Gaotong Wu
ECE172 HW4
A13809639

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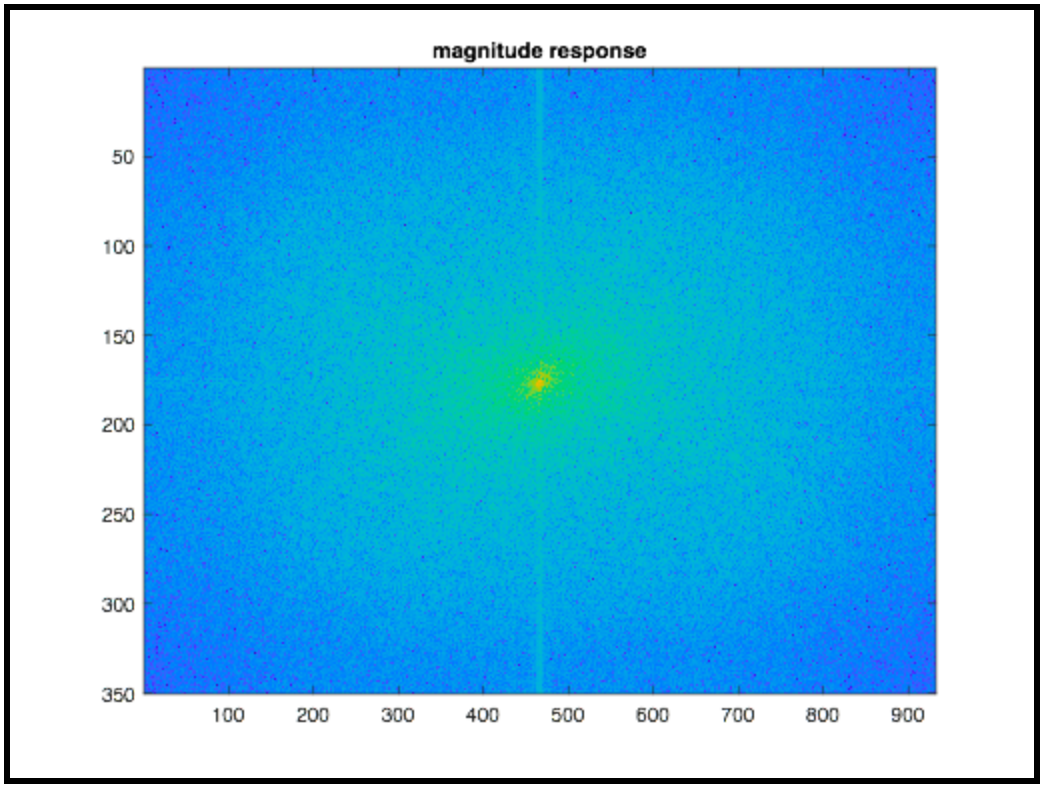
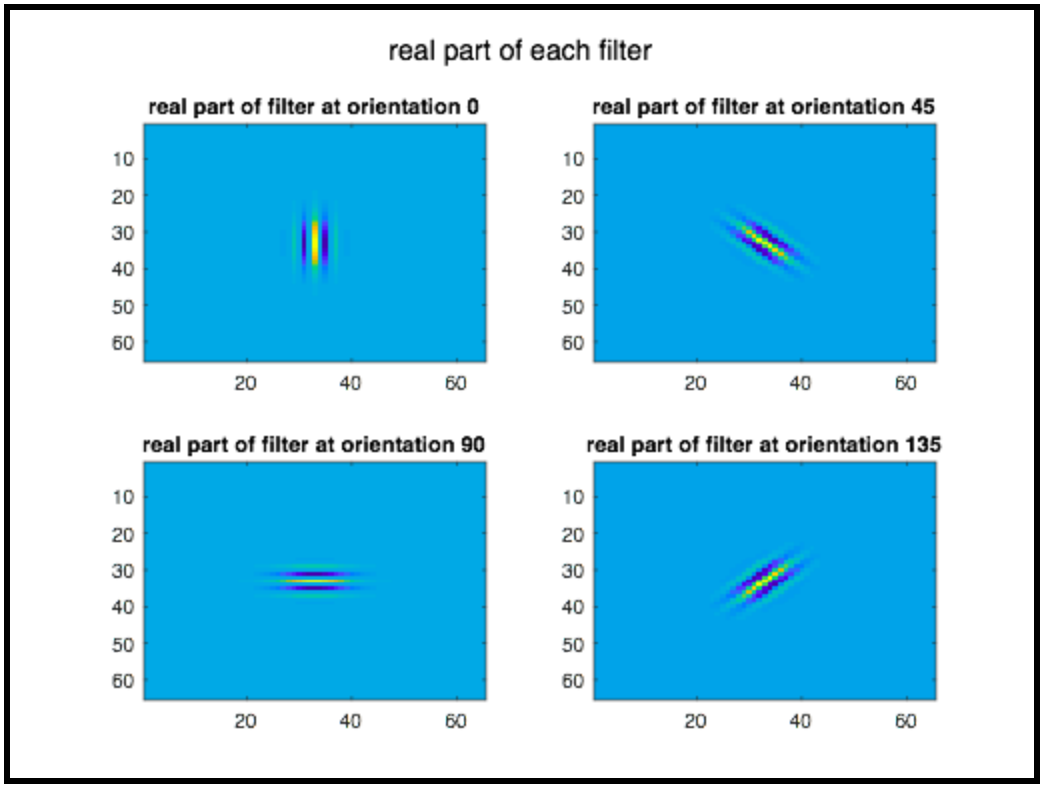
By including this in my report, I agree to abide by the Academic Integrity Policy mentioned above.

Problem 1
(1)

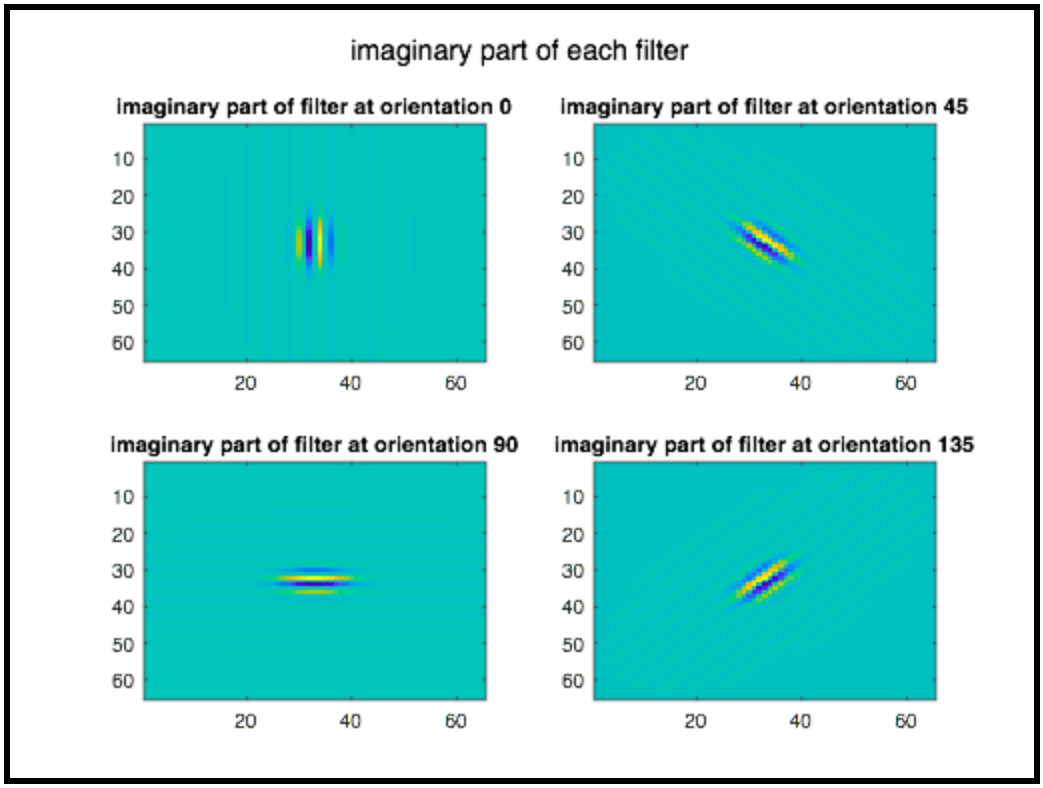
(2)


magnitude response
50
100
150
200
250
300
350
100
200
300
400
500
600
700
800
900

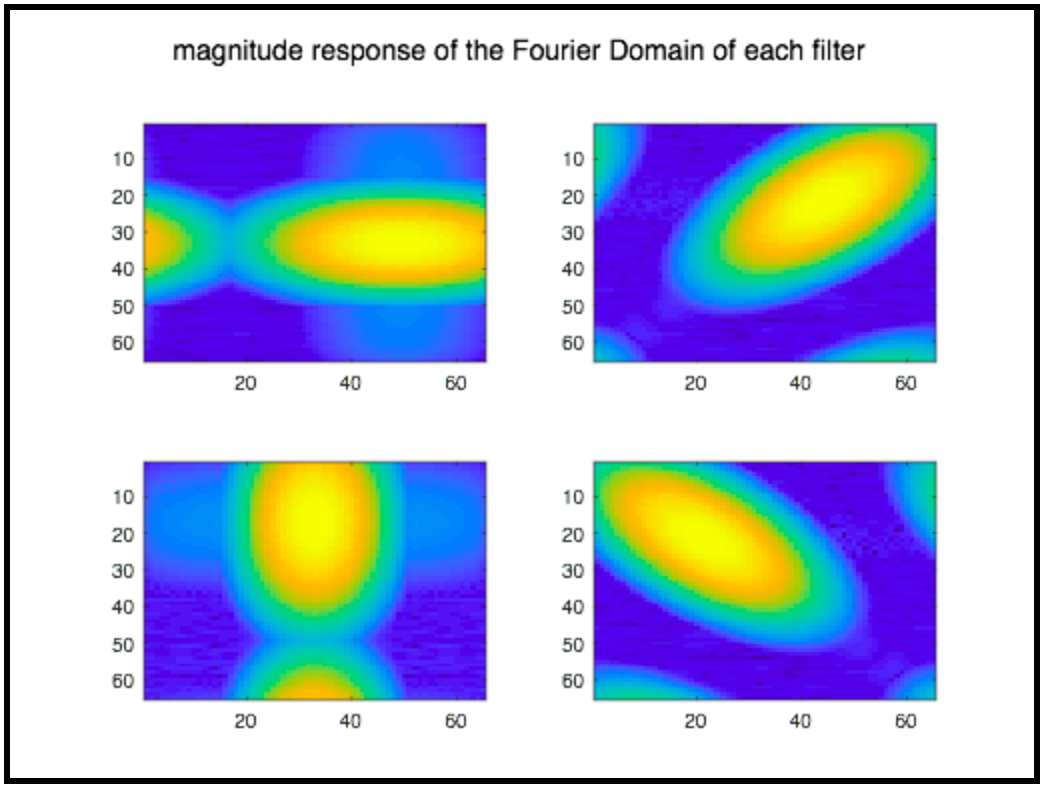
3(a)


real part of each filter
real part of filter at orientation 0
real part of filter at orientation 45
real part of filter at orientation 90
real part of filter at orientation 135
10
20
30
40
50
60
20
40
60

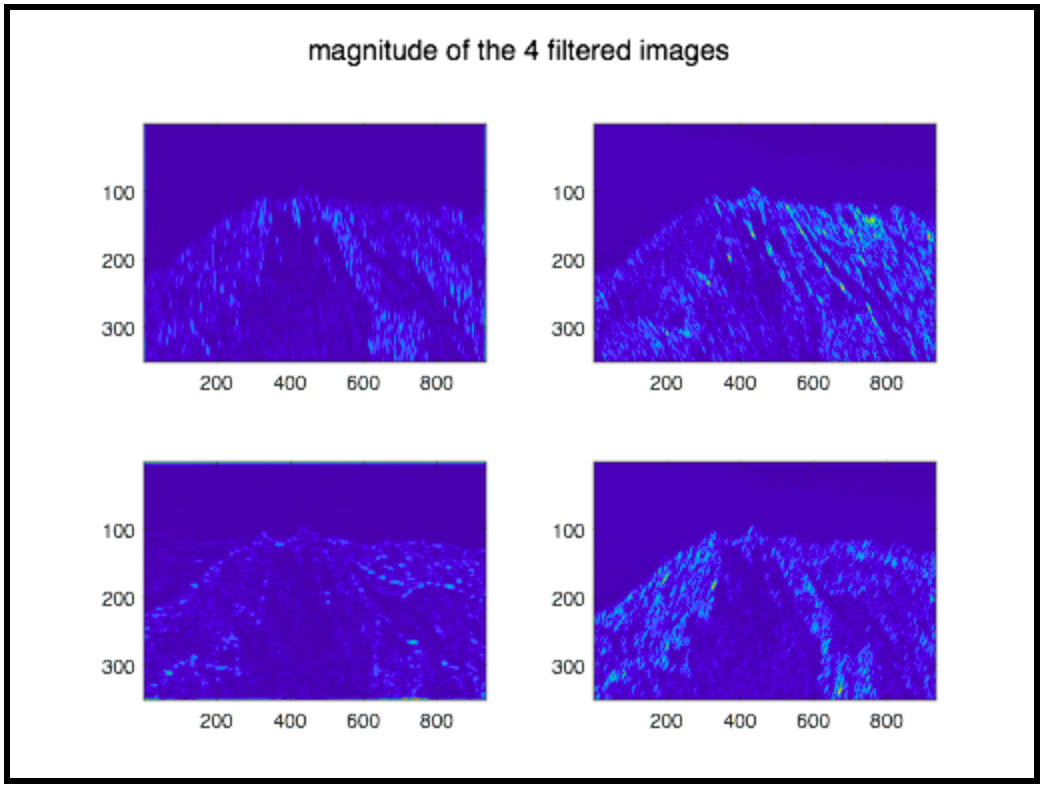
3(b)


imaginary part of each filter
imaginary part of filter at orientation 0
imaginary part of filter at orientation 45
imaginary part of filter at orientation 90
imaginary part of filter at orientation 135
10
20
30
40
50
60
20
40
60

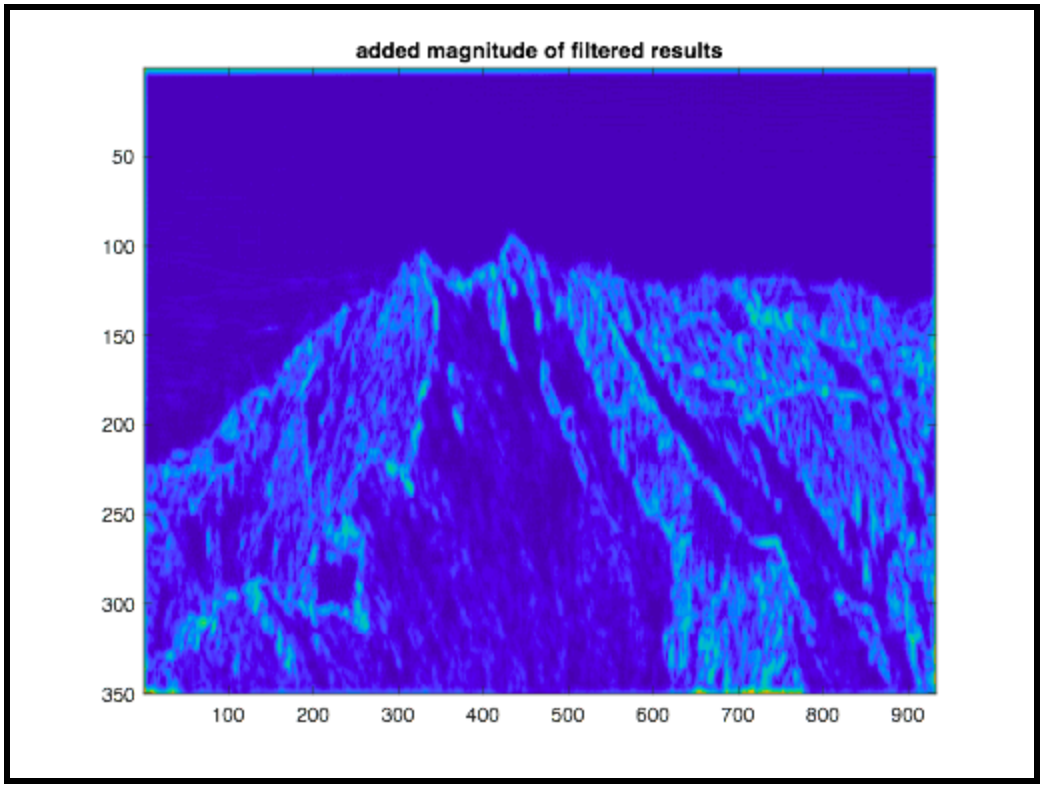
3(c)


magnitude response of the Fourier Domain of each filter
10
20
30
40
50
60
20
40
60

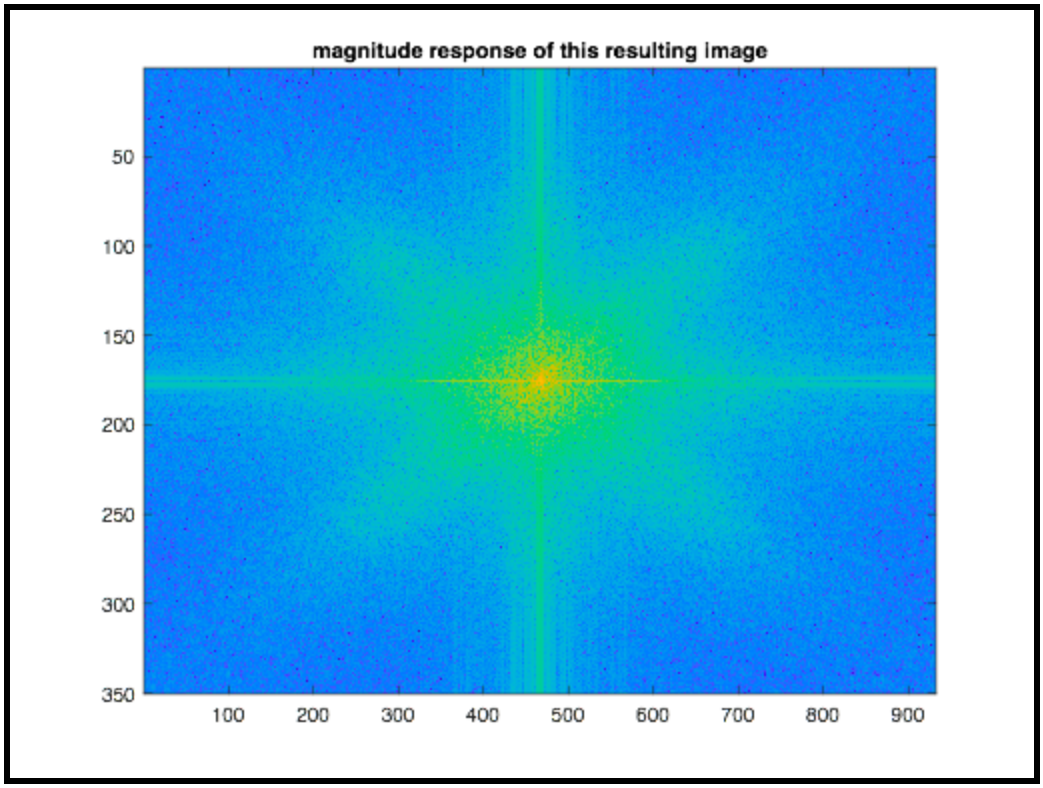
3(d)


magnitude of the 4 filtered images
100
200
300
200
400
600
800

(4)

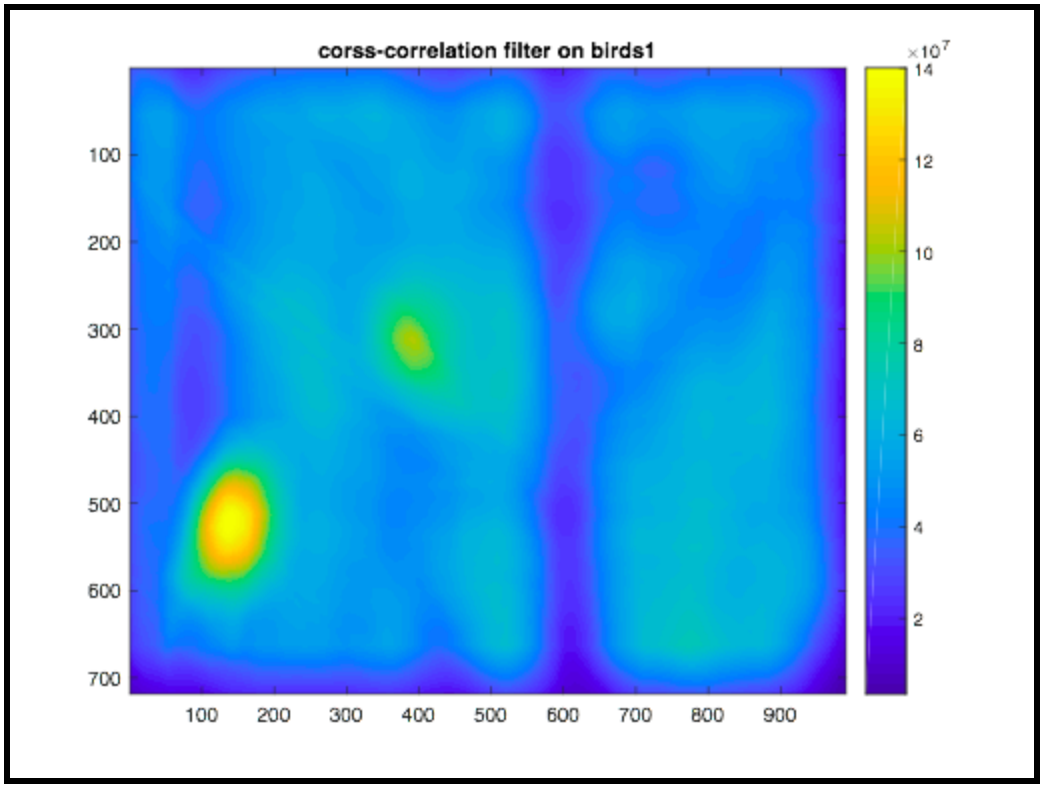

added magnitude of filtered results
50
100
150
200
250
300
350
100
200
300
400
500
600
700
800
900

(5)

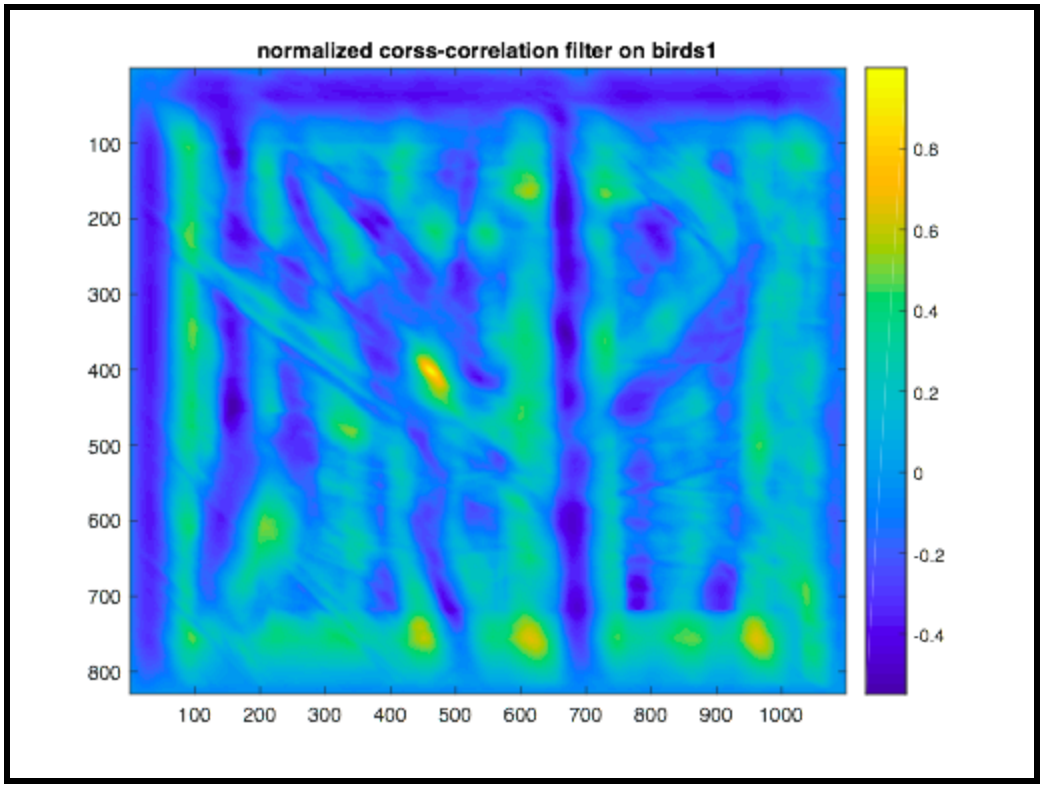

magnitude response of this resulting image
50
100
150
200
250
300
350
100
200
300
400
500
600
700
800
900

Problem2

(i)

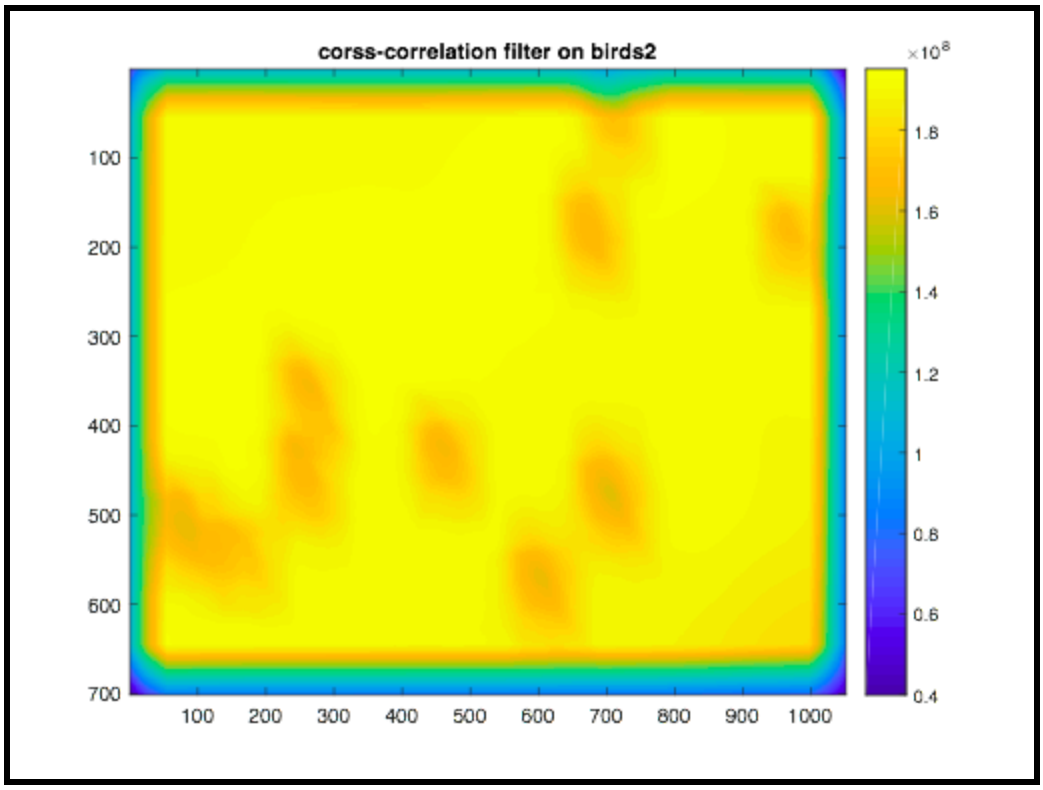


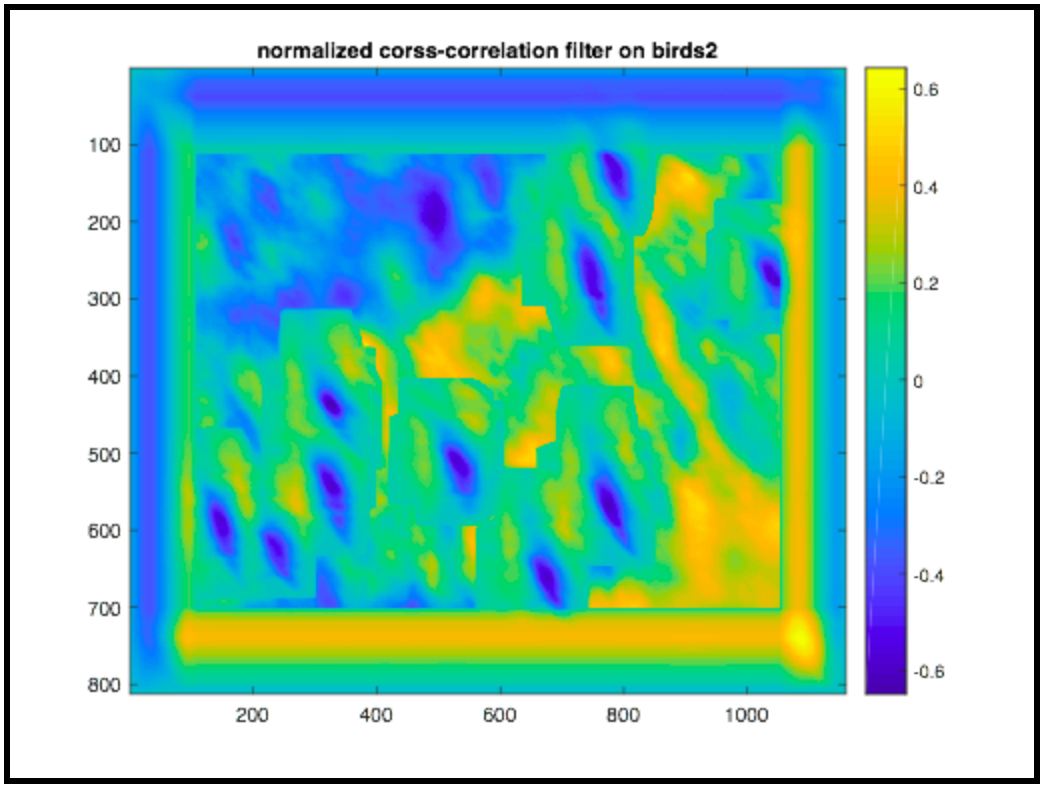
(ii)




birds1 with rectangle box

(iii)


corss-correlation filter on birds2
×10^8
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
100
200
300
400
500
600
700
800
900
1000


normalized corss-correlation filter on birds2
100
200
300
400
500
600
700
800
200
400
600
800
1000
0.6
0.4
0.2
0
-0.2
-0.4
-0.6


birds2 with rectangle box

(iv)

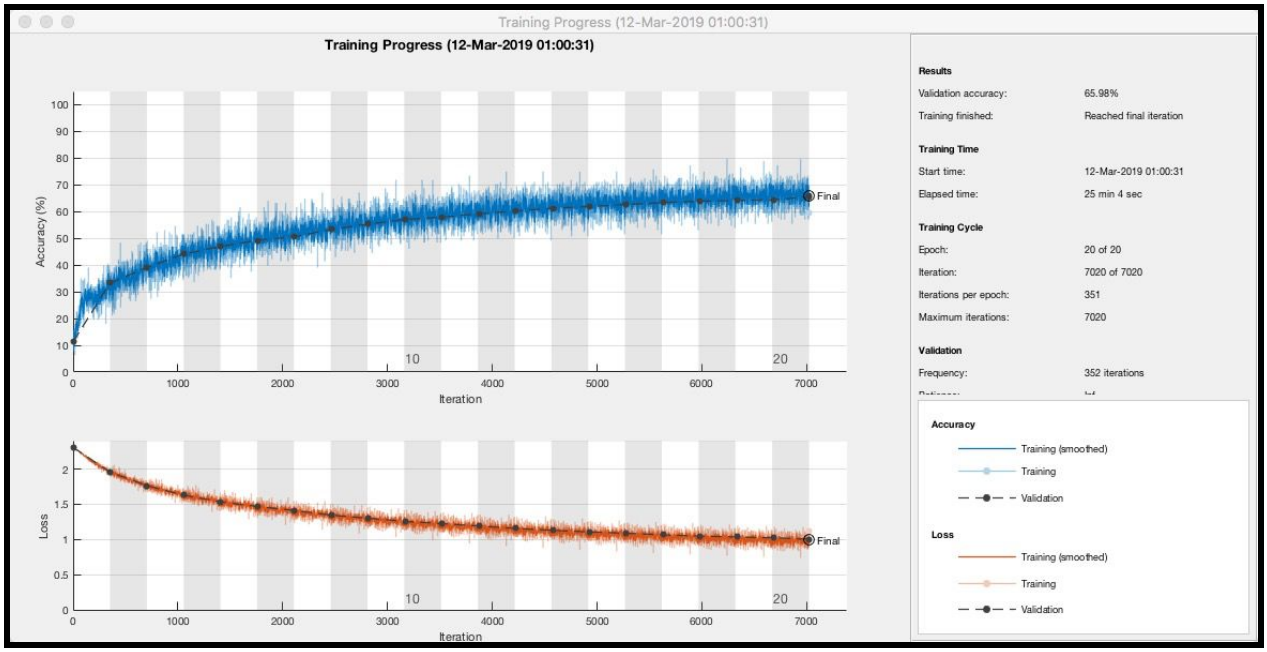
Because when there is a place in the image where it is very bright, the cross-correlation results in higher scores, despite what the template is; in this case, it fails to detect the features. NCC subtracts the template and the image by their own means and normalizes the results. In this way, the correlation score is higher only when darker parts of the template overlap darker parts of the image and brighter only when brighter parts of the template overlap brighter parts of the image.

(v)

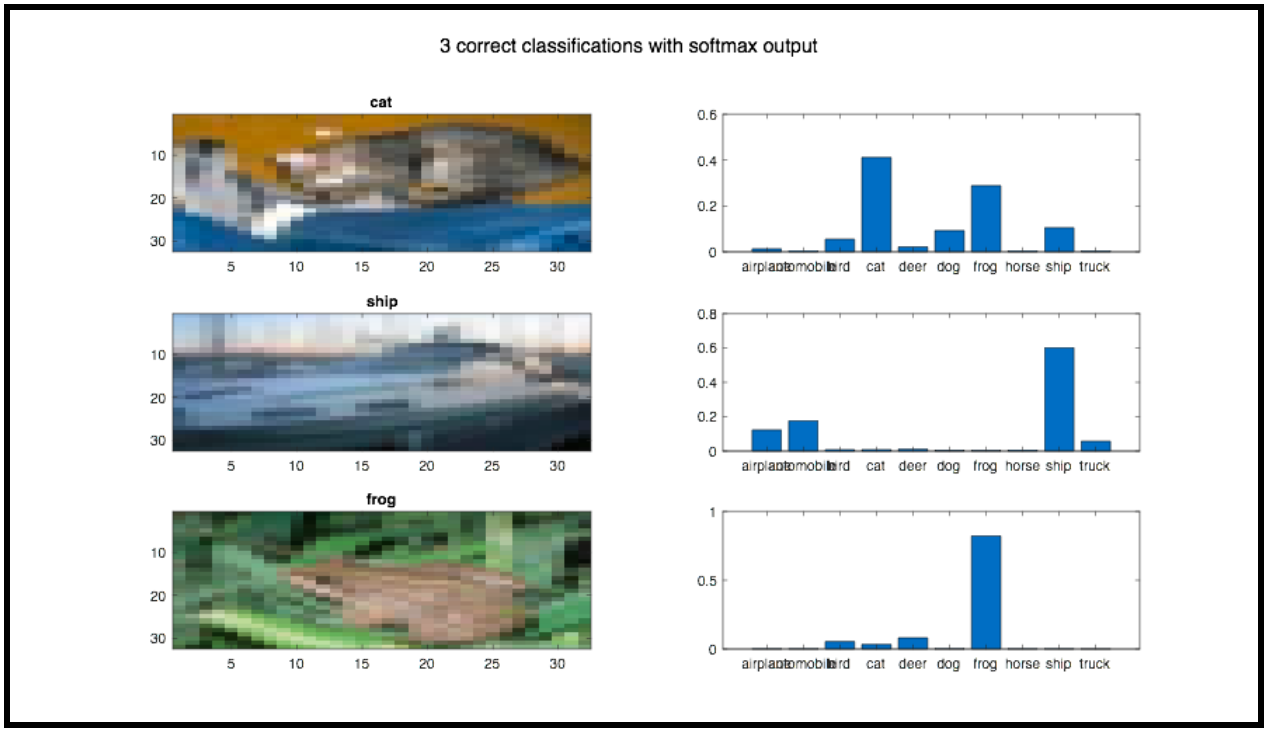
The rectangle shows up at a place where there are no birds (the lower right corner). It cannot be reliable to detect birds.

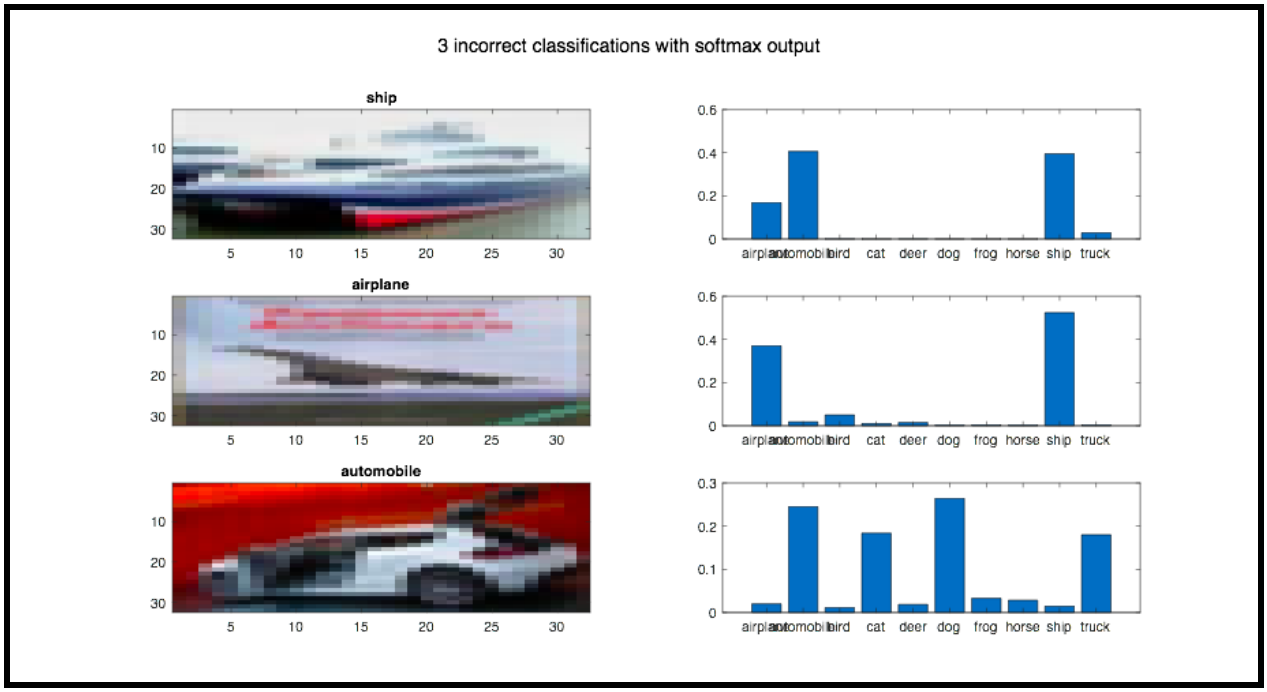
Problem 3

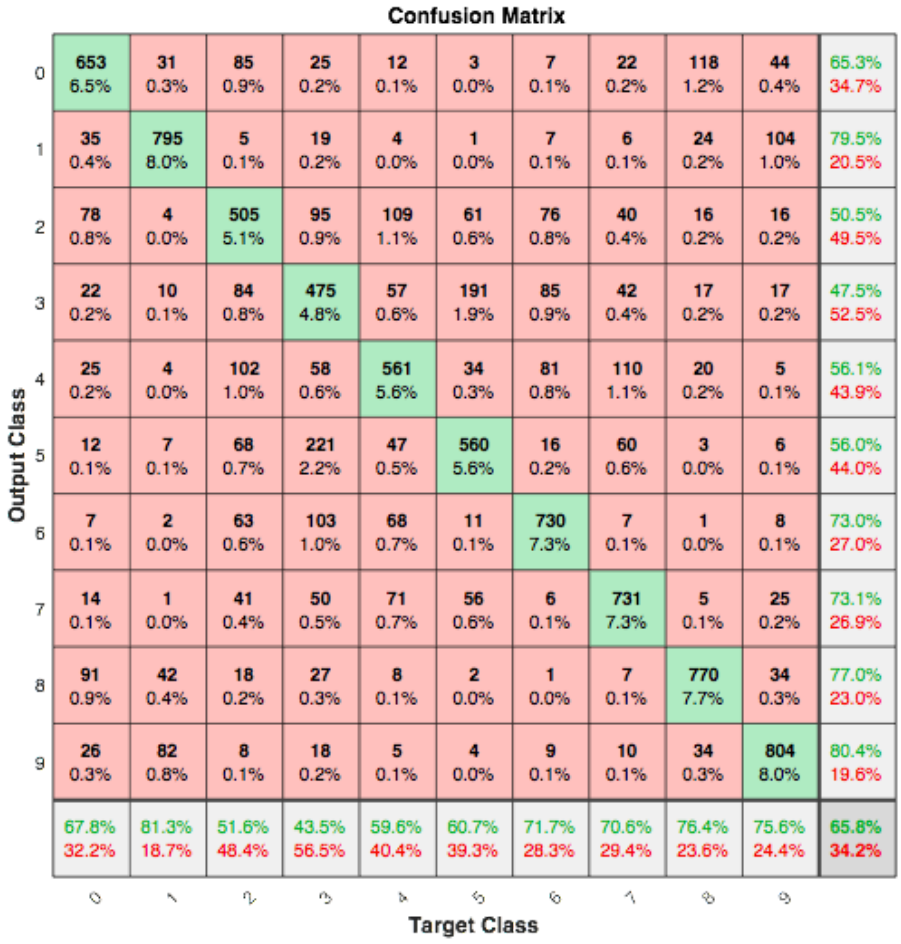
(v)



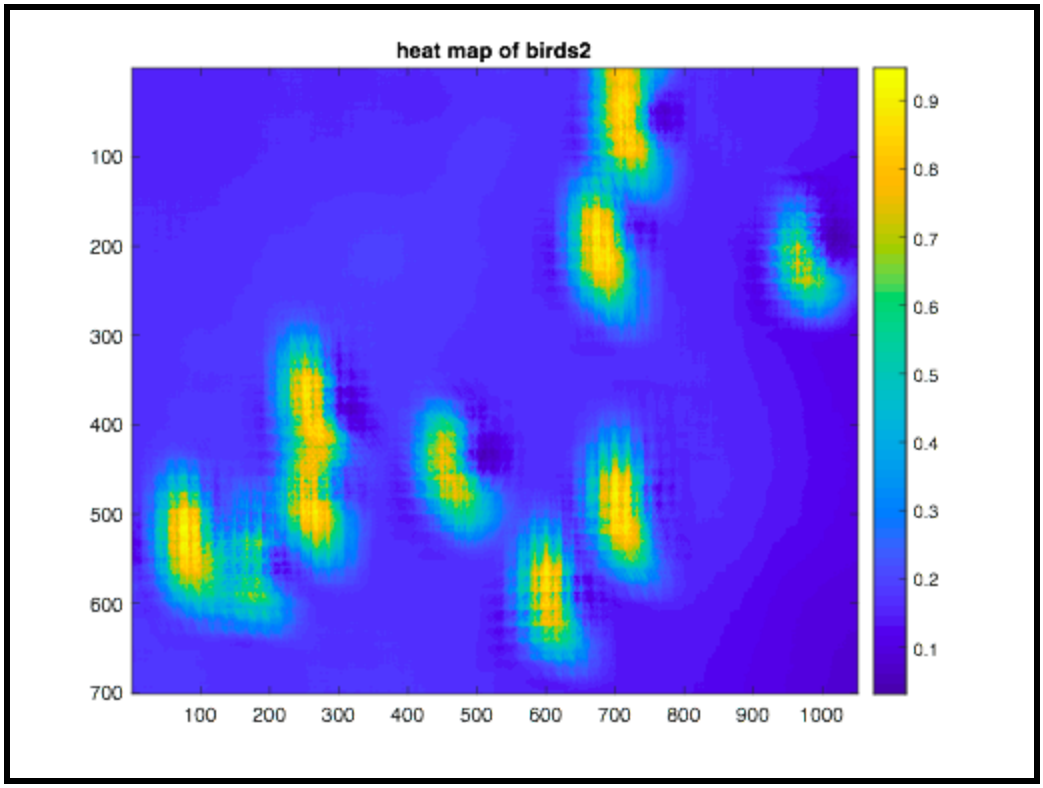
(vi)


3 correct classifications with softmax output
cat
ship
frog
airplane
automobile
bird
cat
deer
dog
frog
horse
ship
truck


3 incorrect classifications with softmax output
ship
airplane
automobile
10
20
30
5
10
15
20
25
30
0.6
0.4
0.2
0
0.3
0.1
airplane
automobile
bird
cat
deer
dog
frog
horse
ship
truck


Confusion Matrix
Output Class
Target Class
0 1 2 3 4 5 6 7 8 9
653 6.5% | 31 0.3% | 85 0.9% | 25 0.2% | 12 0.1% | 3 0.0% | 7 0.1% | 22 0.2% | 118 1.2% | 44 0.4% | 65.3% 34.7%
35 0.4% | 795 8.0% | 5 0.1% | 19 0.2% | 4 0.0% | 1 0.0% | 7 0.1% | 6 0.1% | 24 0.2% | 104 1.0% | 79.5% 20.5%
78 0.8% | 4 0.0% | 505 5.1% | 95 0.9% | 109 1.1% | 61 0.6% | 76 0.8% | 40 0.4% | 16 0.2% | 16 0.2% | 50.5% 49.5%
22 0.2% | 10 0.1% | 84 0.8% | 475 4.8% | 57 0.6% | 191 1.9% | 85 0.9% | 42 0.4% | 17 0.2% | 17 0.2% | 47.5% 52.5%
25 0.2% | 4 0.0% | 102 1.0% | 58 0.6% | 561 5.6% | 34 0.3% | 81 0.8% | 110 1.1% | 20 0.2% | 5 0.1% | 56.1% 43.9%
12 0.1% | 7 0.1% | 68 0.7% | 221 2.2% | 47 0.5% | 560 5.6% | 16 0.2% | 60 0.6% | 3 0.0% | 6 0.1% | 56.0% 44.0%
7 0.1% | 2 0.0% | 63 0.6% | 103 1.0% | 68 0.7% | 11 0.1% | 730 7.3% | 7 0.1% | 1 0.0% | 8 0.1% | 73.0% 27.0%
14 0.1% | 1 0.0% | 41 0.4% | 50 0.5% | 71 0.7% | 56 0.6% | 6 0.1% | 731 7.3% | 5 0.1% | 25 0.2% | 73.1% 26.9%
91 0.9% | 42 0.4% | 18 0.2% | 27 0.3% | 8 0.1% | 2 0.0% | 1 0.0% | 7 0.1% | 770 7.7% | 34 0.3% | 77.0% 23.0%
26 0.3% | 82 0.8% | 8 0.1% | 18 0.2% | 5 0.1% | 4 0.0% | 9 0.1% | 10 0.1% | 34 0.3% | 804 8.0% | 80.4% 19.6%
67.8% 32.2% | 81.3% 18.7% | 51.6% 48.4% | 43.5% 56.5% | 59.6% 40.4% | 60.7% 39.3% | 71.7% 28.3% | 70.6% 29.4% | 76.4% 23.6% | 75.6% 24.4% | 65.8% 34.2%

(vii)



The heat map generated by the neuron network works better to detect birds because the high scores area indicated by the yellow are where the birds at.

Problem 1

```
figure;
imshow(image);
title('original image');
magnitudeR=20*log10(abs(fftshift(fft2(image))));
figure;
imagesc(magnitudeR);
title('magnitude response');
realpart=zeros(65,65,4);
figure;
orientation=["0","45","90","135"];
for i=1:4
  realpart(:,:,i)=real(filters(:,:,i));
  subplot(2,2,i);
  imagesc(realpart(:,:,i));
  title(sprintf('real part of filter at orientation %s',orientation(i)));
end
suptitle('real part of each filter');
imagpart=zeros(65,65,4);
figure;
for i=1:4
  imagpart(:,:,i)=imag(filters(:,:,i));
  subplot(2,2,i);
  imagesc(imagpart(:,:,i));
  title(sprintf('imaginary part of filter at orientation
%s',orientation(i)));
end
suptitle('imaginary part of each filter');
figure;
for i=1:4
    subplot(2,2,i);
    imagesc(20*log10(abs(fftshift(fft2(filters(:,:,i))))));
end
suptitle('magnitude response of the Fourier Domain of each filter');
figure;
for i=1:4
    subplot(2,2,i);
    imagesc(abs(conv2(image,filters(:,:,i),'same')));
end
suptitle('magnitude of the 4 filtered images');
figure;
final_image=abs(conv2(image,filters(:,:,1),'same'))+abs(conv2(image,filter
s(:,:,2),'same'))+abs(conv2(image,filters(:,:,3),'same'))+abs(conv2(image,
filters(:,:,4),'same'));
imagesc(final_image);
```

```
title('added magnitude of filtered results');
figure;
imagesc(20*log10(abs(fftshift(fft2(final_image)))));
title('magnitude response of this resulting image')
```

Problem 2

```
image1o=imread('/Users/wugaotong/Downloads/WI19/ECE172/data
4/Problem_2/birds1.jpeg');
image1=double(rgb2gray(image1o));
image2o=imread('/Users/wugaotong/Downloads/WI19/ECE172/data
4/Problem_2/birds2.jpeg');
image2=double(rgb2gray(image2o));
template=imread('/Users/wugaotong/Downloads/WI19/ECE172/data
4/Problem_2/template.jpeg');
template=double(rgb2gray(template));
%cross-correlation filter
ccfimage1=conv2(image1,template,'same');
figure;
imagesc(ccfimage1);
colorbar;
title('corss-correlation filter on birds1');
nccfimage1=normxcorr2(template,image1);
figure;
imagesc(nccfimage1);
title('normalized corss-correlation filter on birds1');
colorbar;
[ymax1,xmax1]=find(nccfimage1==max(nccfimage1(:)));
figure;
imagesc(image1o);
hold on
rectangle('Position',[xmax1-size(template,2),ymax1-
size(template,1),size(template,2),size(template,1)],'EdgeColor','r','LineW
idth',3);
title('birds1 with rectangle box');
ccfimage2=conv2(image2,template,'same');
figure;
imagesc(ccfimage2);
colorbar;
title('corss-correlation filter on birds2');
nccfimage2=normxcorr2(template,image2);
figure;
imagesc(nccfimage2);
colorbar;
title('normalized corss-correlation filter on birds2');
[ymax2,xmax2]=find(nccfimage2==max(nccfimage2(:)));
figure;
imagesc(image2o);
hold on
```

```
rectangle('Position',[xmax2-size(template,2),ymax2-
size(template,1),size(template,2),size(template,1)],'EdgeColor','r','LineW
idth',3);
title('birds2 with rectangle box');
```

Problem 3

```
[trainData,trainLabels,valData,valLabels,testData,testLabels]=extractCifar
10('/Users/wugaotong/Downloads/WI19/ECE175A/cifar-10-batches-mat');
layers=[ ...
    imageInputLayer([32 32 3])
    convolution2dLayer(3,16)
    batchNormalizationLayer
    reluLayer
    maxPooling2dLayer(2,'Stride',2)
    convolution2dLayer(3,32)
    batchNormalizationLayer
    reluLayer
    maxPooling2dLayer(2,'Stride',2)
    convolution2dLayer(3,16)
    batchNormalizationLayer
    reluLayer
    fullyConnectedLayer(10)
    softmaxLayer
    classificationLayer]
options = trainingOptions('sgdm', ...
    'InitialLearnRate',1e-4, ...
    'MaxEpochs',20, ...
    'MiniBatchSize',128, ...
    'ValidationData',{valData,valLabels},...
    'ValidationFrequency',round(45000/128),...
    'Plots','training-progress')
trainedNet=trainNetwork(trainData,trainLabels,layers,options);

layer='softmax';
featuresTrain=activations(trainedNet,trainData,layer,'OutputAs','rows');
featuresTest=activations(trainedNet,testData,layer,'OutputAs','rows');
classifier=fitcecoc(featuresTrain,trainLabels);
YPred=predict(classifier,featuresTest);
class=
{'airplane';'automobile';'bird';'cat';'deer';'dog';'frog';'horse';'ship';'
truck'};

%plot 3 correct classifications
figure;
subplot(3,2,1)
imagesc(testData(:,:,:,1));
title('cat')
subplot(3,2,2)
```

```
bar(featuresTest(1,:))
set(gca,'xticklabel',class);
subplot(3,2,3)
imagesc(testData(:,:,:,3));
title('ship')
subplot(3,2,4)
bar(featuresTest(3,:))
set(gca,'xticklabel',class);
subplot(3,2,5)
imagesc(testData(:,:,:,5));
title('frog')
subplot(3,2,6)
bar(featuresTest(5,:))
set(gca,'xticklabel',class);
suptitle('3 correct classifications with softmax output')

%plot 3 incorrect classfication
figure
subplot(3,2,1)
imagesc(testData(:,:,:,2));
title('ship')
subplot(3,2,2)
bar(featuresTest(2,:))
set(gca,'xticklabel',class);
subplot(3,2,3)
imagesc(testData(:,:,:,4));
title('airplane')
subplot(3,2,4)
bar(featuresTest(4,:))
set(gca,'xticklabel',class);
subplot(3,2,5)
imagesc(testData(:,:,:,7));
title('automobile')
subplot(3,2,6)
bar(featuresTest(7,:))
set(gca,'xticklabel',class);
suptitle('3 incorrect classifications with softmax output')
plotconfusion(YPred,testLabels);

%generate the heat map
birds2=imread('birds2.jpeg');
win_size=150;
birds2_pad=padarray(birds2,[win_size/2,win_size/2],'symmetric','both');
for i=(win_size/2+1):(size(birds2,1))-win_size/2
 for j=(win_size/2+1):(size(birds2,2))-win_size/2
   context_region=birds2(i-win_size/2:i+win_size/2,j-
win_size/2:j+win_size/2,:);
   resize_context_region=imresize(context_region,[32,32]);
```

```
featurebirds=activations(trainedNet,resize_context_region,layer,'OutputAs'
,'rows');
   heat_map(i-win_size/2,j-win_size/2)=featurebirds(3);
 end
 end
imagesc(heat_map)
colorbar;
title('heat map of birds2')
```