axis('square')
    end
end

% <= enter matlab code here
```

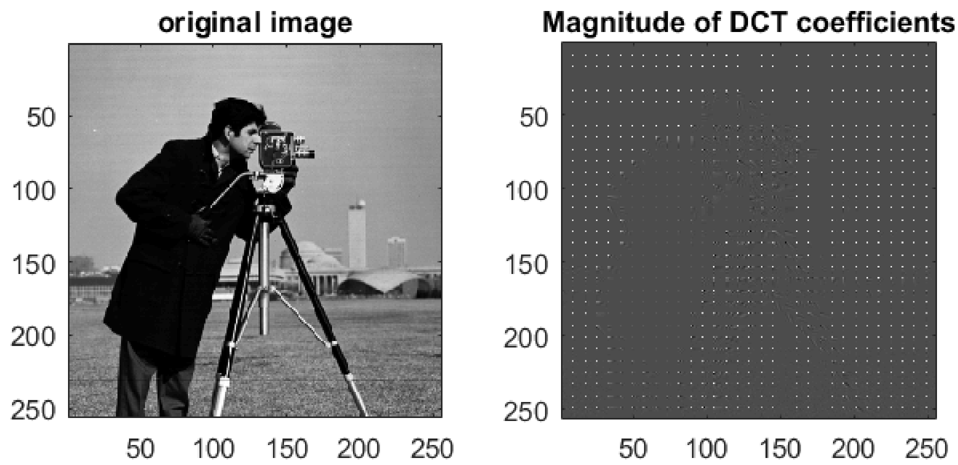


4.3b Block DCT transform

submit two subplots, subplot(1,2,1) title 'original image' subplot(1,2,2), title 'magnitude of DCT coefficients'

```
load cameraman.mat

[M,N] = size(x);
Mblocks = M/8;
Nblocks = N/8;
% compute DCT of 8x8 subimages
for m = 1:Mblocks
    for n=1:Nblocks
        Mrange = (m-1)*8+1:(m-1)*8+8;
        Nrange = (n-1)*8+1:(n-1)*8+8;
        block = x(Mrange,Nrange);
        DCTblock = dct2(block);
        y(Mrange,Nrange) = DCTblock;
    end
end

figure,
subplot(1,2,1)
imagesc(x); colormap('gray'); axis square
title('original image');
```

```
subplot(1,2,2)
imagesc(y); colormap('gray'); axis square
title('Magnitude of DCT coefficients');

% <= enter matlab code here
```



4.3c applying quantization

remember the quantization may be applied to each element in the DCT coefficient matrix. print out compression ratio

```
% quantization matrix
Q = [16 11 10 16 24 40 51 61;
12 12 14 19 26 58 60 55;
14 13 16 24 40 57 69 56;
14 17 22 29 51 87 80 62;
18 22 37 56 68 109 103 77;
24 35 55 64 81 104 113 92;
49 64 78 87 103 121 120 101;
72 92 95 98 112 100 103 99];

yquantized=zeros(M,N); % initialize quanized DCT coefficients
% quantize each DCT coefficient
for m = 1:Mblocks
    for n=1:Nblocks
        Mrange = (m-1)*8+1:(m-1)*8+8;
```

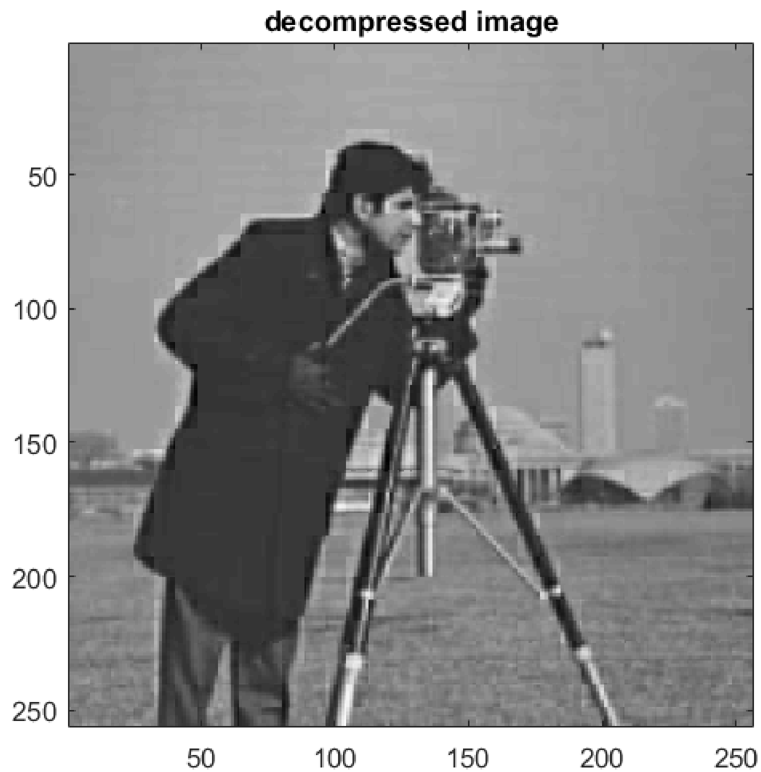
```
        Nrange = (n-1)*8+1:(n-1)*8+8;
        quantized_DCTblock = round(y(Mrange,Nrange)./Q);
        yquantized(Mrange,Nrange)=quantized_DCTblock;
    end
end

% Now compute non-zero quantized DCT coefficients
nNZ=sum(sum(double(abs(yquantized >0)))); % number of non-zero
 entries.
CR = 100*nNZ/(M*N);
fprintf('Compression ratio = %g \n', CR)

% <= enter matlab code here
```

```
Compression ratio = 8.26263
```

4.4d decompression

IDCT needs to be applied block by block submit 1 figure title ('decompressed image')

```
xdecompressed=zeros(M,N);
% Finally reconstruct x from yquantized
for m = 1:Mblocks
    for n=1:Nblocks
        Mrange = (m-1)*8+1:(m-1)*8+8;
        Nrange = (n-1)*8+1:(n-1)*8+8;
        block = yquantized(Mrange,Nrange);
        IDCTblock = idct2(block);
        xdecompressed(Mrange,Nrange) = IDCTblock;
    end
end

figure,
imagesc(xdecompressed),colormap('gray'),axis square
title('decompressed image')

% <= enter matlab code here
```



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