Homework 4

ECE 253

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- Problem 1 2D Discrete Fourier Transforms

1. 7 unpadded images and their corresponding 2D DFT magnitude:

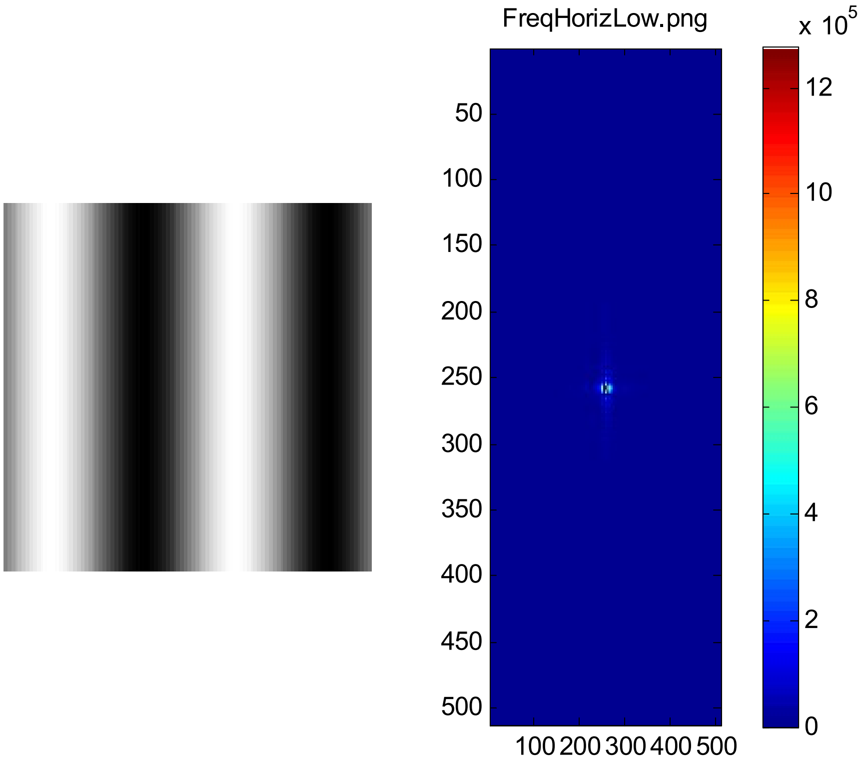


Figure 1 FreqHorizLow

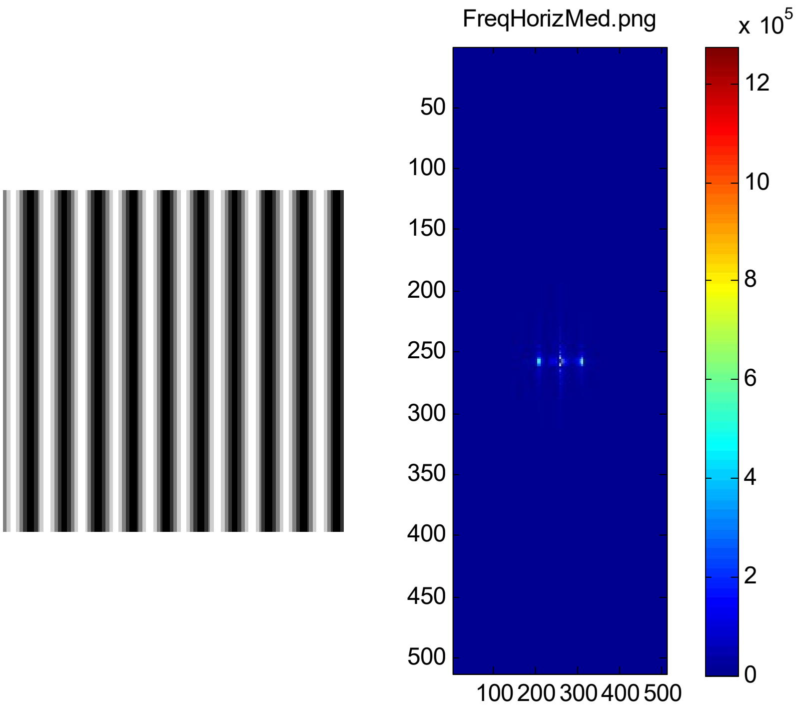


Figure 2 FreqHorizMed

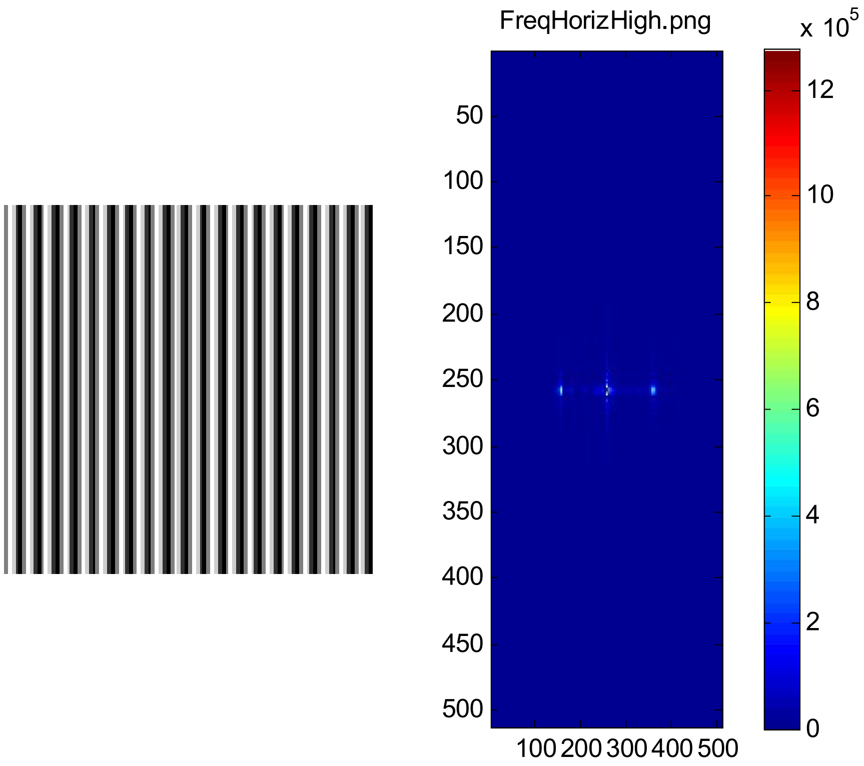


Figure 3 FreqHorizHigh

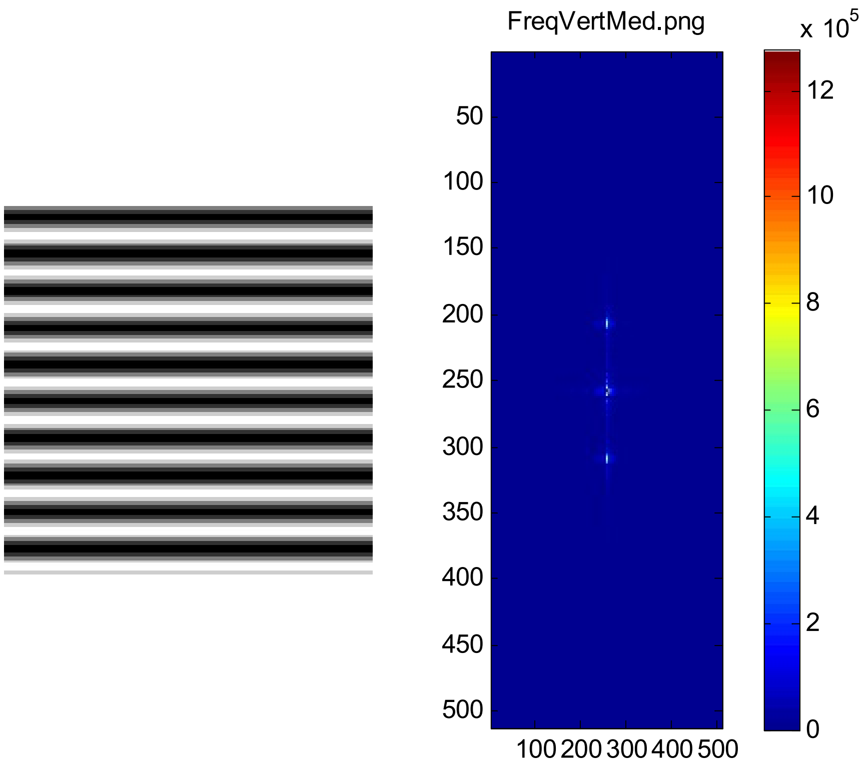


Figure 4 FreqVertMed

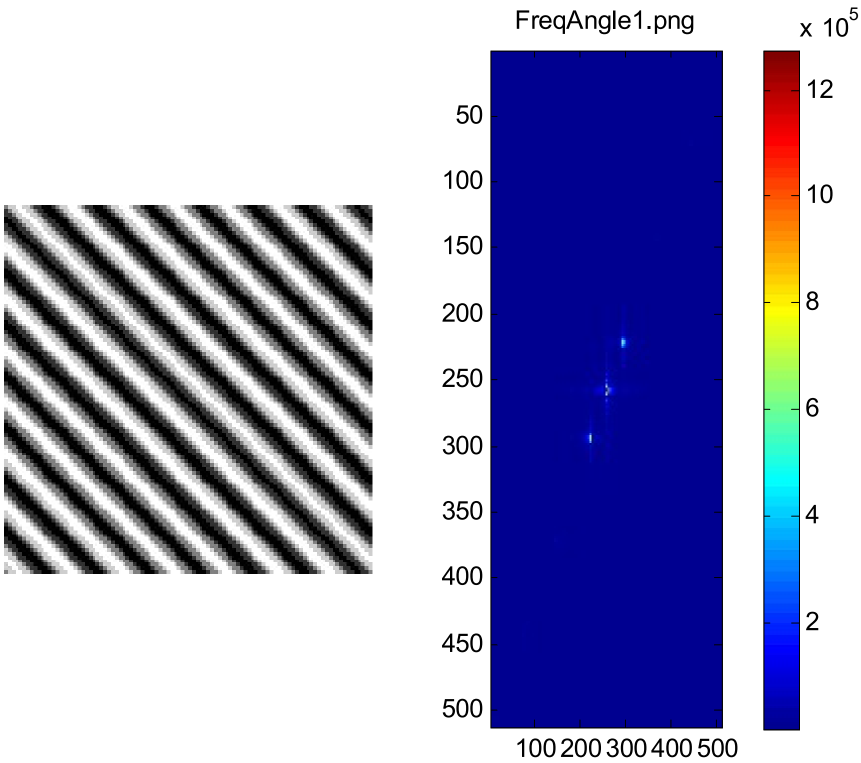


Figure 5 FreqAngle1

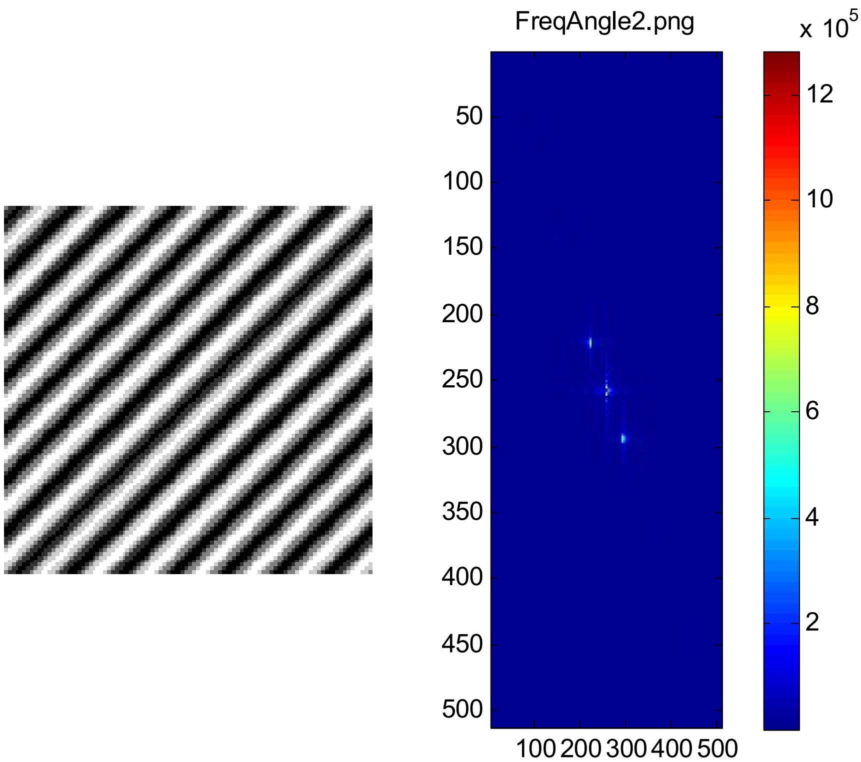


Figure 6 FreqAngle2

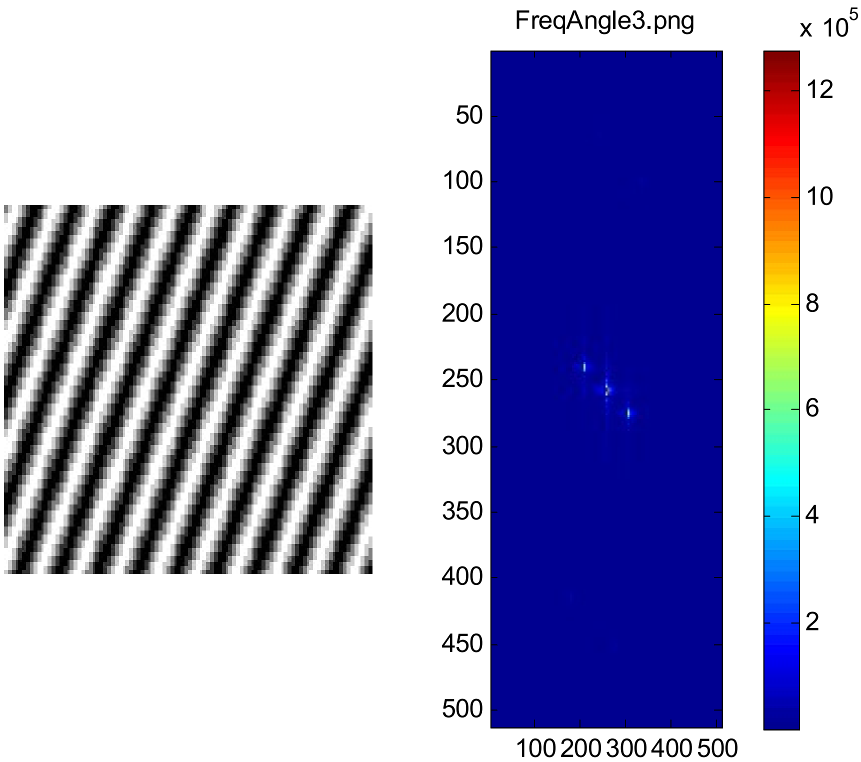


Figure 7 FreqAngle3

2. 2 unpadded images and their corresponding 2D DFT magnitude

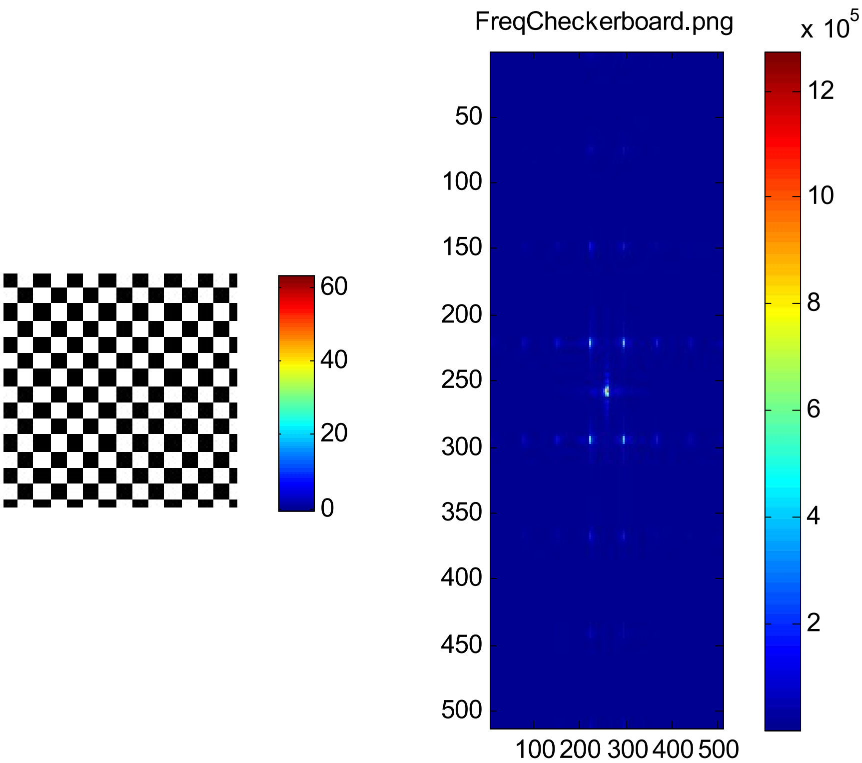


Figure 8 CheckBoard Oirginal

I use HorizMed and VertMed these two images to add to the new checkboard image. The result is:

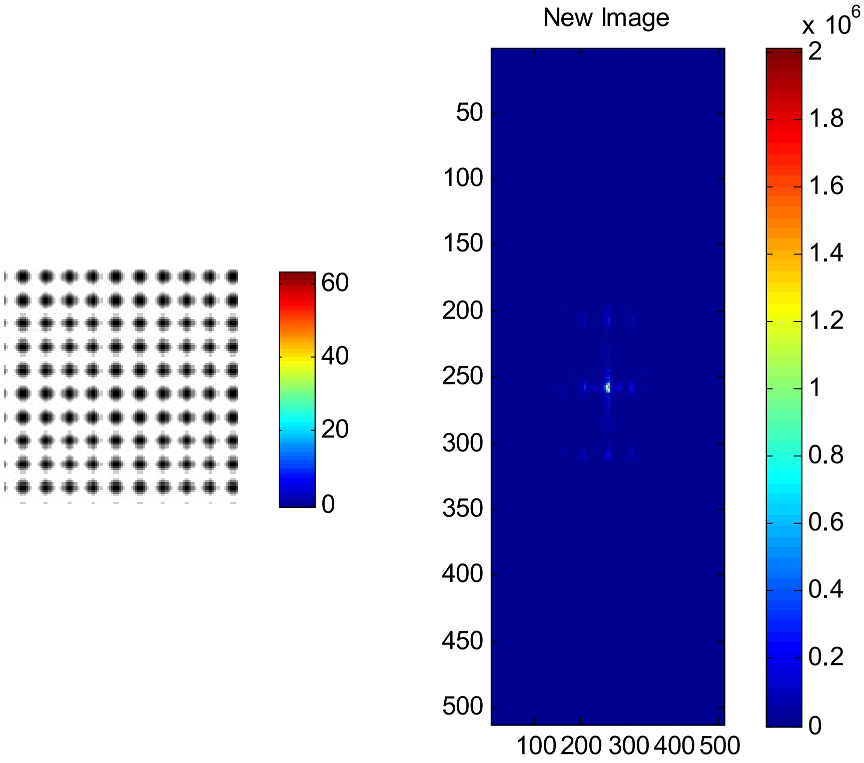


Figure 9 New Image

In spatial domain, it seems that the black blocks is smaller than expected and white ones are bigger. In spatial domain, several burst near the center is similar to the original one. When axis gets far away from the center, it is hard to simulate the checkboard.

3. maskA-D's 2D DFT magnitude, properly labeled.

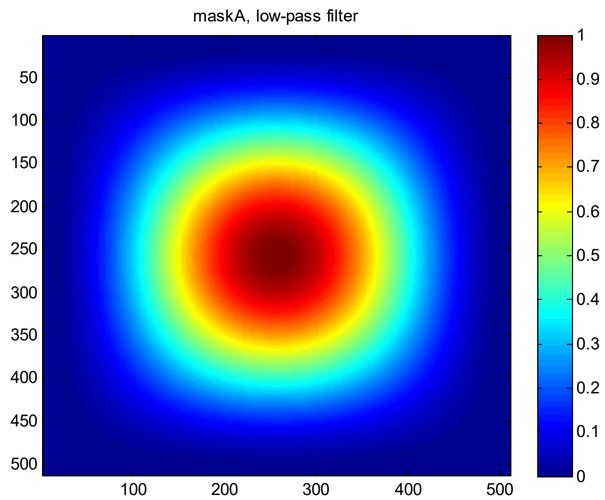


Figure 10 maskA

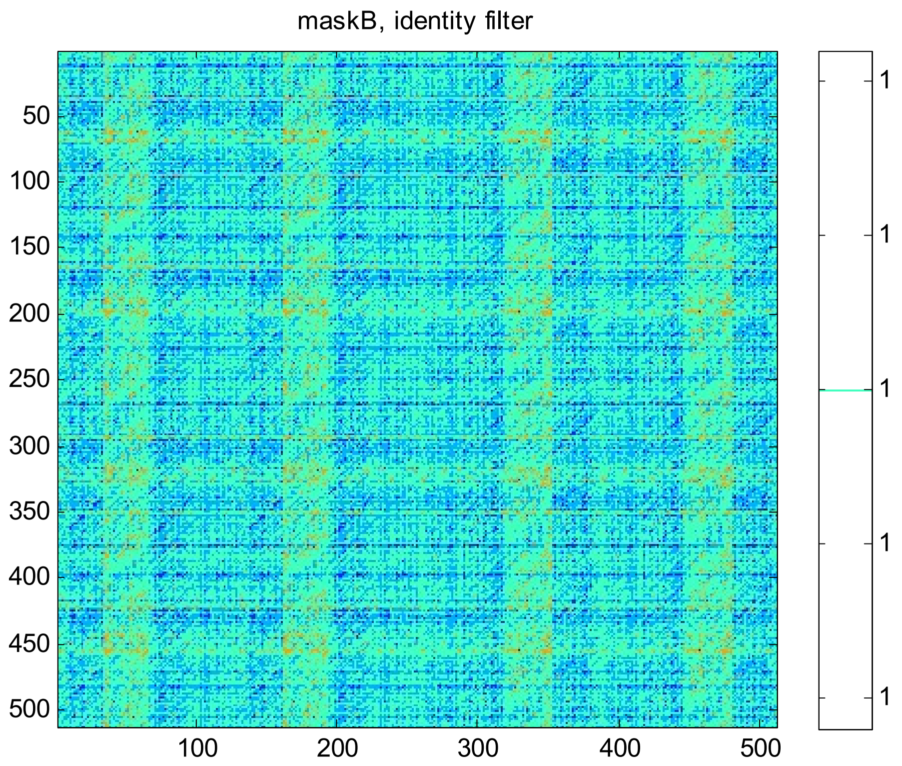


Figure 11 maskB

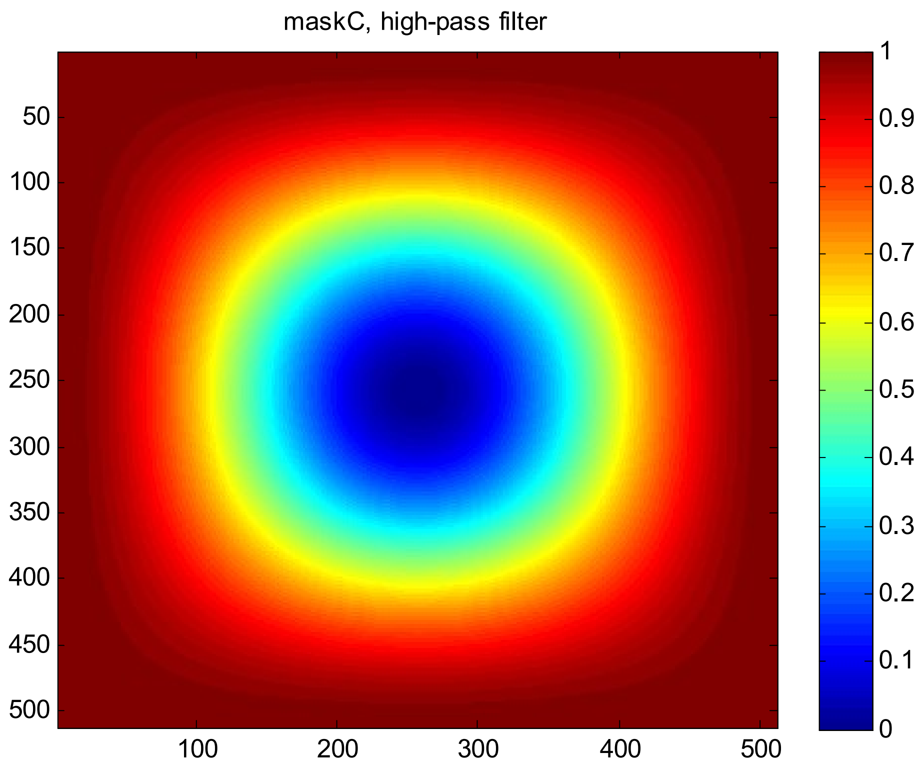


Figure 12 maskC

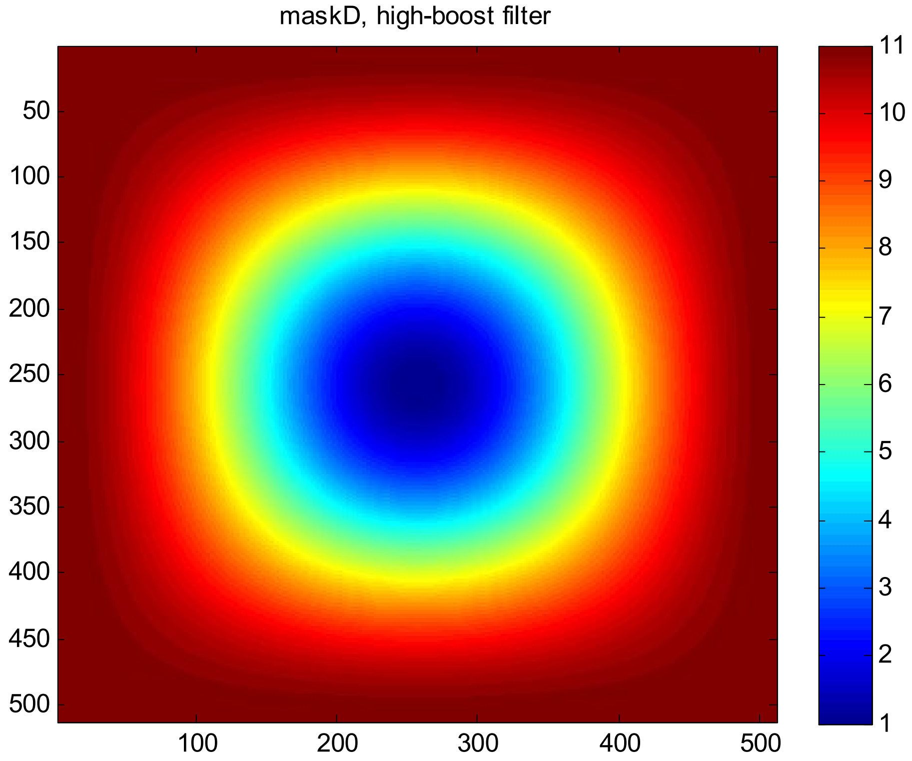


Figure 13 maskD

Code see Appendix

- Problem2 Butterworth Notch Reject Filtering in Frequency Domain

1. 1 unpadded original image, the corresponding 2D DFT log-magnitude, the butterworth Notch Reject Filter in frequency domain HN R(u, v), the final filtered image.
   10 parameters for 2(i): n, D0, u1, v1, ..., u4, v4:
   n = 4; D0 = 25; (u1, v1) = (-90, -80); (u2, v2) = (-82, 85); (u3, v3) = (-90, -170); (u4, v4) = (-82, 175)

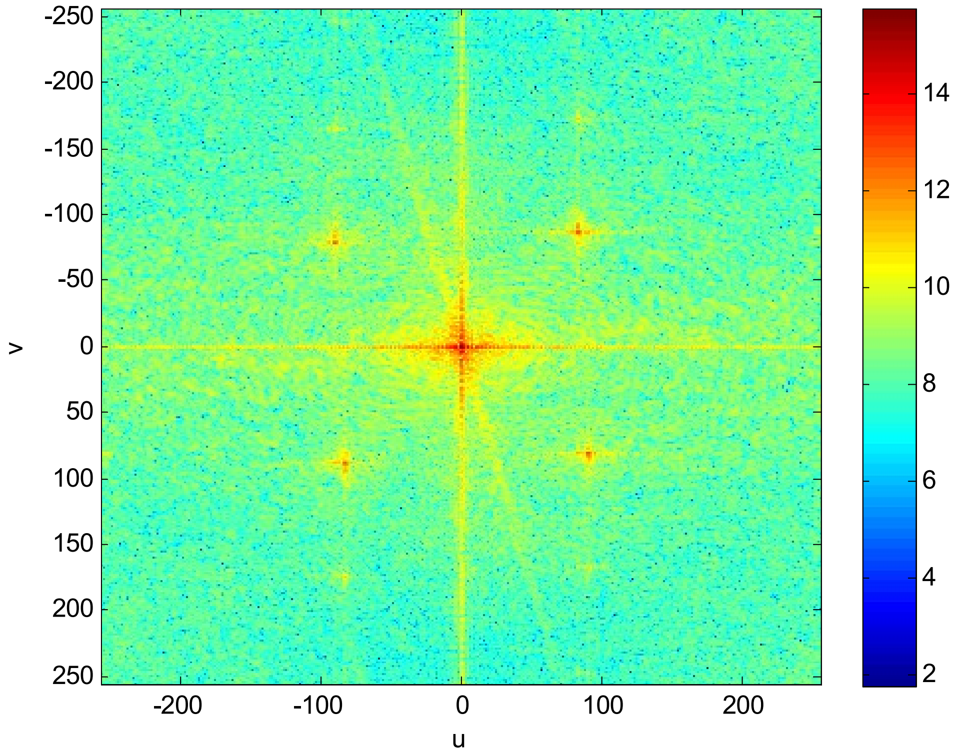


Figure 14 2D DFT log-magnitude

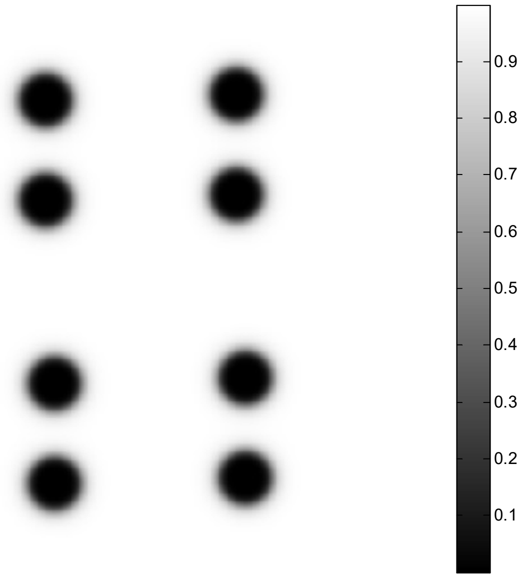


Figure 15 the butterworth Notch Reject Filter in frequency domain HN R(u, v)

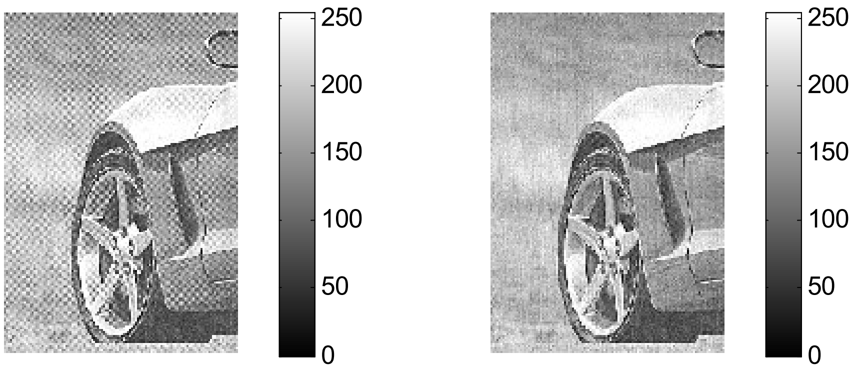


Figure 16 left: orginal image; right: filtered image

2. 1 unpadded original image, the corresponding 2D DFT log-magnitude, the butterworth Notch Reject Filter in frequency domain HN R(u, v), the final filtered image. 6 parameters for 2(ii): n, D0, u1, v1, u2, v2.

n = 4; D0 = 25; (u1, v1) = (0, 170); (u2, v2) = (165, 0);

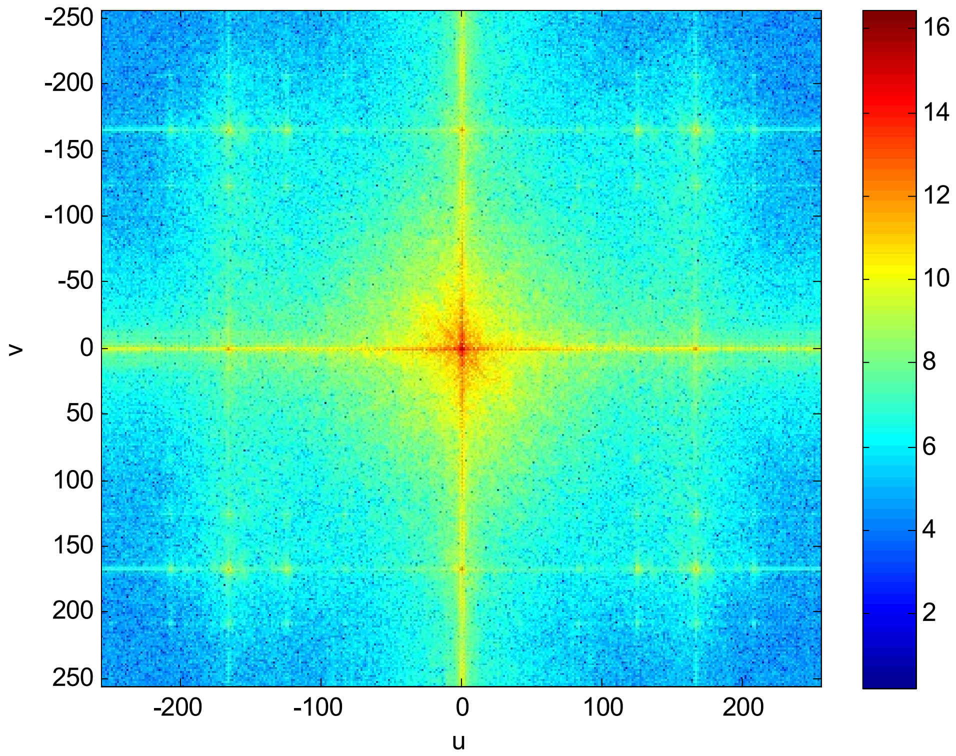


Figure 17 2D DFT log-magnitude

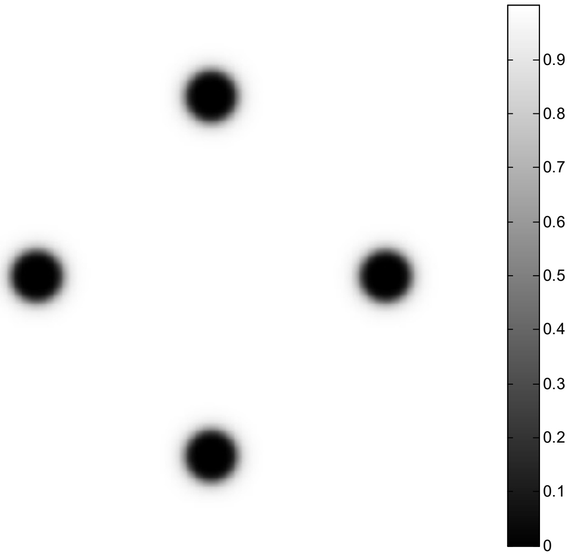


Figure 18 the butterworth Notch Reject Filter in frequency domain HN R(u, v)

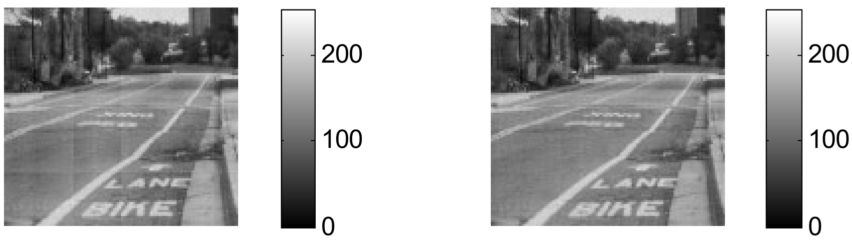
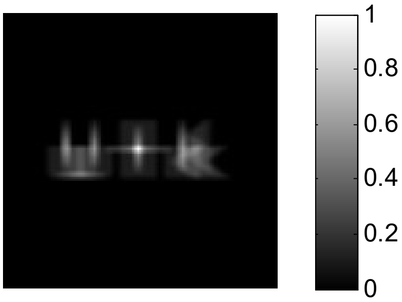


Figure 19 left: orginal image; right: filtered image

- Problem 3 Template Matching

1. cross-correlation images from spatial and frequency methods.



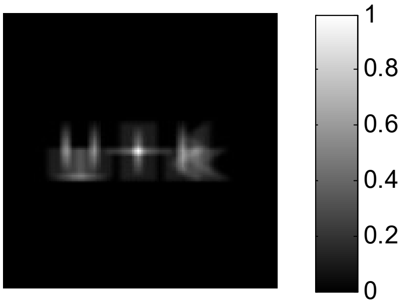


Figure 20 above: spatial domain; below: frequency domain

2. cross-correlation images from spatial and frequency methods.

Figure 21 above: spatial domain; below: frequency domain

3. normalized cross-correlation image and original image with rectangular box overlayed

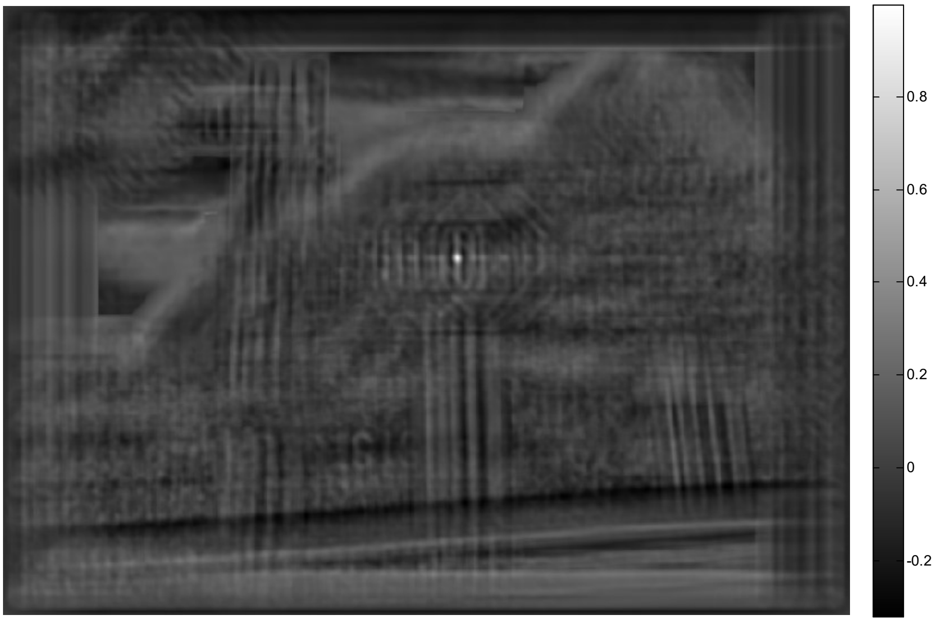


Figure 22 normalized cross-correlation image

Figure 23 original image with rectangular box overlayed

4. The result won't be perfect as the above one. Because the result rectangle is highest response of normal cross-correlation along the image, and if the template and part of image is perfectly matched, the highest score will be exactly the target area.
   But when the template is different, it may exist higher score in other area when do normal cross-correlation. And in this case, the result may be not what we want.

- **Appendix:**

P1.m

```
clear;clc;

%% i

horizlow = imread('D:\ucsd\ece253\hw4\FreqHorizLow.png');

horizmed = imread('D:\ucsd\ece253\hw4\FreqHorizMed.png');

horizhigh = imread('D:\ucsd\ece253\hw4\FreqHorizHigh.png');

vertmed = imread('D:\ucsd\ece253\hw4\FreqVertMed.png');

angle1 = imread('D:\ucsd\ece253\hw4\FreqAngle1.png');

angle2 = imread('D:\ucsd\ece253\hw4\FreqAngle2.png');

angle3 = imread('D:\ucsd\ece253\hw4\FreqAngle3.png');


dft_horizlow = fftshift(fft2(horizlow, 512, 512));

dft_horizmed = fftshift(fft2(horizmed, 512, 512));

dft_horizhigh = fftshift(fft2(horizhigh, 512, 512));

dft_vertmed = fftshift(fft2(vertmed, 512, 512));

dft_angle1 = fftshift(fft2(angle1, 512, 512));

dft_angle2 = fftshift(fft2(angle2, 512, 512));

dft_angle3 = fftshift(fft2(angle3, 512, 512));


figure;subplot(121);imshow(horizlow(:,:,[1 1

1]));subplot(122);imagesc(abs(dft_horizlow));colorbar;title('FreqHorizLow.png')

;
```

```
figure;subplot(121);imshow(horizmed(:,:,[1 1
1]));subplot(122);imagesc(abs(dft_horizmed));colorbar;title('FreqHorizMed.png
');
figure;subplot(121);imshow(horizhigh(:,:,[1 1
1]));subplot(122);imagesc(abs(dft_horizhigh));colorbar;title('FreqHorizHigh.pn
g');
figure;subplot(121);imshow(vertmed(:,:,[1 1
1]));subplot(122);imagesc(abs(dft_vertmed));colorbar;title('FreqVertMed.png');
figure;subplot(121);imshow(angle1(:,:,[1 1
1]));subplot(122);imagesc(abs(dft_angle1));colorbar;title('FreqAngle1.png');
figure;subplot(121);imshow(angle2(:,:,[1 1
1]));subplot(122);imagesc(abs(dft_angle2));colorbar;title('FreqAngle2.png');
figure;subplot(121);imshow(angle3(:,:,[1 1
1]));subplot(122);imagesc(abs(dft_angle3));colorbar;title('FreqAngle3.png');

%% ii
checkboard = imread('D:\ucsd\ece253\hw4\FreqCheckerboard.png');
dft_newimage = fftshift(fft2(checkboard, 512, 512));
figure;subplot(121);imshow(checkboard(:,:,[1 1
1]));colorbar;subplot(122);imagesc(abs(dft_newimage));colorbar;title('FreqChe
ckerboard.png');
```

```
newimage = uint8(double(horizmed) + double(vertmed));
dft_newimage = fftshift(fft2(newimage, 512, 512));
figure;subplot(121);imshow(newimage(:,:,[1 1
1]));colorbar;subplot(122);imagesc(abs(dft_newimage));colorbar;title('New
Image');

%% iii
maskA = (1/16)*[1 2 1; 2 4 2; 1 2 1];
weight = 10;
[a,b] = size(maskA);
maskB = zeros( size(maskA) );
maskB(ceil(a/2), ceil(b/2)) = 1;
maskC = maskB - maskA;
maskD = maskB + weight * maskC;

dft_maskA = fftshift(fft2(maskA, 512, 512));
figure;imagesc(abs(dft_maskA));colorbar;title('maskA, low-pass filter');
dft_maskB = fftshift(fft2(maskB, 512, 512));
figure;imagesc(abs(dft_maskB));colorbar;title('maskB, identity filter');
dft_maskC = fftshift(fft2(maskC, 512, 512));
figure;imagesc(abs(dft_maskC));colorbar;title('maskC, high-pass filter');
dft_maskD = fftshift(fft2(maskD, 512, 512));
```

```
figure;imagesc(abs(dft_maskD));colorbar;title('maskD, high-boost filter');
```

---

p2.m

```
clear;clc;

car = imread('D:\ucsd\ece253\hw4\Car.tif');

dft_car = fftshift(fft2(car,512, 512));

figure;imagesc(-256:255,-256:255,log(abs(dft_car))); colorbar;

xlabel('u'); ylabel('v');

[u,v] = meshgrid(-256:255);

uk = [-90.0, -82.0, -90.0, -82.0 ];

vk = [-80.0, 85.0, -170.0, 175.0];


Hnr = ones(512, 512);

n = 4;

D0 = 25;

for i = 1:4

    Duv = sqrt((u - uk(i)).^2 + (v - vk(i)).^2);

    ButterworthHighPassPart1 = 1 ./ (1 + ((D0 ./ Duv).^(2*n)));


    DuvConj = sqrt((u + uk(i)).^2 + (v + vk(i)).^2);

    ButterworthHighPassPart2 = 1 ./ (1 + ((D0 ./ DuvConj).^(2*n)));

    Hnr = Hnr .* ButterworthHighPassPart1 .* ButterworthHighPassPart2;
```

```
end
figure
imshow(Hnr,[]);colorbar();

filtered = dft_car .* Hnr;
out = ifft2(ifftshift(filtered));
figure;subplot(121);imshow(car);colorbar;subplot(122);imshow(out(1:246,
1:168), [0, 255]);colorbar;

car = imread('D:\ucsd\ece253\hw4\Street.png');
dft_car = fftshift(fft2(car,512, 512));
figure;imagesc(-256:255,-256:255,log(abs(dft_car))); colorbar;
xlabel('u'); ylabel('v');
[u,v] = meshgrid(-256:255);
uk = [0,165];
vk = [170,0];

Hnr = ones(512, 512);
n = 4;
D0 = 25;
for i = 1:2
    Duv = sqrt((u - uk(i)).^2 + (v - vk(i)).^2);
```

```
        ButterworthHighPassPart1 = 1 ./ (1 + ((D0 ./ Duv).^(2*n)));

        DuvConj = sqrt((u + uk(i)).^2 + (v + vk(i)).^2);
        ButterworthHighPassPart2 = 1 ./ (1 + ((D0 ./ DuvConj).^(2*n)));
        Hnr = Hnr .* ButterworthHighPassPart1 .* ButterworthHighPassPart2;
end
figure
imshow(Hnr,[]);colorbar;

filtered = dft_car .* Hnr;
out = ifft2(ifftshift(filtered));
figure;subplot(121);imshow(car);colorbar;subplot(122);imshow(out(1:332,
1:359), [0, 255]);colorbar;
```

---

p3.m

```
clear;clc;
%% i
letters = imread('D:\ucsd\ece253\hw4\Letters.jpg');
letters_tem = imread('D:\ucsd\ece253\hw4\LettersTemplate.jpg');
[m, n] = size(letters);
[m2, n2] = size(letters_tem);
```

```
filtered_spa = conv2(double(letters), double(flip(flip(letters_tem, 1), 2)),
'same');
maxPixelValue = max(max(filtered_spa));
minPixelValue = min(min(filtered_spa));
filtered_spa = ((filtered_spa + minPixelValue)/maxPixelValue);

dft_letters = fft2(letters, m+m2-1, n+n2-1);
dft_letter_tem = fft2(letters_tem, m+m2-1, n+n2-1);

dft_filtered_fre = dft_letters .* flip(flip(dft_letter_tem,1),2);
filtered_fre = ifft2(dft_filtered_fre);
maxPixelValue = max(max(filtered_fre));
minPixelValue = min(min(filtered_fre));
filtered_fre = circshift(((filtered_fre + minPixelValue)/maxPixelValue),[20, 20]);

figure;subplot(211);imshow(filtered_spa);colorbar;subplot(212);imshow(filtered
_fre(1:m, 1:n));colorbar;

%% ii
clear;clc;
letters = rgb2gray(imread('D:\ucsd\ece253\hw4\StopSign.jpg'));
letters_tem =
```

```
rgb2gray(imread('D:\ucsd\ece253\hw4\StopSignTemplate.jpg'));
[m, n] = size(letters);
[m2, n2] = size(letters_tem);

filtered_spa = conv2(double(letters), double(flip(flip(letters_tem, 1), 2)),
'same');
maxPixelValue = max(max(filtered_spa));
minPixelValue = min(min(filtered_spa));
filtered_spa = ((filtered_spa + minPixelValue)/maxPixelValue);

dft_letters = fft2(letters, m+m2-1, n+n2-1);
dft_letter_tem = fft2(letters_tem, m+m2-1, n+n2-1);

dft_filtered_fre = dft_letters .* flip(flip(dft_letter_tem,1),2);
filtered_fre = ifft2(dft_filtered_fre);
maxPixelValue = max(max(filtered_fre));
minPixelValue = min(min(filtered_fre));
filtered_fre = circshift(((filtered_fre + minPixelValue)/maxPixelValue), [20, 45]);

figure;subplot(211);imshow(filtered_spa);colorbar;subplot(212);imshow(filtered
_fre(1:m, 1:n));colorbar;
```

```
%% iii

img = rgb2gray(imread('D:\ucsd\ece253\hw4\StopSign.jpg'));

template = rgb2gray(imread('D:\ucsd\ece253\hw4\StopSignTemplate.jpg'));


c = normxcorr2(template, img);

figure

imshow(c,[]);colorbar;


[ypeak, xpeak] = find(c==max(c(:)));

yoffSet = ypeak-size(template,1);

xoffSet = xpeak-size(template,2);

hFig = figure;

hAx   = axes;

imshow(img,'Parent', hAx);

imrect(hAx, [xoffSet, yoffSet, size(template,2), size(template,1)]);
```