Lab 8: Image Processing and Compression, Dan Wortmann, May 9th, 2014

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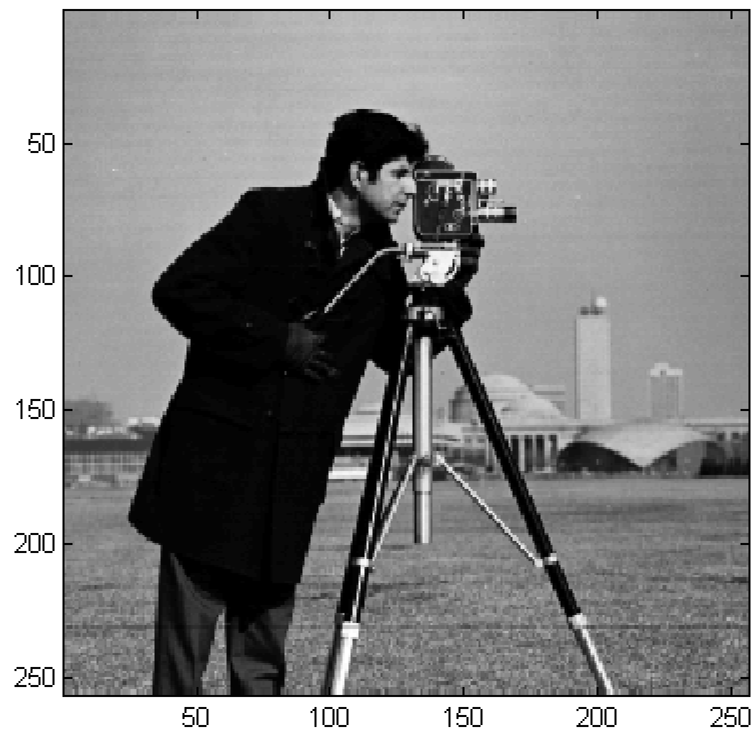
Warm up

3.1

```
clc
clear
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')

% When taking the fft of the image we get a display of several diagonal
% lines that are coming from the center of image. This may be caused by the
% contrasting colors between the cameraman, the cameran and the light
% background. So as you transfer from the dark jacke to the sky, it gives a
% prominant diagnal.
```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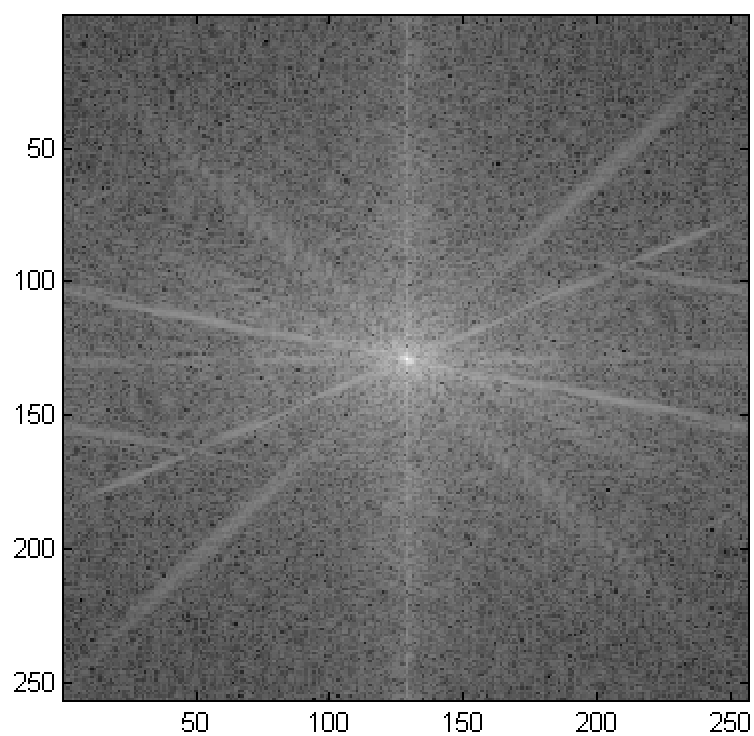
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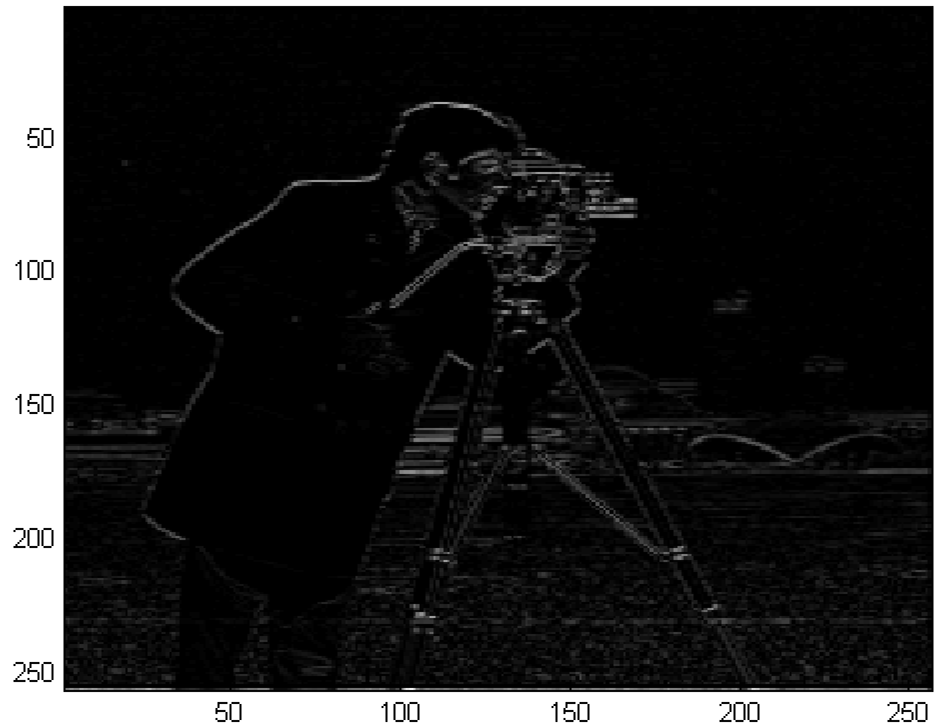
3.2

```
hh = [1/4 1/4; -1/4 -1/4];
hv = [1/4 -1/4; 1/4 -1/4];

yh = conv2(x,hh,'same');
yv = conv2(x,hv,'same');

figure(3)
imagesc(abs(yh));
colormap(gray)

figure(4)
imagesc(abs(yv));
colormap(gray)

%The two filters seems to detect edges in contrasting colors. As we see
%clear lines on colors that have large changes from black to white, but
%very dim - if any lines - on a lot of the gray background.

hlp = [1/4 1/4; 1/4 1/4];
ylp = conv2(x,hlp,'same');

figure(5)
imagesc(x - ylp)
colormap(gray);

%Blurring the image causes the original values to be dilluded and have
%smoother transitions. However once we subtract the original values from
%slightly smaller blurred values we get almost zeroes every EXCEPT where
%there is a sharp peak in contrast of the original image.
```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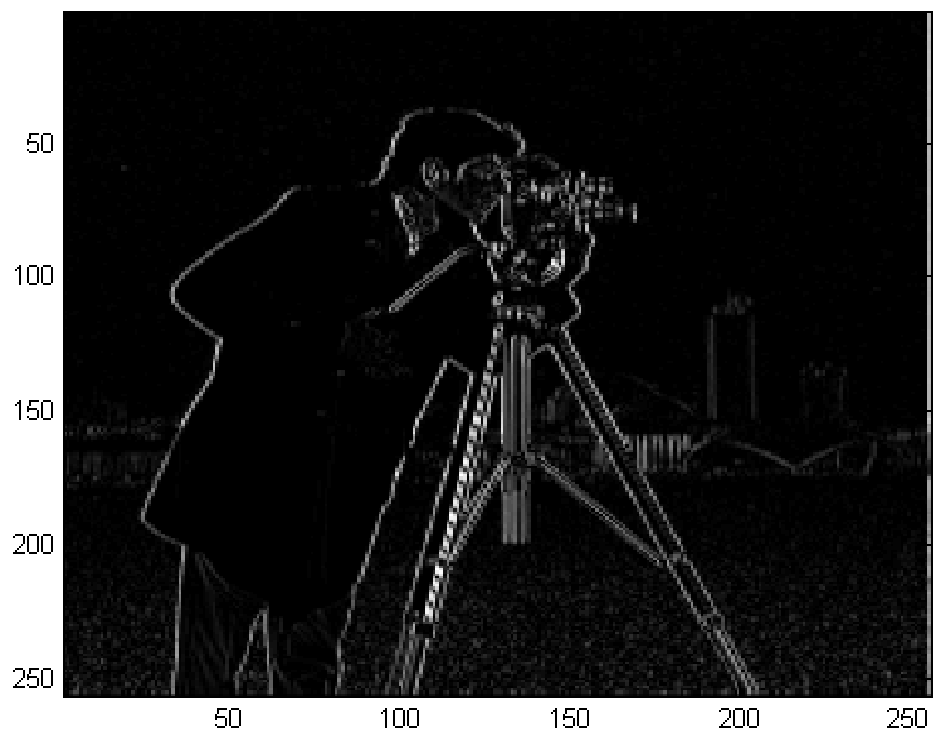
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3.3

```
img = fft2(x);
filter = fft2(hlp, 256, 256);

result = real(ifft2(img .* filter, 256, 256));

figure(6)
imagesc(abs(x - result))
colormap(gray);
```

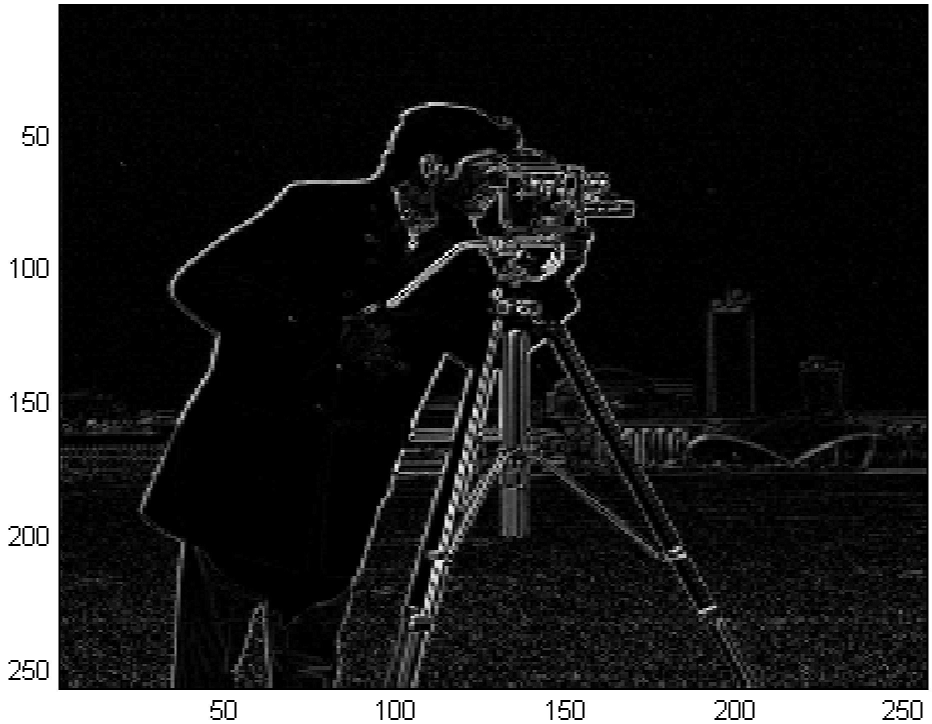


Image Processing, the DFT and DCT

```
clc
clear
close all

load nimes_france.mat
load blur.mat
load blurinv.mat
```

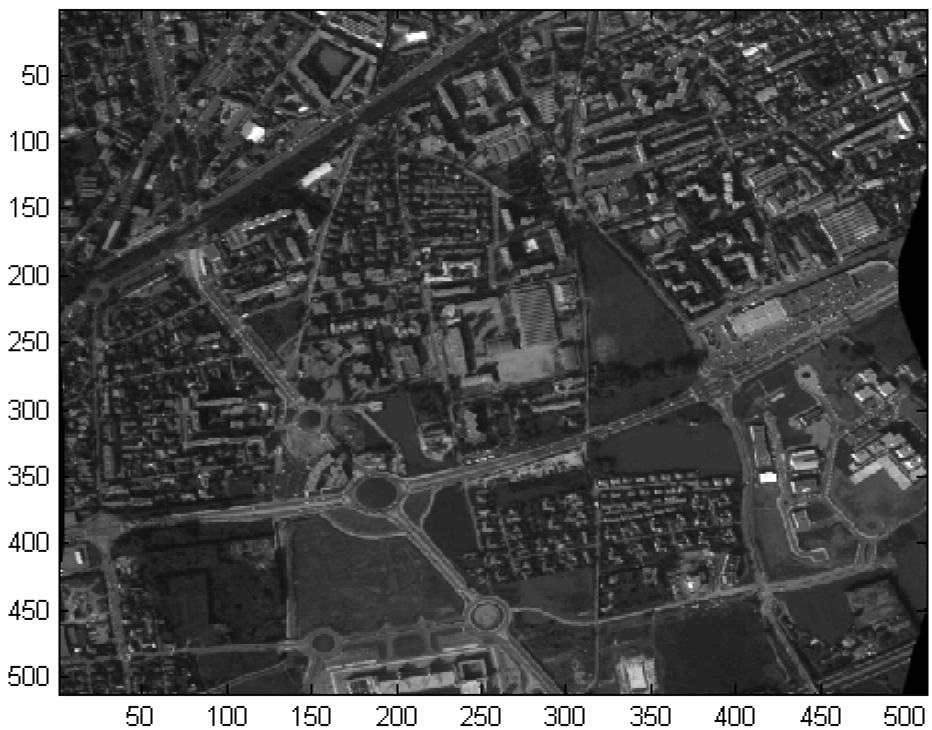
4.1 Image Restoration

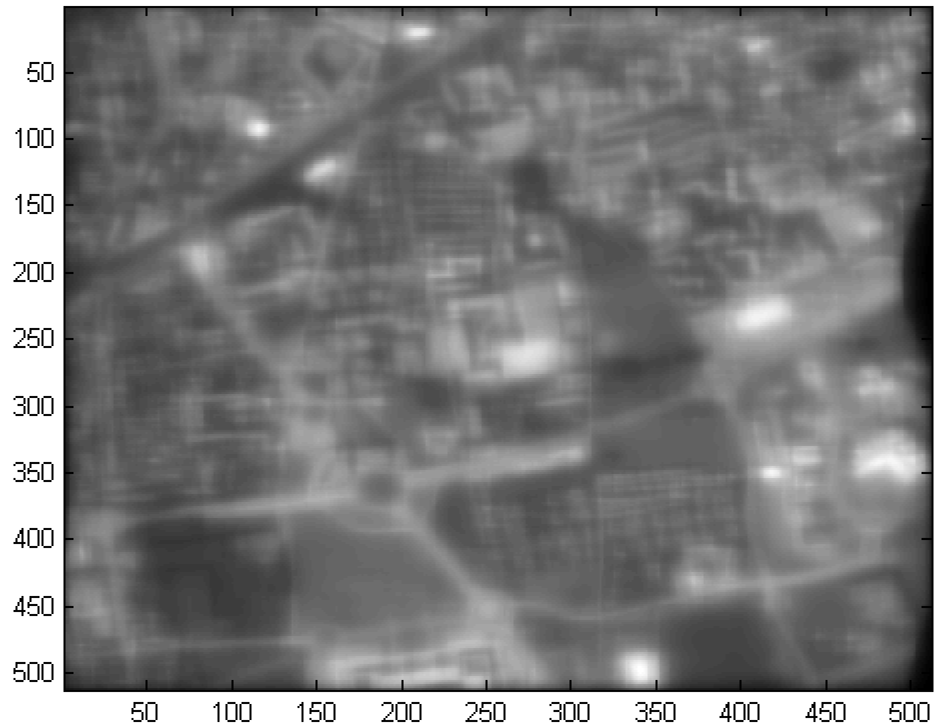
```
%Original
figure(1)
imagesc(x);
colormap(gray)

% a)
blurred = conv2(x, h, 'same');

figure(2)
imagesc(blurred);
colormap(gray)

% b)
```

```
tic;
unblurred = conv2(blurred, invh, 'same');
conv2time = toc

figure(3)
imagesc(unblurred);
colormap(gray)

% c)
tic
DFT_blurred = fft2(blurred);
DFT_filter = fft2(h, 512, 512);

restored = ifft2(DFT_blurred ./ DFT_filter, 512, 512);
dfttime = toc

figure(4)
imagesc(restored)
colormap(gray);

% d)
N = 512;
shift = exp(-1j*2*pi*21/N*(0:N-1)')*exp(-1j*2*pi*21/N*(0:N-1));
restored1 = real(ifft2(fft2(restored).*shift));

figure(5)
imagesc(restored1)
colormap(gray);

%When we use the DFT method, we treat the image as an infinitely periodic
%string of images. This makes us pick up weird edge effects caused by the
%filter picking up parts of the bordering 'images'. By shifting the image
%slightly before taking the ifft, we do not read from the copies of the
%image and only end up restoring a single instance of the original.

% e)
blurred_noise = conv2(x,h,'same') + randn(size(x));

DFT_blurred_noise = fft2(blurred_noise);
DFT_filter_noise = fft2(h, 512, 512);

restored_noise = ifft2(DFT_blurred_noise ./ DFT_filter_noise, 512, 512);

figure(6)
imagesc(restored_noise)
colormap(gray);

%Dramatic effect on the overall image quality, although we definitely see
%the image it looks like an old tv turned onto a static station.
Hf = DFT_filter_noise;

improvedRestored = fft2(blurred_noise).*conj(Hf)./(abs(Hf).^2 + 0.001);

figure(7)
```

```
imagesc(abs(ifft2(improvedRestored)))
colormap(gray);

% By changing the slight offset in the denominator of the function we see
% drastic changes in the blurriness of the image if we increase it, and a
% large increase to static interference if we decrease the offset. This is
% caused by the relative weight to the values of the DFTs. If we divide by
% a small number, we can get relatively large values quickly so we can't
% decrease it too much. The same goes for increasing it too much and not
% filtering out the noise well enough.
```

```
conv2time =

    0.0185


dfttime =

    0.0098
```

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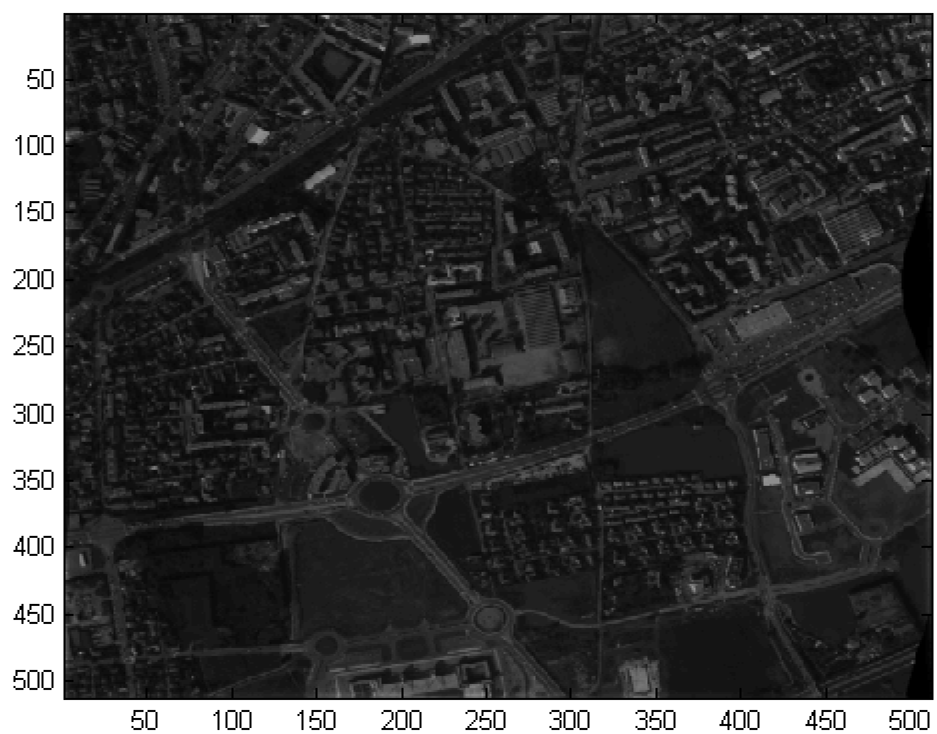
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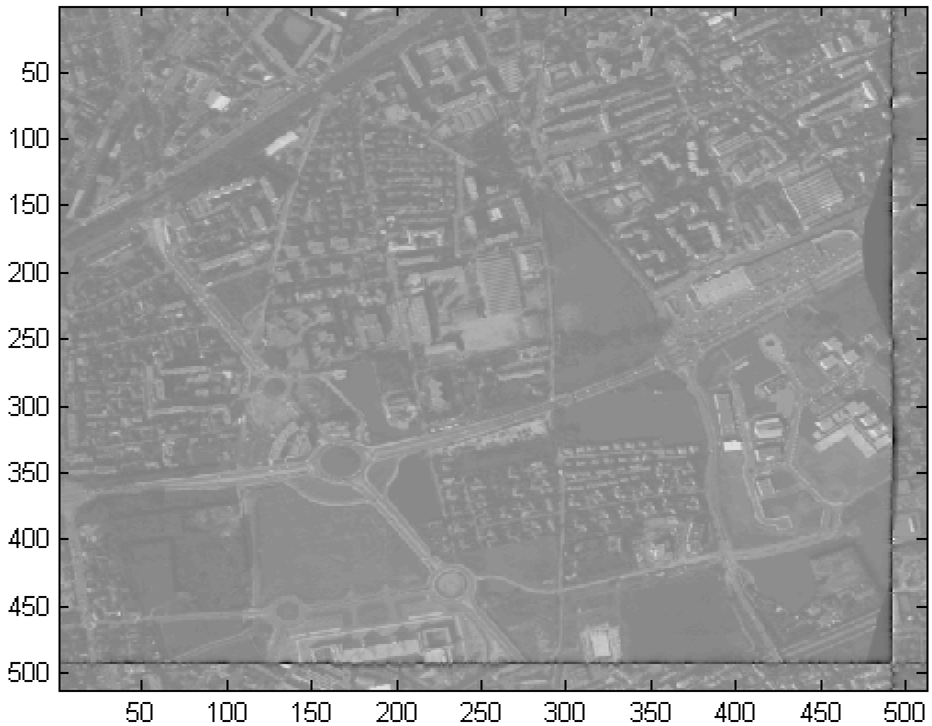
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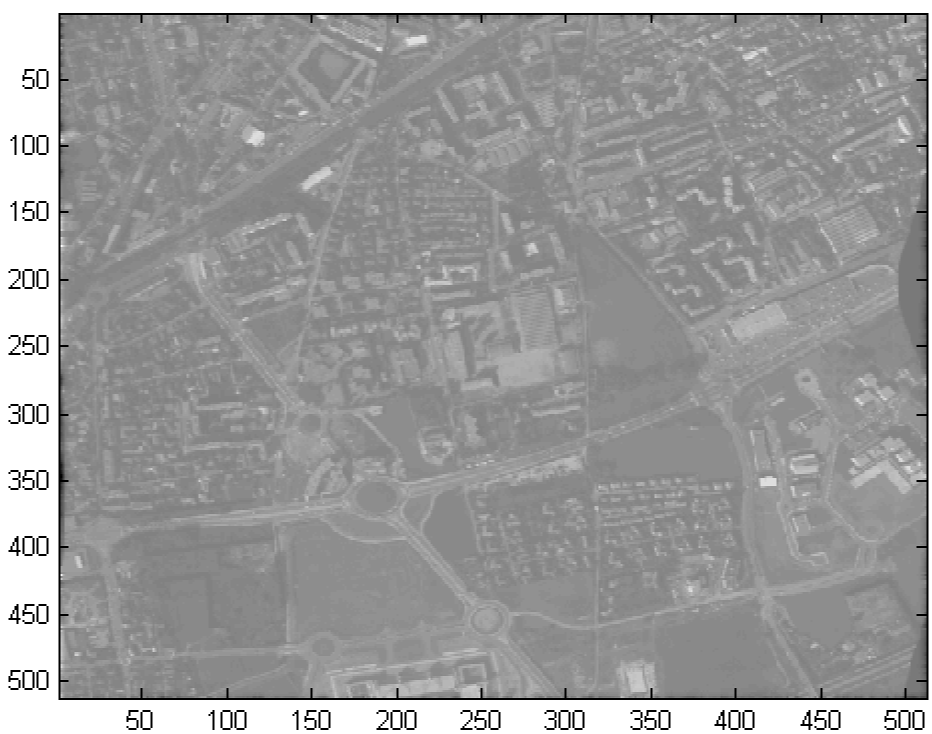
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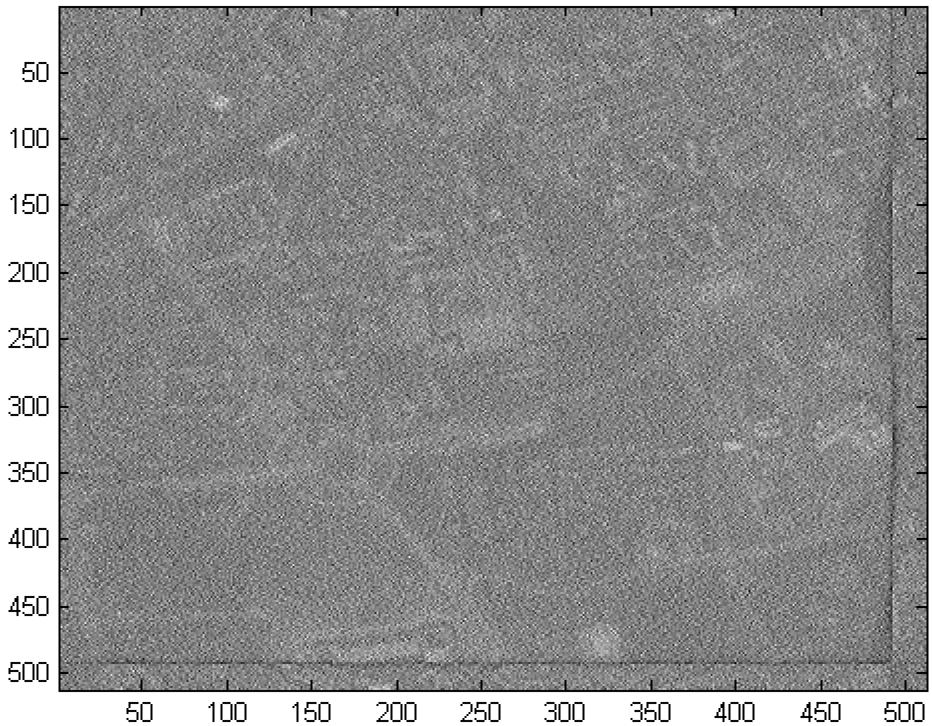
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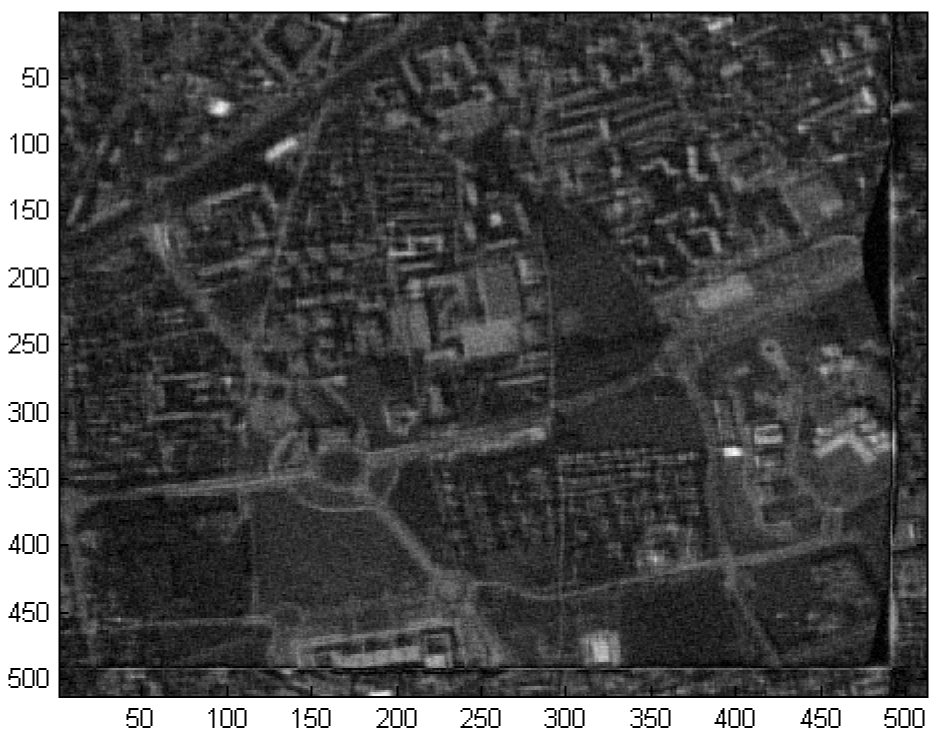
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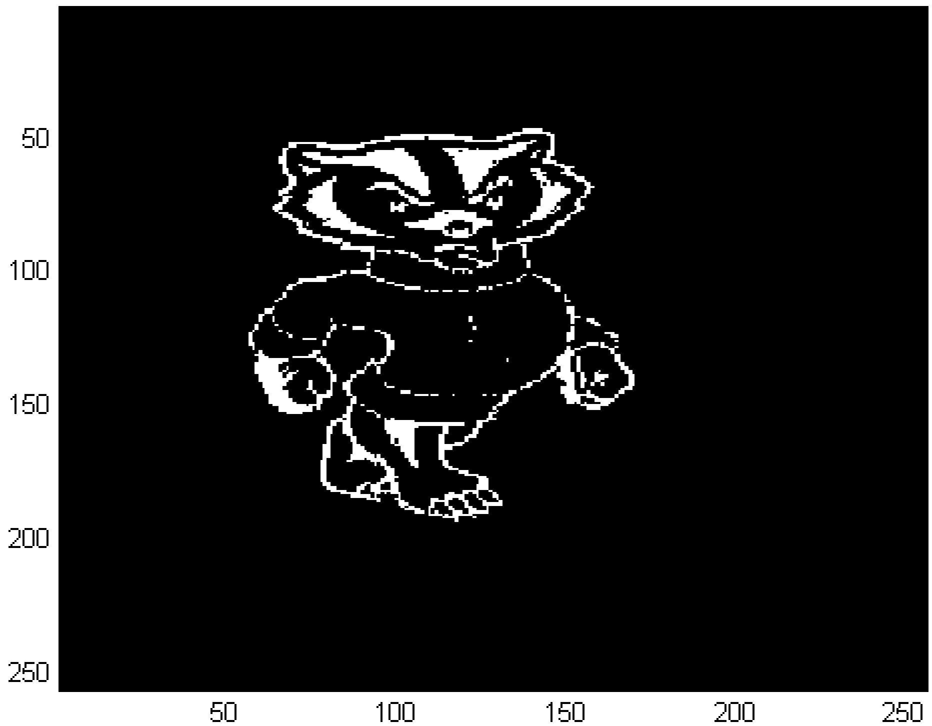
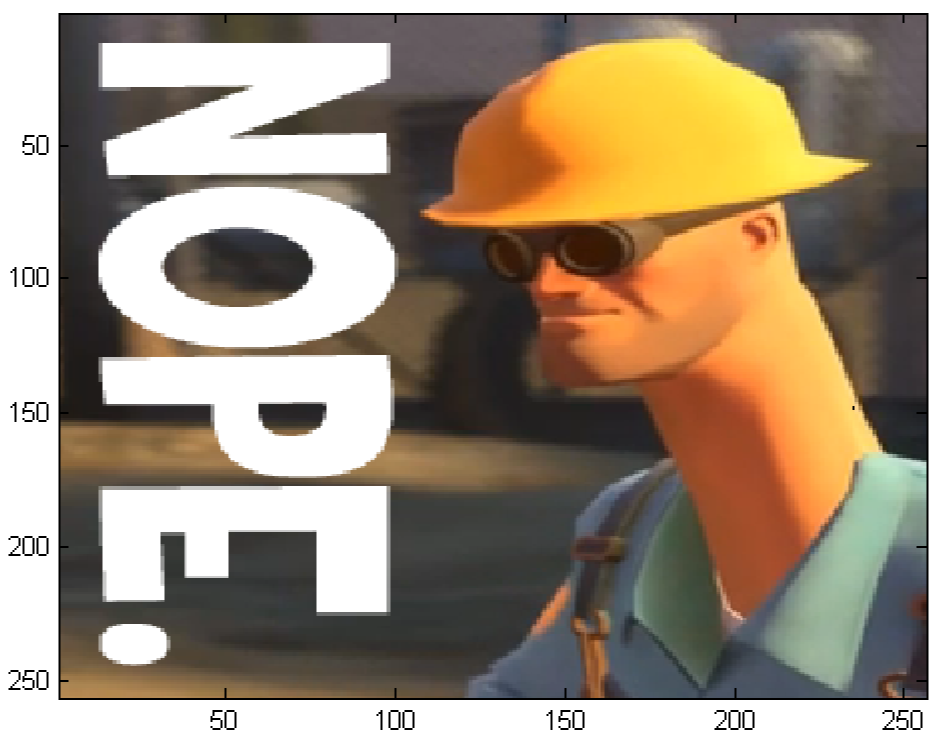
4.2 Image Quantization and Digital Watermarking

```
clc
clear
load cam_wm.mat

% a)
%To get the LSB, just determine whether the number is even - 0 or odd - 1
%for each pixel in the original image.

[M, N] = size(y);
watermark = zeros(M);

for m = 1:M
    for n = 1:N
        if(mod( y(m,n), 2) == 0)
            watermark(m,n) = 0;
        else
            watermark(m,n) = 1;
        end
    end
end

%Bucky the Badger
figure(8)
imagesc(watermark)
colormap(gray);

% b)
%For simplicity I will use the watermark I extracted from the previous step
%and implant it into another picture.

% load imagine using imread
x = imread('lab8matlab.jpg');
% convert data from int to double
%x = im2double(x_int);

figure(9)
imagesc(x)
colormap(gray)
title('Original Image')

%put the watermark into the picture
M = 256; N = 256;

for m = 1:M
    for n = 1:N
        if(watermark(m,n) == 1)
           if(mod(x(m,n),2) == 0)
               x(m,n) = x(m,n) + 1;
           end
```

```
        else
            if(mod(x(m,n),2) == 1)
                x(m,n) = x(m,n) - 1;
            end
        end
    end
end

figure(10)
imagesc(x)
colormap(gray)
title('Watermarked Image')

%Now extract the watermark again
watermark1 = zeros(M);

for m = 1:M
    for n = 1:N
        if(mod( y(m,n), 2) == 0)
            watermark1(m,n) = 0;
        else
            watermark1(m,n) = 1;
        end
    end
end

%Bucky the Badger - again from the new image
figure(11)
imagesc(watermark1)
colormap(gray);
title('Watermark')
```



Original Image




Watermarked Image
NOPE!
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250
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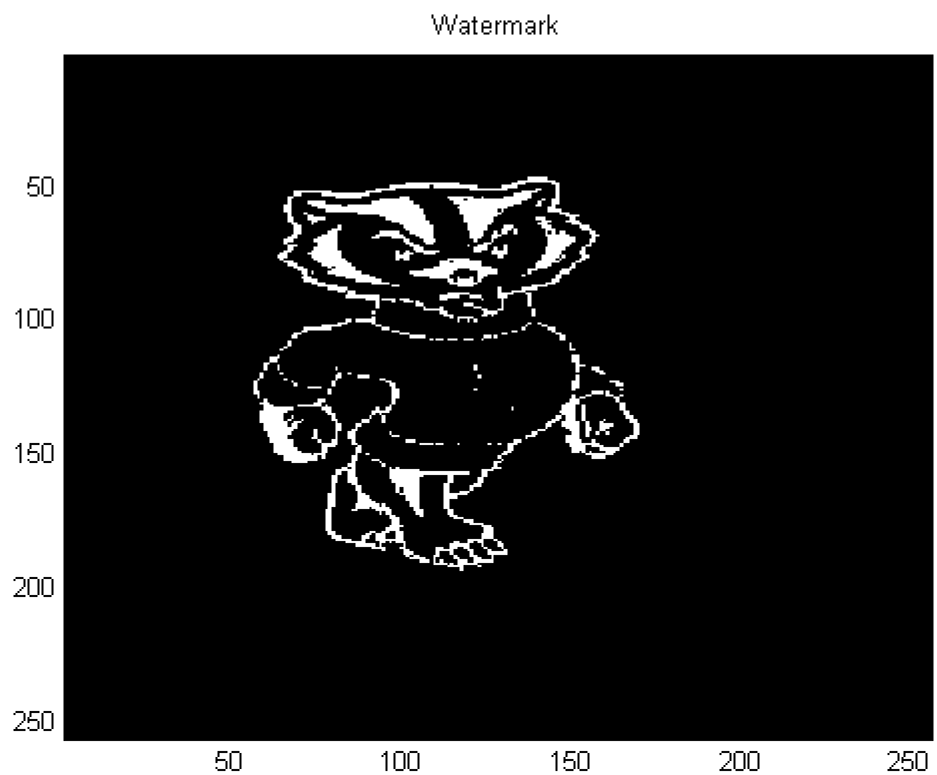
Watermark
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100
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200
250
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150
200
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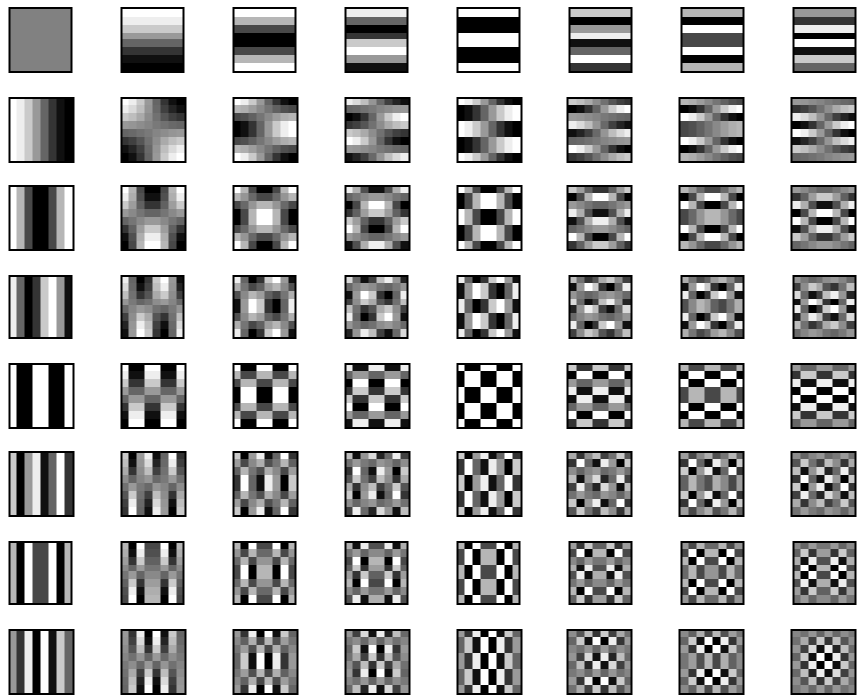
4.3 Image Compression

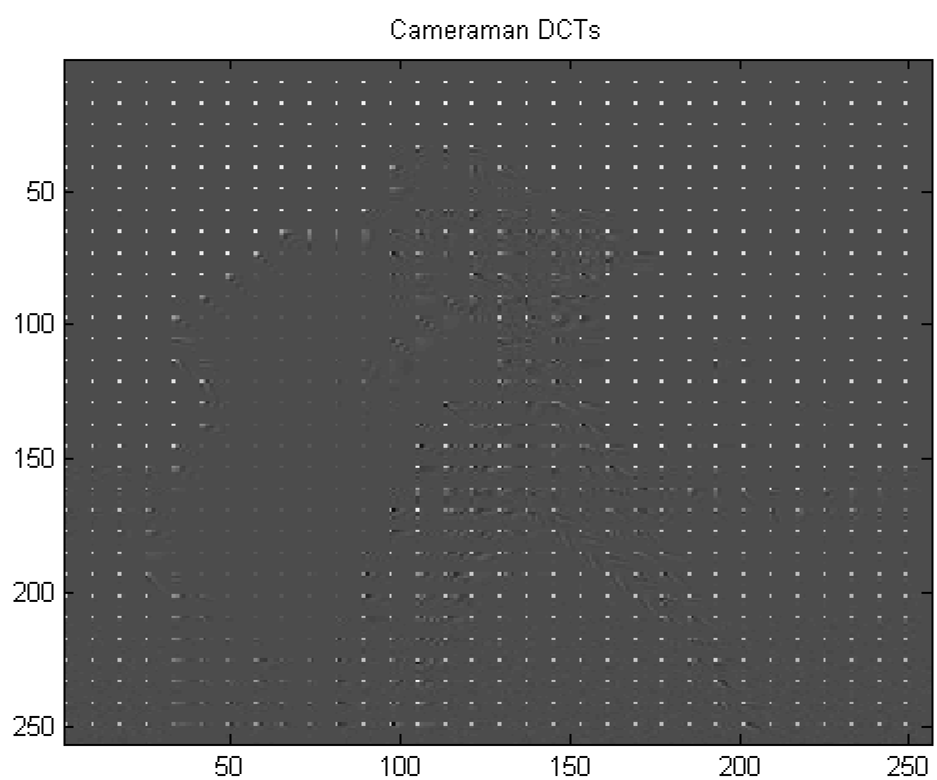
```
clc
clear
close all

% a)

figure(12)
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

% b)

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(13)
imagesc(y)
colormap(gray);
title('Cameraman DCTs')

%Since the DCT divides the picture up into blocks of 8x8, the information
%stored is in smaller blocks that only hold the coefficients used to
%reconstruct the original picture. This leads to smaller space used for
%saving data.
```

```
% c)

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];

[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);
        quantized_DCTblock = round(DCTblock./Q);
        y(Mrange,Nrange) = DCTblock;
        yy(Mrange,Nrange) = quantized_DCTblock;
    end
end

figure(14)
imagesc(y)
colormap(gray);
title('Cameraman DCTs')

figure(15)
imagesc(yy)
colormap(gray);
title('Cameraman DCTs - quantized')

[M,N] = size(x);
Mblocks = M/8;
Nblocks = N/8;
nonZeroCount = 0;

for m = 1:M
    for n = 1:N
        if(yy(m,n) ~= 0)
            nonZeroCount = nonZeroCount + 1;
        end
    end
end

compressionRatio = nonZeroCount / (M*N) %0.1478

% d)
```

```
reconstructed = zeros(N);
scalar = 1;
% compute inverse 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 = yy(Mrange,Nrange);
        inverseDCTblock = round(block.*(Q*scalar));
        block = idct2(inverseDCTblock);
        reconstructed(Mrange,Nrange) = block;
    end
end

figure(16)
imagesc(reconstructed)
colormap(gray);
title('Cameraman DCTs - reconstructed')

%This reconstruction results in the original image, however there are some
%noticeable blurs in areas of a lot of detail and color change. This was
%particularily highlighted around the camera and the edges of the camera
%mans jacket. As we decrease the value of the scalar the image gets more
%and more distorted. As we reach values of around 1/100 we start to see a
%drastic change in the image quality where we can hardly make out the
%camera man. On the opposite end, when we increase the scalar over 1 we see
%minimal improvements to the image. After values of about 100 we see less
%blotches in solid colors around the camera man, however the general
%sharpness of the image is about the same as with a scalar of 1.
```

```
        compressionRatio =

            0.1478
```




Cameraman DCTs
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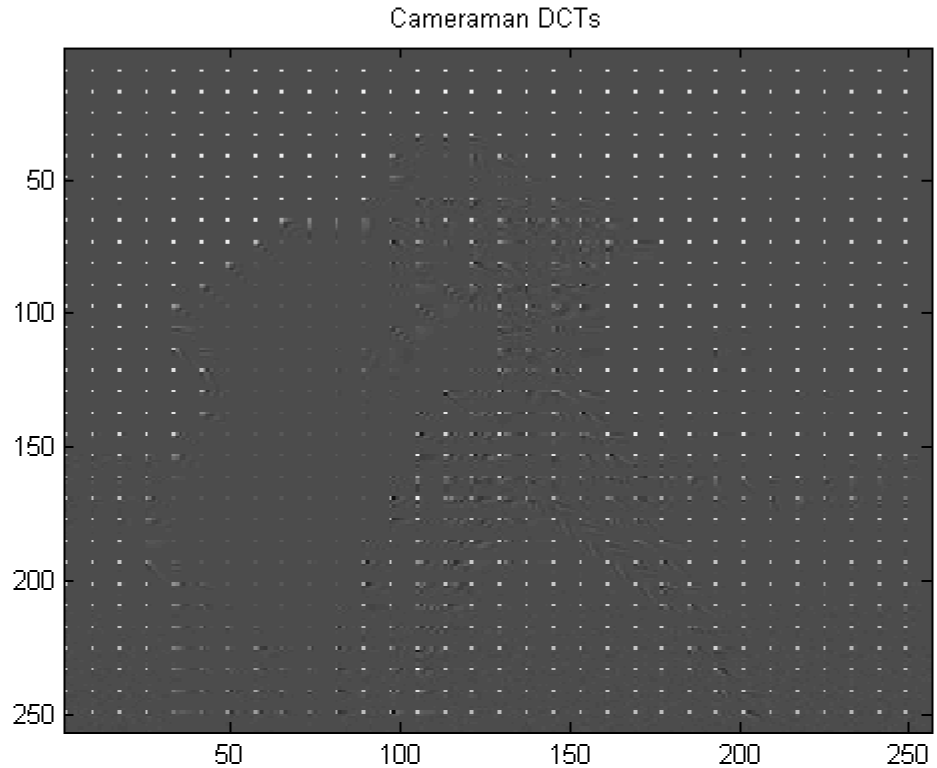
Cameraman DCTs
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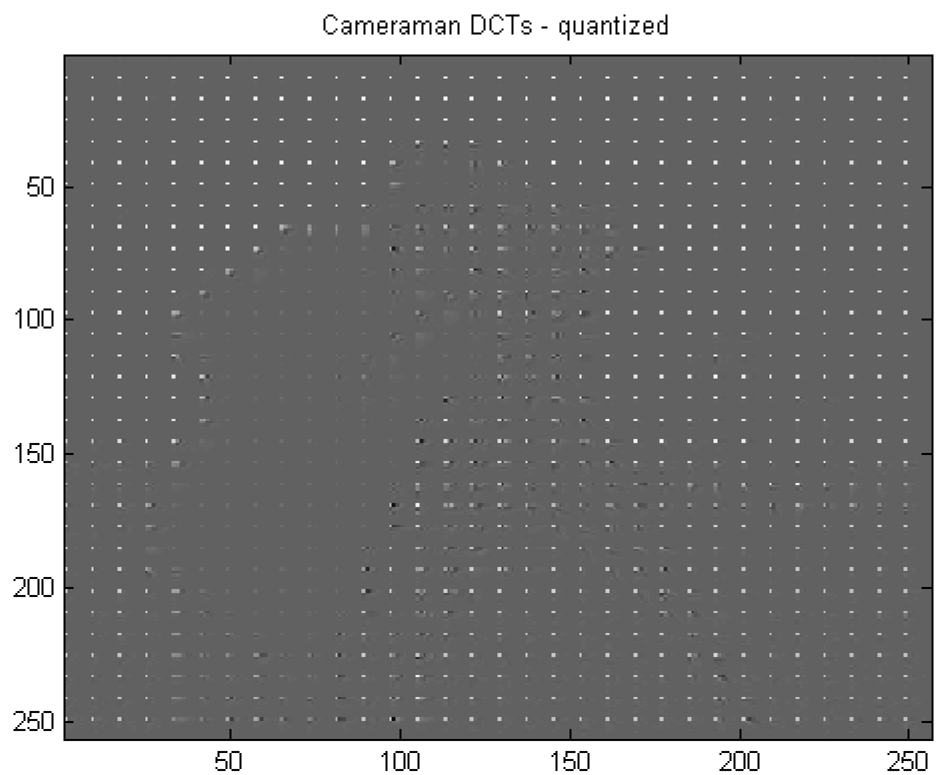
Cameraman DCTs - quantized
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