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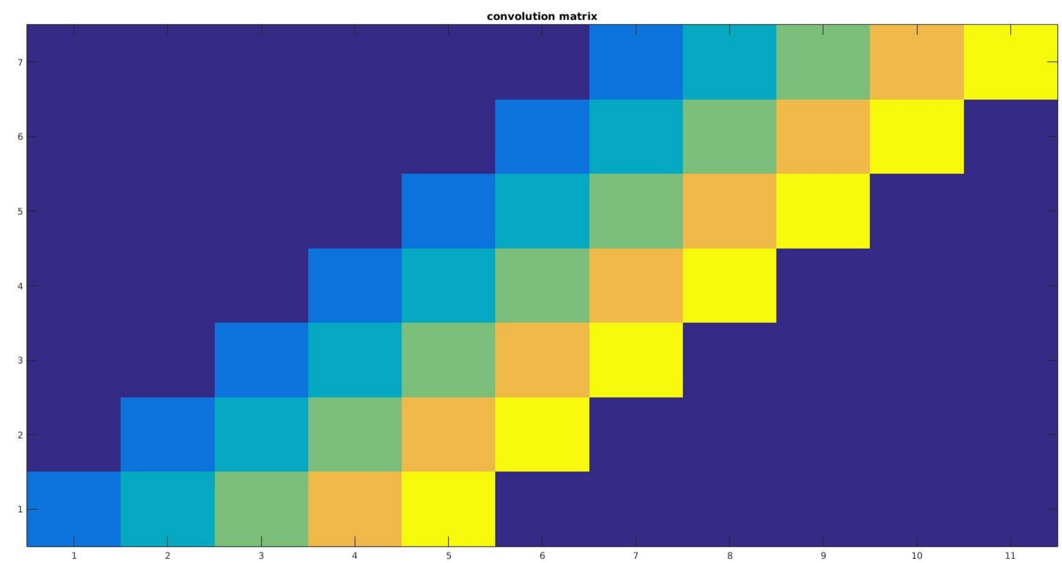
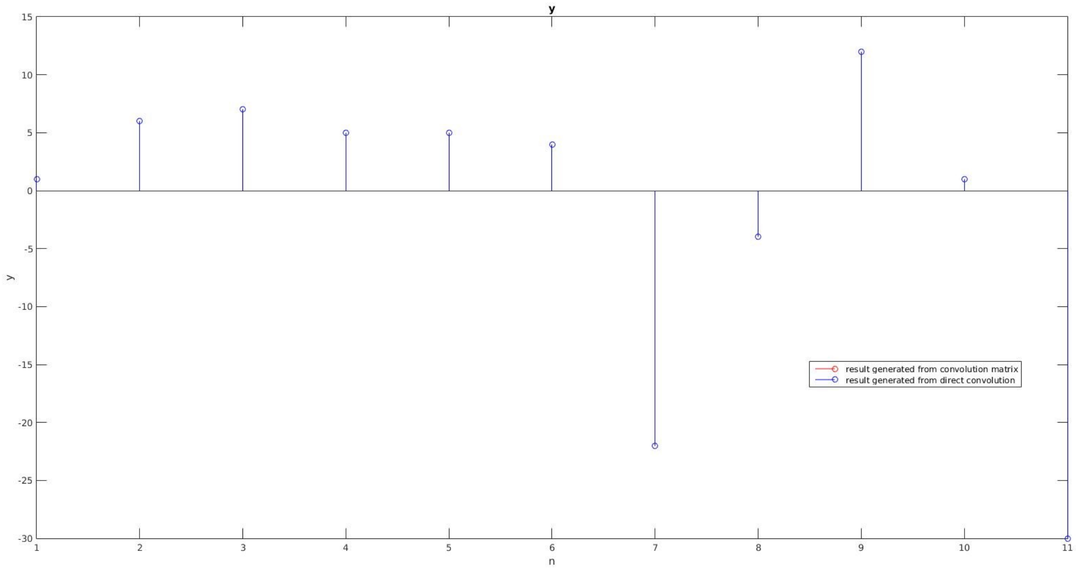
Report Item 1:

code:
```
x = [1,4,-4,-3,2,5,-6];
h = [1,2,3,4,5];
H = convmtx(h,length(x));
y = x*H;
from_conv = conv(x,h);
y == from_conv
figure(1)
imagesc(H)
axis('xy')
title('convolution matrix')
figure(2)
stem(y,'r');
title('y')
xlabel('n')
ylabel('y')
hold on
stem(from_conv,'b')
legend('result generated from convolution matrix','result generated from direct convolution')
```



The structure of the convolution matrix is diagonal.



Report Item 2:
$A^H A = V\Sigma^H U^H U \Sigma V^H$
$A^H A = V\Sigma^H \Sigma V^H$
$A^H A v = V\Sigma^H \Sigma$

Thus $A^H A$ is the eigenvector of V.

Report Item 3:
code:

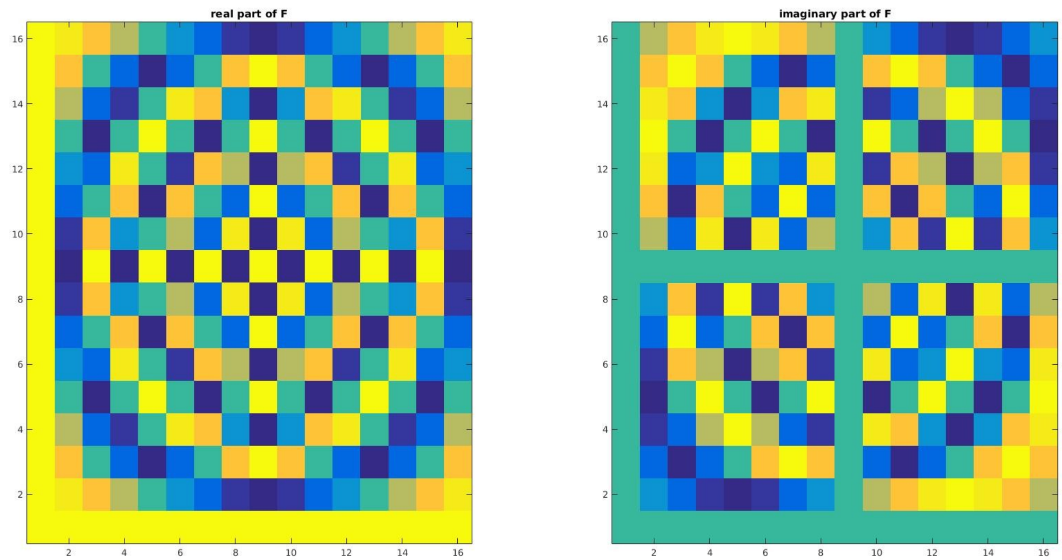
```
A = [1,4,-2;3,11,5;7,7,7];
[V1,D1] = eig(A*(A'));
[V2,D2] = eig((A')*A);
[U,S,V] = svd(A);
```

It is verified that verified that U = V1 and V = V2

Report Item 4:
code:

```
x = [1,1,4,-4,-3,2,5,-6,3,2,4,-2,5,9,-8,4];
F = dftmtx(length(x))

subplot(121)
imagesc(real(F))
axis('xy')
title('real part of F')
subplot(122)
```

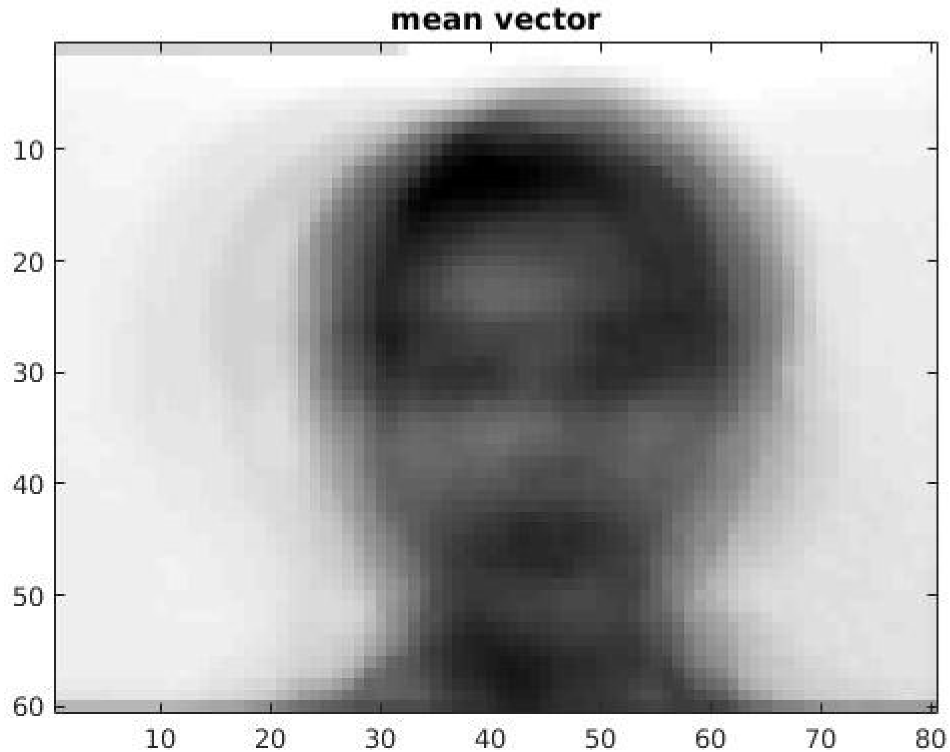
```
imagesc(imag(F))
axis('xy')
title('imaginary part of F')
```
Figure:




```
The dot product of DFT coefficient and x results in the DFT of x.
In each row, the color seems to alternate with different frequency. At higher row
number, The frequency of the color changing seems to increase and decrease after
certain row.

Report Item 5:
```
```
x = [1,1,4,-4,-3,2,5,-6,3,2,4,-2,5,9,-8,4];
F = dftmtx(length(x))
inverse_F = 1/length(x) * F'
A = inverse_F' * inverse_F
```

The columns of this matrix are orthogonal to each other.

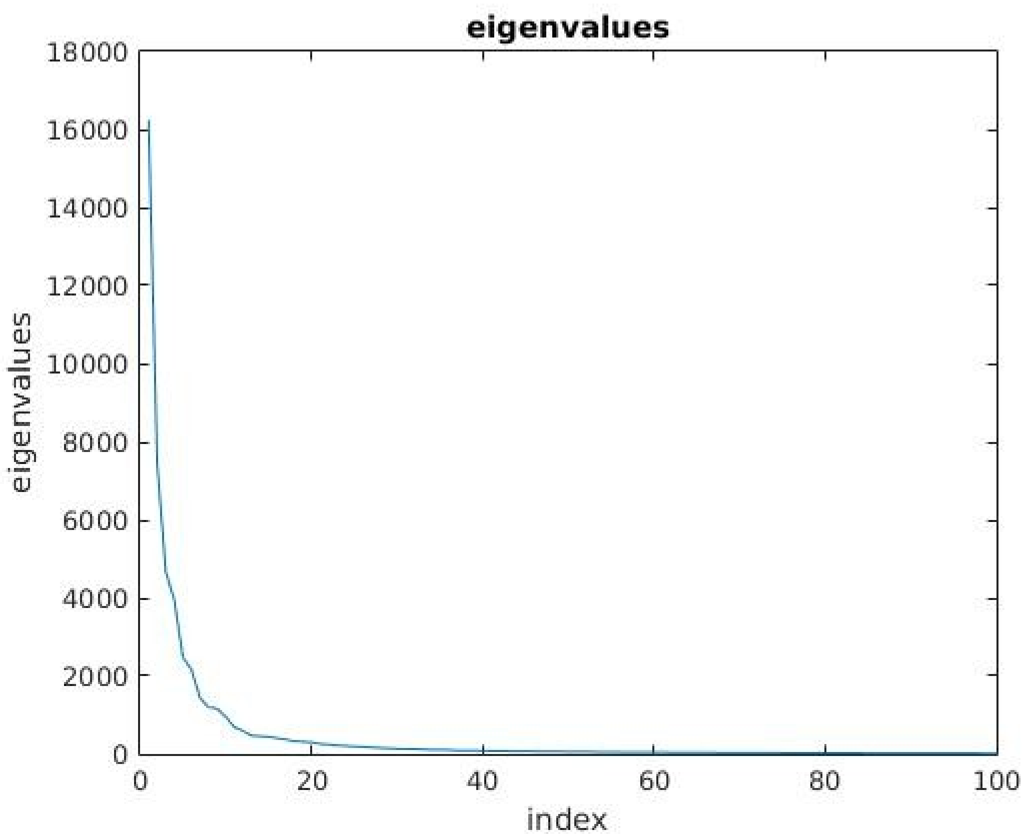
Report Item 6:
Code:
```
X = loadImages('yalefaces');
mean = computeMeanVec(X)
reshape_mean = reshape(mean,[60,80])
colormap gray
imagesc(reshape_mean)
title('mean vector')

function mean = computeMeanVec(x)
[M,N] = size(x);
mean = 1/M * sum(x)
end
```

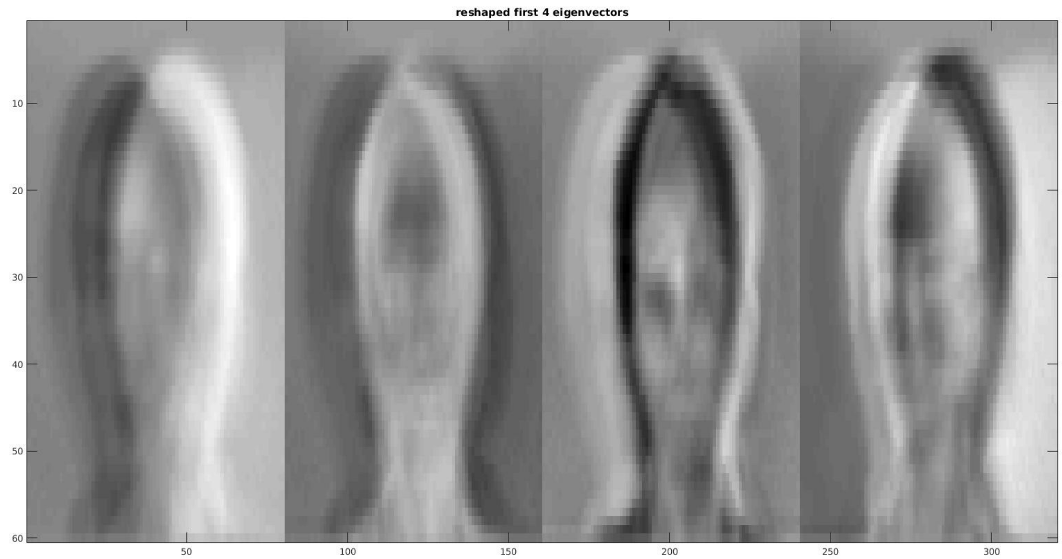


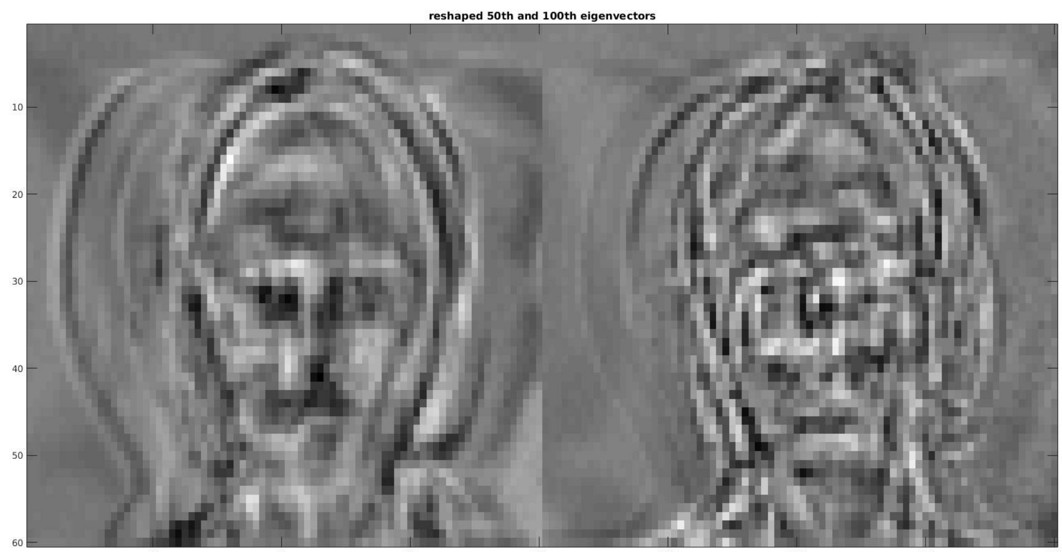

```
We see a blurry figure.

Report Item 7:
```

```
[row,col] = size(X);
X_delta = zeros(row,col);
for i = 1:row
X_delta(i,:) = X(i,:) - mean; %mean vector from last report item
end

R = X_delta' * X_delta;
[U,S,V] = svd(R);

%eigen values
eigen = diag(S);
eigen_values = eigen(1:100);

%eigen_vector
eigen_vectors = U(:,1:100);
figure(1)
```

```
plot(eigen_values)
title('eigenvalues')
xlabel('index')
ylabel('eigenvalues')

figure(2)
first_4 = U(:,1:4);
reshape_first_4 = reshape(first_4,[60,320]);
colormap gray
imagesc(reshape_first_4)
title('reshaped first 4 eigenvectors')

fif_hund = zeros(4800,2);
fif_hund(:,1) = eigen_vectors(:,50);
fif_hund(:,2) = eigen_vectors(:,100);
reshape_fif_hund = reshape(fif_hund,[60,160]);
figure(3)
colormap gray
imagesc(reshape_fif_hund)
title('reshaped 50th and 100th eigenvectors')
```







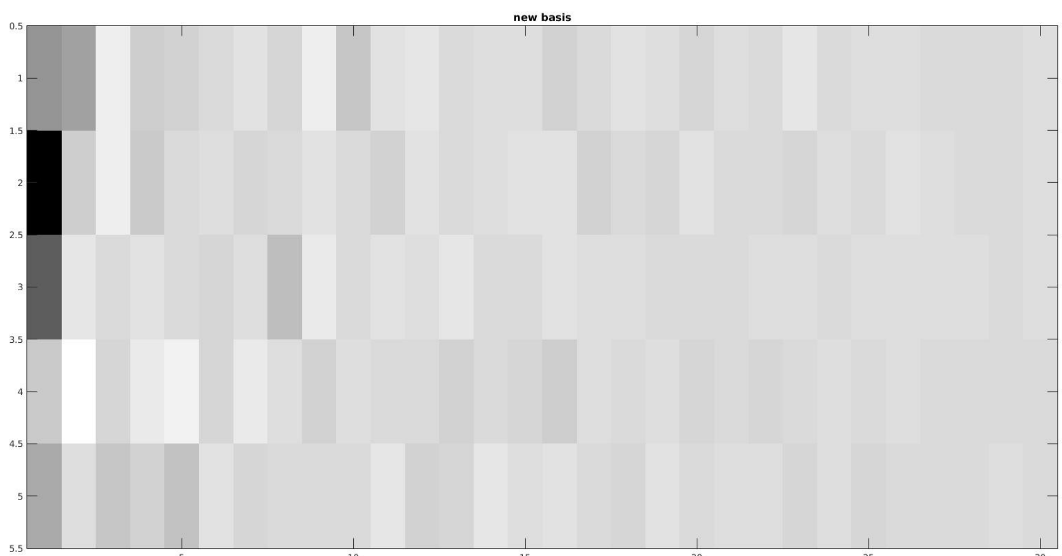
The first 20 eigenvalues are much greater than the rest of the eigenvalues.
We can see 4 almost clear figures from the first 4 eigenvectors.
We see two figures from the 50^{th} and 100^{th} eigenvecto, but they are much more blurry than images from first 4 eigenvectors. For n >= 50, the eigenvectors should have really low magnitude, which almost equal 0.

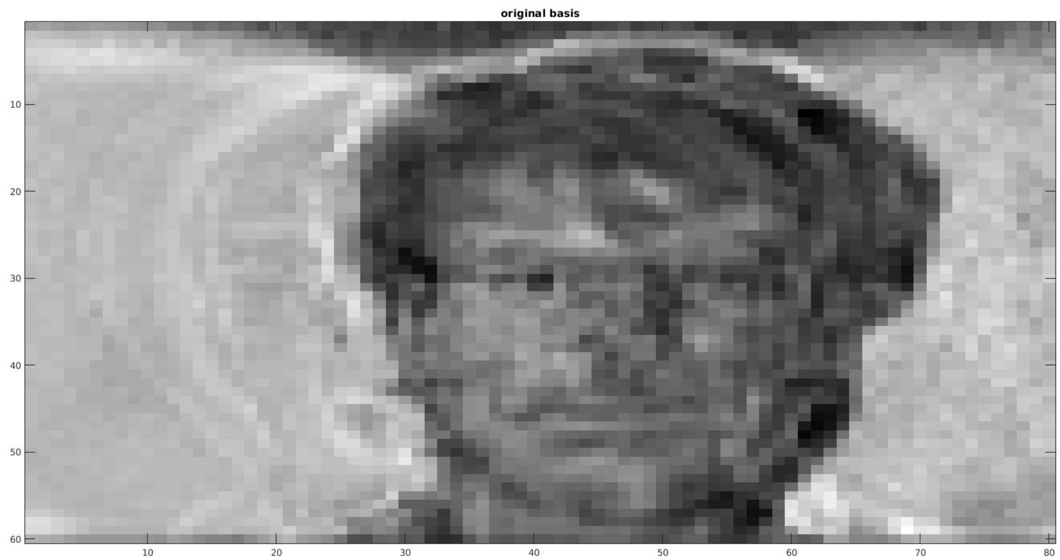
Report Item 8:

```
function pca_basis = PCA_transform(mean,V,x_orig)
x_orig_til = x_orig-mean;

pca_basis = V' * x_orig_til';

end

function orig = invPCAtransform(mean,V,pca)
orig = V * pca + mean';

end
```

Report Item 9:

```
image = imread('noisy_face.tiff');
mean = (computeMeanVec(X));
x_orig = reshape(image,[1,4800]);
pca = PCA_transform(mean,U(:,1:150),double(x_orig));
new = invPCAtransform(mean,U(:,1:150),pca);


imagesc(reshape(pca,[5,30]))
colormap gray
title('new basis')
figure(2)
colormap gray
imagesc(reshape(new,[60,80]))
title('original basis')
```




original basis
10
20
30
40
50
60
10
20
30
40
50
60
70
80