Subject : Computer Vision (CS 6643)
Project 2 : Face Recognition

Name : Hitarthi Umangbhai Shah **N10271073**
Email : hus206@nyu.edu

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1. Code (Matlab Code)

```
%%%%%%%%%%%%%%%%%%%%%%% Face Recognition using Eigenface Method %%%%%%%%%%%%%%%%%%%%%%

%closes all the previous open windows
close all;

%clears command window
clc


%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Training Process %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Providing path for Training and Testing folder

% The training Images are renamed in training folder as 1.jpg, 2.jpg, ...
% 8.jpg for the convenience of the program.

% The testing Images are renamed in testing folder as 1.jpg, 2.jpg, ...
% 18.jpg for the convenience of the program. (17 test faces and apple being the 18th image)

TrainDatabasePath = 'C:\Users\Hitarthi\Desktop\Project2\Face Dataset\training\';
TestDatabasePath = 'C:\Users\Hitarthi\Desktop\Project2\Face Dataset\testing\';

% Training images(8) are saved in I1, I2,... I8
I1 = strcat(TrainDatabasePath,'1','.jpg');
I2 = strcat(TrainDatabasePath,'2','.jpg');
I3 = strcat(TrainDatabasePath,'3','.jpg');
I4 = strcat(TrainDatabasePath,'4','.jpg');
I5 = strcat(TrainDatabasePath,'5','.jpg');
I6 = strcat(TrainDatabasePath,'6','.jpg');
I7 = strcat(TrainDatabasePath,'7','.jpg');
I8 = strcat(TrainDatabasePath,'8','.jpg');


% 1. We are reading the image and converting it into 2-D array of type double. This will
% create matrix for the image on with which we can work further.
% 2. Saving images after resizing in A, B...H
% 3. Plotting the images in figure window all together



% Figure(Name,Value): modifies properties of the figure using one or more name-value pair arguments
% Subplot : Create axes in tiled positions
% pcolor(C) : draws a pseudocolor plot. The elements of C are linearly mapped to an index into the
current colormap.
% flipud : Flip array up to down
% shading interp varies the color in each line segment and face by interpolating the colormap index or
% true color value across the line or face.

% 'Xtick' and 'Ytick' : Set or query x-axis and y-axis tick values. Here
% they are set to null.
```

```
figure('Name','Training Data')
A = imresize(double(imread(I1)),[195,231]);
subplot(3,3,1), pcolor(flipud(A)), shading interp, colormap(gray), set(gca, 'Xtick', [], 'Ytick', []);
title('1.jpg');

B = imresize(double(imread(I2)),[195,231]);
subplot(3,3,2), pcolor(flipud(B)), shading interp, colormap(gray), set(gca, 'Xtick', [], 'Ytick', []);
title('2.jpg');

C = imresize(double(imread(I3)),[195,231]);
subplot(3,3,3), pcolor(flipud(C)), shading interp, colormap(gray), set(gca, 'Xtick', [], 'Ytick', []);
title('3.jpg');

D = imresize(double(imread(I4)),[195,231]);
subplot(3,3,4), pcolor(flipud(D)), shading interp, colormap(gray), set(gca, 'Xtick', [], 'Ytick', []);
title('4.jpg');

E = imresize(double(imread(I5)),[195,231]);
subplot(3,3,5), pcolor(flipud(E)), shading interp, colormap(gray), set(gca, 'Xtick', [], 'Ytick', []);
title('5.jpg');

F = imresize(double(imread(I6)),[195,231]);
subplot(3,3,6), pcolor(flipud(F)), shading interp, colormap(gray), set(gca, 'Xtick', [], 'Ytick', []);
title('6.jpg');

G = imresize(double(imread(I7)),[195,231]);
subplot(3,3,7), pcolor(flipud(G)), shading interp, colormap(gray), set(gca, 'Xtick', [], 'Ytick', []);
title('7.jpg');

H = imresize(double(imread(I8)),[195,231]);
subplot(3,3,8), pcolor(flipud(H)), shading interp, colormap(gray), set(gca, 'Xtick', [], 'Ytick', []);
title('8.jpg');


% Number of Training images = n = 8, Each of dimension MxN (195x231)
% For each training image, the rows are stacked together to form a column
% vector Ri of dimension MN x 1

% MN * 1 (Column Vector)
% reshape : Reshape array returned as a vector, matrix, multidimensional array, or cell array.
% The data type and number of elements in the reshaped array are the same as the data type and number of
elements in original array.

% A,B .. H are reshaped in vector R1,R2, ... R8

R1= reshape(A,195*231,1);
R2= reshape(B,195*231,1);
R3= reshape(C,195*231,1);
R4= reshape(D,195*231,1);
R5= reshape(E,195*231,1);
R6= reshape(F,195*231,1);
R7= reshape(G,195*231,1);
R8= reshape(H,195*231,1);
```

```
% Generating mean face : By taking the average of n training face images
Avg_face = (R1+R2+R3+R4+R5+R6+R7+R8)/8;

% reshaping the Avg_face into original dimensions to plot it as figure on screen.
Show_Avg_face = reshape(Avg_face,195,231);
figure('Name','Mean Image'),subplot(1,1,1), pcolor(flipud(Show_Avg_face)), shading interp,
colormap(gray), set(gca, 'Xtick', [], 'Ytick', []);



% Subtract mean face from each training images and save that value
% reshape to plot the output after subtraction process.
% All training images after subtracting the average face is then plotted
% altogether.

figure('Name','Original Image - Mean Image')
s1 = R1-Avg_face;
sr1 = reshape(s1,195,231);
subplot(3,3,1), pcolor(flipud(sr1)), shading interp, colormap(gray), set(gca, 'Xtick', [], 'Ytick', []);
title('1.jpg');

s2 = R2-Avg_face;
sr2 = reshape(s2,195,231);
subplot(3,3,2), pcolor(flipud(sr2)), shading interp, colormap(gray), set(gca, 'Xtick', [], 'Ytick', []);
title('2.jpg');

s3 = R3-Avg_face;
sr3 = reshape(s3,195,231);
subplot(3,3,3), pcolor(flipud(sr3)), shading interp, colormap(gray), set(gca, 'Xtick', [], 'Ytick', []);
title('3.jpg');

s4 = R4-Avg_face;
sr4 = reshape(s4,195,231);
subplot(3,3,4), pcolor(flipud(sr4)), shading interp, colormap(gray), set(gca, 'Xtick', [], 'Ytick', []);
title('4.jpg');

s5 = R5-Avg_face;
sr5 = reshape(s5,195,231);
subplot(3,3,5), pcolor(flipud(sr5)), shading interp, colormap(gray), set(gca, 'Xtick', [], 'Ytick', []);
title('5.jpg');

s6 = R6-Avg_face;
sr6 = reshape(s6,195,231);
subplot(3,3,6), pcolor(flipud(sr6)), shading interp, colormap(gray), set(gca, 'Xtick', [], 'Ytick', []);
title('6.jpg');

s7 = R7-Avg_face;
sr7 = reshape(s7,195,231);
subplot(3,3,7), pcolor(flipud(sr7)), shading interp, colormap(gray), set(gca, 'Xtick', [], 'Ytick', []);
title('7.jpg');

s8 = R8-Avg_face;
sr8 = reshape(s8,195,231);
```

```
subplot(3,3,8), pcolor(flipud(sr8)), shading interp, colormap(gray), set(gca, 'Xtick', [], 'Ytick', []);
title('8.jpg');


% Creating data matrix by putting all training faces into a single matrix 'Data'
% Data is a 8x45045 vector, where each row represent one training image.
Data = [reshape(s1,1,195*231)
    reshape(s2,1,195*231)
    reshape(s3,1,195*231)
    reshape(s4,1,195*231)
    reshape(s5,1,195*231)
    reshape(s6,1,195*231)
    reshape(s7,1,195*231)
    reshape(s8,1,195*231)];


% Covariance matrix
L = (Data)*(Data');

% L is of nxn dimension
size(L)



% eigs : returns subset of eigenvalues and eigenvectors of covariance matrix
% eigs of L will grab largest magnitude of 8 eigenvectors possible.



%%%%%%%% Di %%%%%%%%
% is diagonal matrix, the elements of this eigenvalues are arranged from
% largest to smallest, largest being the most important and smallest being
% the least.

%%%%%%%% V %%%%%%%%
% are the eigenvectors, the first eigenvector of this has dominant avegrage face,
% second eigenvector tells about the feature space.


[V,Di] = eigs(L,8,'largestabs');



% Eigenfaces/ Facespace/ Eigenspace can be found as follows:
% U is dimension of MN x n

u = V*Data;
U = u';


% Each column of U represents an eigenface. we can output each eigenface as
% an MxN image
% Eigen faces of Training images are combined and plotted in figure to
% display.
```

```
figure('Name','EigenFaces')
subplot(3,3,1), face1=reshape(U(:,1),195,231); pcolor(flipud(face1)), shading interp, colormap(gray),
set(gca, 'Xtick', [], 'Ytick', []); title('1.jpg');
subplot(3,3,2), face1=reshape(U(:,2),195,231); pcolor(flipud(face1)), shading interp, colormap(gray),
set(gca, 'Xtick', [], 'Ytick', []); title('2.jpg');
subplot(3,3,3), face1=reshape(U(:,3),195,231); pcolor(flipud(face1)), shading interp, colormap(gray),
set(gca, 'Xtick', [], 'Ytick', []); title('3.jpg');
subplot(3,3,4), face1=reshape(U(:,4),195,231); pcolor(flipud(face1)), shading interp, colormap(gray),
set(gca, 'Xtick', [], 'Ytick', []); title('4.jpg');
subplot(3,3,5), face1=reshape(U(:,5),195,231); pcolor(flipud(face1)), shading interp, colormap(gray),
set(gca, 'Xtick', [], 'Ytick', []); title('5.jpg');
subplot(3,3,6), face1=reshape(U(:,6),195,231); pcolor(flipud(face1)), shading interp, colormap(gray),
set(gca, 'Xtick', [], 'Ytick', []); title('6.jpg');
subplot(3,3,7), face1=reshape(U(:,7),195,231); pcolor(flipud(face1)), shading interp, colormap(gray),
set(gca, 'Xtick', [], 'Ytick', []); title('7.jpg');
subplot(3,3,8), face1=reshape(U(:,8),195,231); pcolor(flipud(face1)), shading interp, colormap(gray),
set(gca, 'Xtick', [], 'Ytick', []); title('8.jpg');



% Each training face then can be projected onto the face space
% generating PCA coefficients of training faces
% Ωi = u*si for i = 1 to 8 as face1 to face8

face1 = u*s1;
face2 = u*s2;
face3 = u*s3;
face4 = u*s4;
face5 = u*s5;
face6 = u*s6;
face7 = u*s7;
face8 = u*s8;



%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Testing Process %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%Extracting the PCA features from test image


% Enter the number of test image that needs to be recognised into Test 1.
% Test image path is stored in Test1, and it is then being read and
% converted into matrix form.

Test1 = strcat(TestDatabasePath,'18','.jpg');
T1 = imresize( double( imread(Test1)), [195,231]);

% reshaping the test image to show at the end as the input of the program.
input1 = reshape(T1,195*231,1);

%subtract mean face from Input face
figure('Name','Test Image - Mean Image');
Diff = input1-Avg_face;
```

```
% reshaping the test image after subtracting the mean to display.
Difference = reshape(Diff,195,231);

% plotting it as figure.
subplot(1,1,1), pcolor(flipud(Difference)), shading interp, colormap(gray), set(gca, 'Xtick', [],
'Ytick', []);


%Compute its projection onto face space
%Test image feature vector
%PCA coefficients of each test image are stored in variable ProjectedTestImage.
ProjectedTestImage = u*Diff;

%Reconstruct input face image from eigenfaces.
figure('Name','Reconstructed Image');
Recon = U*ProjectedTestImage;

%plotting the reconstructed face.
Reconstruction = reshape(Recon,195,231);
subplot(1,1,1), pcolor(flipud(Reconstruction)), shading interp, colormap(gray), set(gca, 'Xtick', [],
'Ytick', []);


% Computing distance between input face image and its reconstruction
% n = norm(v) returns the Euclidean norm of vector v.
distance = norm( Recon - input1 );


% concatenating all projected training faces into single array.
% C = horzcat(A1,...,AN) horizontally concatenates arrays A1,...,AN.
% All arrays in the argument list must have the same number of rows.
ProjectedImages = horzcat(face1,face2,face3,face4,face5,face6,face7,face8);


% Calculating Euclidean distances
% Euclidean distances between the projected test image and the projection
% of all centered training images are calculated. Test image is
% supposed to have minimum distance with its corresponding image in the
% training database.
% Euc_dist will have Euclidean distances between all training image and
% test image.

Euc_dist = [];
for i = 1 : 8
    q = ProjectedImages(:,i);
    temp = norm( ProjectedTestImage - q );
    Euc_dist = [Euc_dist temp];
End

% Minimum Euclidean distance is generated in Euc_dist_min
% Whichever distance is minimum between the projected test image and the projection
% of all centered training images, that training image's index is noted.
[Euc_dist_min , Recognized_index] = min(Euc_dist);
```

```
% The recognised output image name is saved and it is showed as Equivalent
% image compared to the test image.
figure('Name','Test Image');
input1 = imresize(double(imread(Test1)),[231,195]);
subplot(1,1,1), pcolor(flipud(input1)), shading interp, colormap(gray), set(gca, 'Xtick', [], 'Ytick',
[]);


% the fetched recognized index is then saved in OutputName
% the training image at that index is fetched.
OutputName = strcat(int2str(Recognized_index),'.jpg');
SelectedImage = strcat(TrainDatabasePath,OutputName);
figure('Name','Equivalent Image');

%output is then plotted into figure window.
output1 = imresize(double(imread(SelectedImage)),[231,195]);
subplot(1,1,1), pcolor(flipud(output1)), shading interp, colormap(gray), set(gca, 'Xtick', [], 'Ytick',
[]); title('Matched Training Image');
```

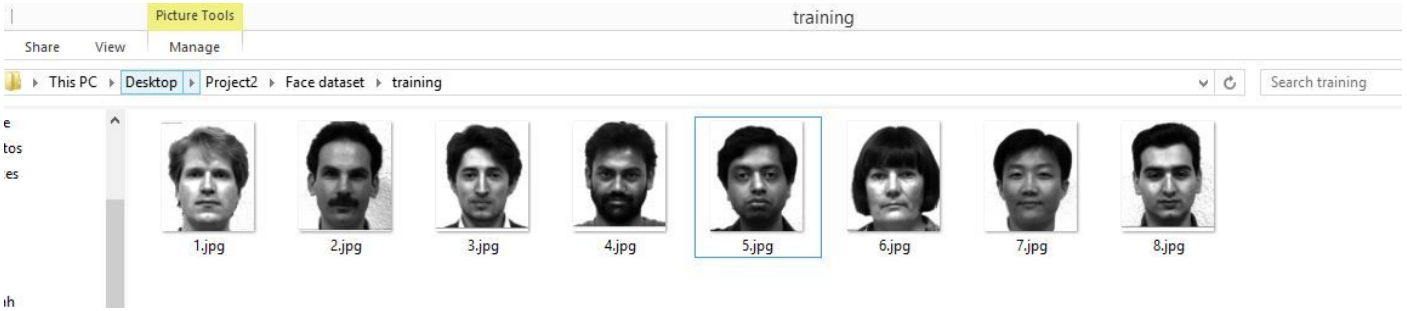
2. Language & Compiler

- Language Used : Matlab
- File extension : *.m
- Compiler : MATLAB Compiler (www.mathworks.com/help/compiler/index.html)

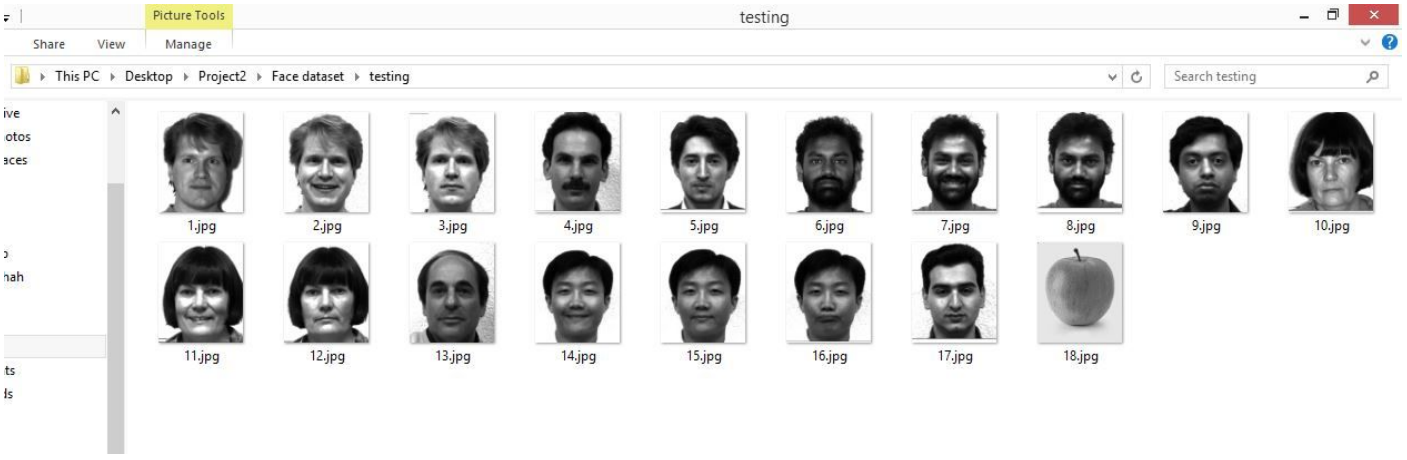
3. Instructions on executing the program

- Load the above mentioned code in Matlab R2017b under the file name Face_Recognition.m
- Rename the strings which specify the name of the training and testing folders based on the system path where the training and testing folders are located.
- Rename the files to be named 1.jpg through 8.jpg in the training folder, as I have renamed those files for the sake of simplicity.
- Rename the files in testing folder from 1.jpg to 18.jpg, for the sake of simplicity, or simply pass the name of the file on which testing has to be done. If more number of images have to be tested, rename them accordingly or pass the correct name of image to be tested in the “Test1” variable.
- Click on “Compiler & Run” button available in Matlab R2017b and the output would be shown in several new windows.
- The workspace in matlab shows calculated variables for each test image incase we want to varify with the values written here.
- Following images show how the training and testing folders should look for my project :

1. **Training Images Data Folder :**



2. **Testing Images Data Folder :**



- Hence, it is not necessary to rename all the names of files in testing data folder, but it is necessary that training folder contains only 8 images labelled from 1.jpg to 8.jpg.

4. Mean Face m

- The Mean Face obtained from all the given 8 training faces is as shown below :

5. Eigenfaces

- The Eigenfaces for each training image that is generated is as shown below :

1.jpg

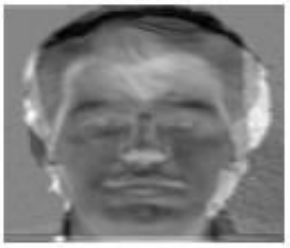
2.jpg

3.jpg

4.jpg

5.jpg

6.jpg



7.jpg

8.jpg

6. The PCA coefficients for each Training Image

- The PCA coefficients value for each training image is as shown below :

1. Subject 1 :
    a. -45465159.8438012
    b. -37182030.8693160
    c. 62268936.6416469
    d. 31921622.1793352
    e. -18331989.4172045
    f. -109476571.345616
    g. -1916801.24769890
    h. 32086661.5608897
2. Subject 2 :
    a. -25267233.4301786
    b. 15523403.4051443
    c. -67343593.4575588
    d. 46331455.2159492
    e. 12016135.7995268
    f. 81262009.6416997
    g. -31247363.3525023
    h. 33337381.5254491
3. Subject 3 :
    a. 71586685.9304944
    b. -22442864.8689439
    c. -26838795.5499260
    d. -16755510.6000549
    e. -31062301.5610203
    f. 3827511.81158293
    g. -4972939.14625926
    h. 61771946.8204623
4. Subject 7 :
    a. 61865388.9085934
    b. 46023684.4636647
    c. -132252772.887412
    d. -18013810.3684925
    e. 40637176.8453830
    f. 69543453.3871319
    g. 8126320.95479954
    h. 48256194.5426077
5. Subject 10 :
    a. -7530637.97909631
    b. -9406385.35416027
    c. -8238308.84402016
    d. 19201251.1233737
    e. -63750362.6256691
    f. -15863694.2726755

    g. 57024391.4109556
    h. -63610031.0083028
6. Subject 11 :
    a. -81368179.4896583
    b. 6578144.48610068
    c. 206524843.478925
    d. -70935738.0160370
    e. 37942936.8305273
    f. -56452086.1575121
    g. -106905439.936225
    h. -189272341.418878
7. Subject 14 :
    a. -51065463.3673782
    b. -16734846.8750620
    c. 20021464.2458230
    d. -48809504.5604108
    e. -38905357.1684611
    f. -49610979.5756523
    g. 53615384.4916647
    h. -9447723.55515200
8. Subject 15 :
    a. 77244599.2710244
    b. 17640895.6125729
    c. -54141773.6274766
    d. 57060235.0263369
    e. 61453761.2969176
    f. 76770356.5110417
    g. 26276446.8252656
    h. 86877911.5329249

7. Testing Images result.

1. Subject 01 - Center Light
    a. Test Image after Subtracting Mean Face

    b. Reconstructed Face Image

    c. PCA Coefficients
        i. -30244591.1247202
        ii. -7589079.13167136
        iii. 29154658.9302855
        iv. 14471650.2451715
        v. -767515.219443414
        vi. -22074378.6219023
        vii. -15179729.7018291
        viii. -8335337.20038529
    d. Distances d_i
        i. 110751806.826435
        ii. 154021219.431589
        iii. 145974444.031279
        iv. 228736070.982650
        v. 119222346.821205

vi. 292234609.749850
vii. 107479477.613849
viii. 212998843.023769

e. Classification Result : Subject 01 - Normal

2. Subject 01 - Happy
   a. Test Image after Subtracting Mean Face

   b. Reconstructed Face Image

   c. PCA Coefficients
      i. -31654282.9601907
      ii. -23408549.4378143
      iii. 26356877.2589447
      iv. 31260371.2124790
      v. -8972438.45365907
      vi. -63761227.3184477
      vii. -6421151.04815534
      viii. 37450542.4226739

d. Distances d_i
    i. 62426890.2939423
    ii. 180745471.746671
    iii. 146440303.382916
    iv. 248417739.118140
    v. 147151728.272609
    vi. 331707775.711178
    vii. 117357133.487273
    viii. 221158003.803358
e. Classification Result : Subject 01 - Normal

3. Subject 01 - Normal
    a. Test Image after Subtracting Mean Face

    b. Reconstructed Face Image

    c. PCA Coefficients
        i. -45465159.8438012
        ii. -37182030.8693160
        iii. 62268936.6416469
        iv. 31921622.1793352

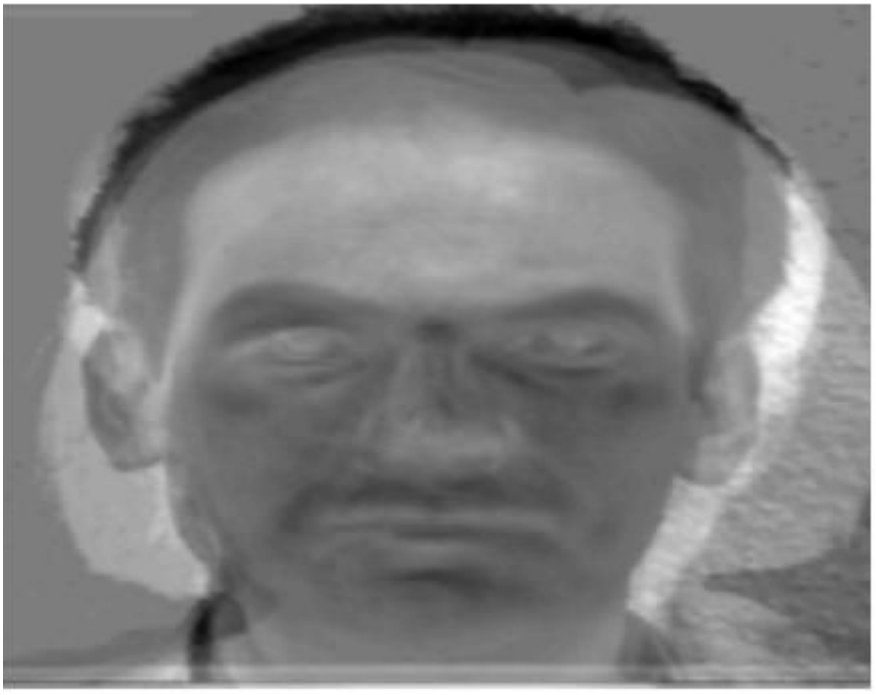
v. -18331989.4172045
vi. -109476571.345616
vii. -1916801.24769890
viii. 32086661.5608897

d. Distances d_i
i. 0
ii. 241571793.542559
iii. 195239496.651352
iv. 307673740.489579
v. 175504172.252824
vi. 317165995.620829
vii. 132543939.204745
viii. 277663944.426984

e. Classification Result : Subject 01 - Normal

4. Subject 02 - Normal
a. Test Image after Subtracting Mean Face

b. Reconstructed Face Image



c. PCA Coefficients
    i. -25267233.4301786
    ii. 15523403.4051443
    iii. -67343593.4575588
    iv. 46331455.2159492
    v. 12016135.7995268
    vi. 81262009.6416997
    vii. -31247363.3525023
    viii. 33337381.5254491
d. Distances d_i
    i. 241571793.542559
    ii. 0
    iii. 160603381.726869
    iv. 140018649.995924
    v. 193727210.168367
    vi. 408533295.656098
    vii. 217125742.036521
    viii. 139435953.876930
e. Classification Result : Subject 02 - Normal

5. Subject 03 - Normal

a. Test Image after Subtracting Mean Face

b. Reconstructed Face Image

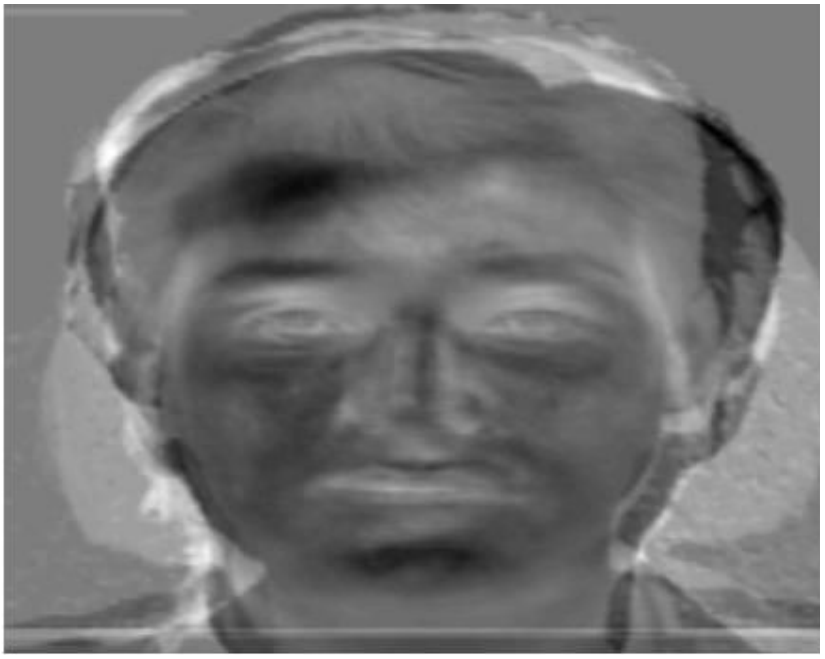
c. PCA Coefficients
    i. 71586685.9304944
    ii. -22442864.8689439
    iii. -26838795.5499260
    iv. -16755510.6000549
    v. -31062301.5610203
    vi. 3827511.81158293
    vii. -4972939.14625926
    viii. 61771946.8204623
d. Distances d_i
    i. 195239496.651352
    ii. 160603381.726869

iii. 0
iv. 160341910.570695
v. 170554770.832653
vi. 404277524.894721
vii. 172399224.684626
viii. 152707730.057506

e. Classification Result : Subject 03 - Normal

6. Subject 07 - Center Light
   a. Test Image after Subtracting Mean Face

   b. Reconstructed Face Image



   c. PCA Coefficients
      i. -17396008.4957121
      ii. 10415928.9257975
      iii. -34114389.1200964

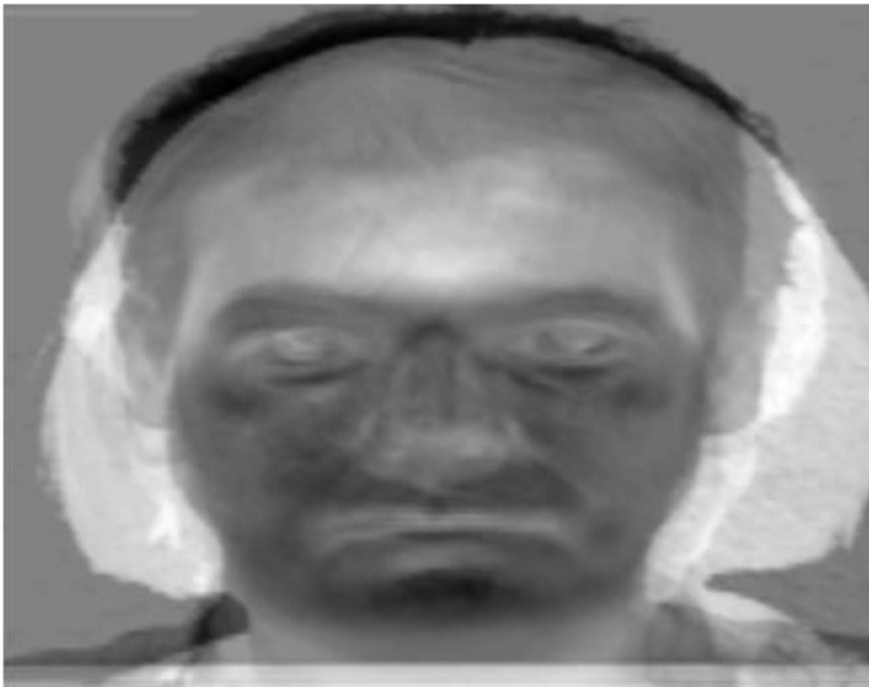
iv. -30899541.5605468
v. -20257474.0948151
vi. 6893643.66420389
vii. 33645103.5418783
viii. -24673420.1784695

d. Distances d_i
i. 185261376.213672
ii. 145963606.728741
iii. 135428609.489862
iv. 175927712.283431
v. 90233525.8302830
vi. 343314045.747584
vii. 96402303.7159470
viii. 202989016.711296

e. Classification Result : Subject 10 - Normal

7. Subject 07 - Happy
a. Test Image after Subtracting Mean Face

b. Reconstructed Face Image

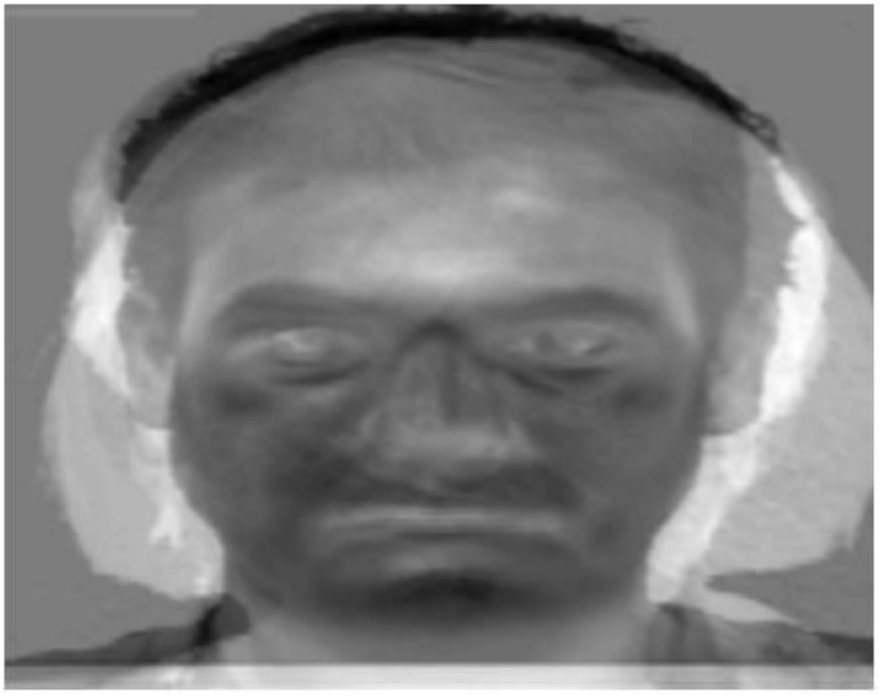


c. PCA Coefficients
    i. 31915486.7078409
    ii. 15597306.3954348
    iii. -77502296.4177258
    iv. 6695118.58574729
    v. 5387421.55526371
    vi. 44799260.9352116
    vii. 25560694.7148933
    viii. 38945469.0419249
d. Distances d_i
    i. 232618778.013750
    ii. 97857985.7450390
    iii. 102947551.855411
    iv. 87614920.3833202
    v. 164628997.494131
    vi. 424917454.462808
    vii. 185814326.045243
    viii. 107725950.589187
e. Classification Result : Subject 07 - Normal

8. Subject 07 - Normal

a. Test Image after Subtracting Mean Face

b. Reconstructed Face Image



c. PCA Coefficients
    i. 61865388.9085934
    ii. 46023684.4636647
    iii. -132252772.887412
    iv. -18013810.3684925
    v. 40637176.8453830
    vi. 69543453.3871319
    vii. 8126320.95479954
    viii. 48256194.5426077
d. Distances d_i
    i. 307673740.489579

ii. 140018649.995924
iii. 160341910.570695
iv. 0
v. 240310345.726450
vi. 474528245.567224
vii. 258363347.640803
viii. 122825753.492712

e. Classification Result : Subject 07 - Normal

9. Subject 10 - Normal
   a. Test Image after Subtracting Mean Face

   b. Reconstructed Face Image

   c. PCA Coefficients
      i. -7530637.97909631

ii. -9406385.35416027
iii. -8238308.84402016
iv. 19201251.1233738
v. -63750362.6256691
vi. -15863694.2726755
vii. 57024391.4109556
viii. -63610031.0083028

d. Distances d_i
i. 175504172.252824
ii. 193727210.168367
iii. 170554770.832653
iv. 240310345.726450
v. 0
vi. 338538515.845197
vii. 109883554.146810
viii. 243532387.903863

e. Classification Result : Subject 10 - Normal

10. Subject 11 - Center Light
a. Test Image after Subtracting Mean Face

b. Reconstructed Face Image

c. PCA Coefficients
    i. -60295049.3995911
    ii. 22773625.0467066
    iii. 119315389.044649
    iv. -46841435.5826537
    v. 52401519.6896027
    vi. 9708821.91151891
    vii. -102589887.700900
    viii. -128885741.236968
d. Distances d_i
    i. 261778714.519141
    ii. 288026408.822973
    iii. 307544717.979845
    iv. 356282524.383544
    v. 261407858.118308
    vi. 130934627.208750
    vii. 249059376.751693
    viii. 357163999.917770
e. Classification Result : Subject 11 - Normal

11. Subject 11 - Happy

a. Test Image after Subtracting Mean Face

b. Reconstructed Face Image

c. PCA Coefficients
   i. -82408597.4968826
   ii. 9695052.39353175
   iii. 193904184.373891
   iv. -69333430.2555289
   v. 42651261.5978256
   vi. -44403780.9053276
   vii. -108182248.026654
   viii. -178304729.018654

d. Distances d_i
    i. 307657293.069981
    ii. 390345531.033459
    iii. 390241223.574648
    iv. 457156844.923547
    v. 327498856.127994
    vi. 21491736.8577676
    vii. 306116191.474248
    viii. 454414034.347091
e. Classification Result : Subject 11 - Normal

12. Subject 11 - Normal
    a. Test Image after Subtracting Mean Face

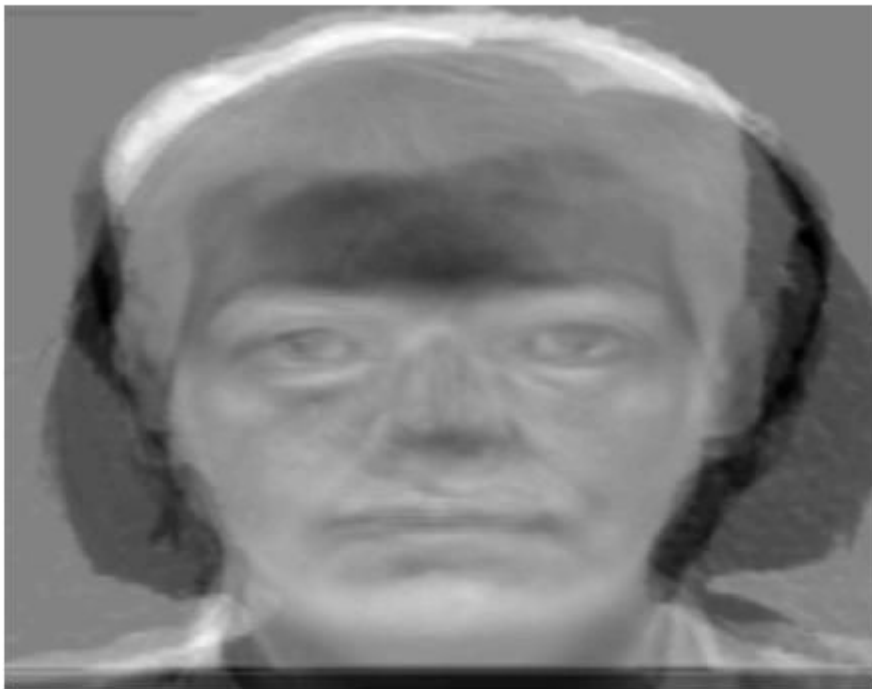
b. Reconstructed Face Image

c. PCA Coefficients
    i. -81368179.4896583
    ii. 6578144.48610068
    iii. 206524843.478925
    iv. -70935738.0160370
    v. 37942936.8305273
    vi. -56452086.1575121
    vii. -106905439.936225
    viii. -189272341.418878
d. Distances d_i
    i. 317165995.620829
    ii. 408533295.656098
    iii. 404277524.894721
    iv. 474528245.567224
    v. 338538515.845197
    vi. 0
    vii. 317476172.550880
    viii. 471070915.788474
e. Classification Result : Subject 11 - Normal

13. Subject 12 - Normal

a. Test Image after Subtracting Mean Face

b. Reconstructed Face Image



c. PCA Coefficients
   i. -60821390.3761192
   ii. -6794875.13983478
   iii. 43357854.8079859
   iv. -1861388.33550452
   v. -11865537.2160805
   vi. -39856812.9913125
   vii. 1747453.75911826
   viii. -40597168.6930999

d. Distances d_i
    i. 113327867.568314
    ii. 195280935.130114
    iii. 189017455.119664
    iv. 267586252.859595
    v. 113160769.186822
    vi. 262033939.870862
    vii. 86194893.6487806
    viii. 261660932.151127
e. Classification Result : Subject 11 - Normal

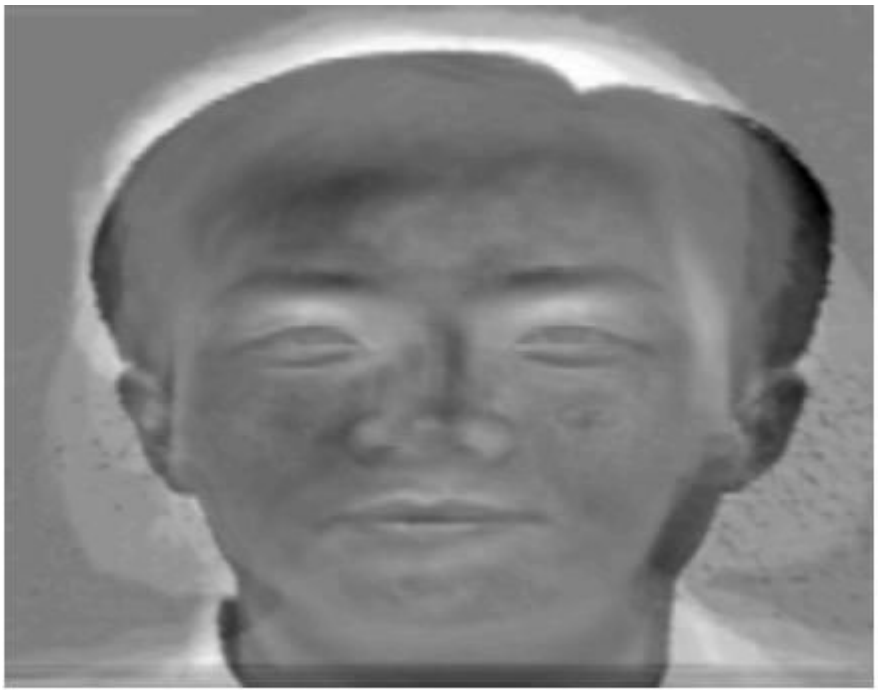
14. Subject 14 - Happy
    a. Test Image after Subtracting Mean Face

b. Reconstructed Face Image

c. PCA Coefficients
    i. -37778699.0284510
    ii. -16029768.8088801
    iii. 10471391.9563193
    iv. -36277242.4491295
    v. -31329695.9750712
    vi. -54304310.7913392
    vii. 39106199.6044730
    viii. 7075009.15197863
d. Distances d_i
    i. 115593938.888483
    ii. 199819750.586563
    iii. 148624254.738784
    iv. 240117591.801279
    v. 110602656.763863
    vi. 326686882.613490
    vii. 31436155.2779180
    viii. 244076346.250688
e. Classification Result : Subject 14 - Normal

15. Subject 14 - Normal

a. Test Image after Subtracting Mean Face

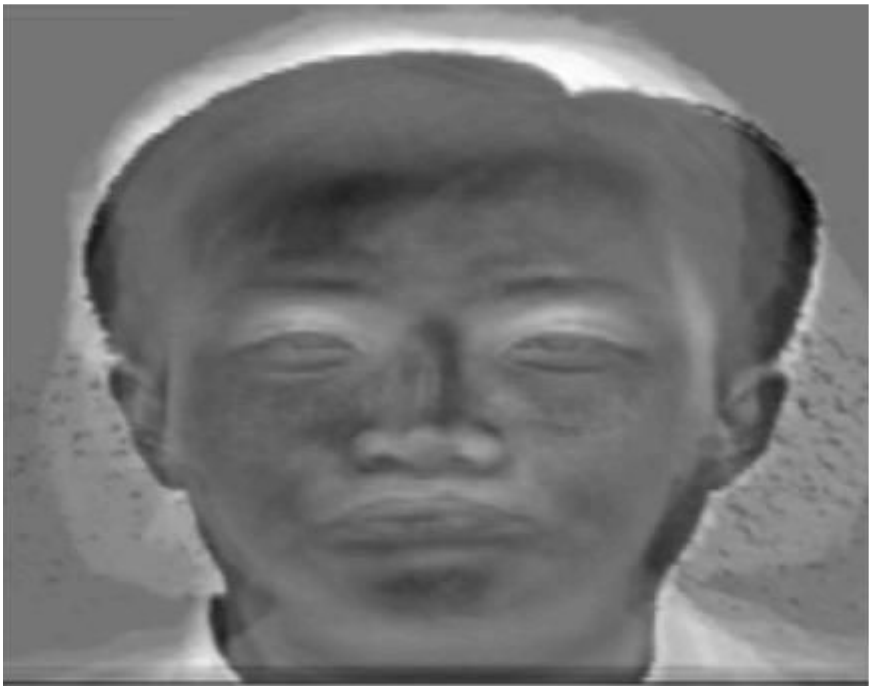


b. Reconstructed Face Image

c. PCA Coefficients
   i. -51065463.3673782
   ii. -16734846.8750620
   iii. 20021464.2458230
   iv. -48809504.5604108
   v. -38905357.1684611
   vi. -49610979.5756523
   vii. 53615384.4916647
   viii. -9447723.55515200

d. Distances d_i
    i. 132543939.204745
    ii. 217125742.036521
    iii. 172399224.684626
    iv. 258363347.640803
    v. 109883554.146810
    vi. 317476172.550880
    vii. 0
    viii. 265375190.467984
e. Classification Result : Subject 14 - Normal

16. Subject 14 - Sad
    a. Test Image after Subtracting Mean Face



b. Reconstructed Face Image

c. PCA Coefficients
    i. -38425827.4832853
    ii. -12497776.7863330
    iii. 1380150.50814328
    iv. -43343218.0173024
    v. -37314159.1507082
    vi. -36435897.1531181
    vii. 43988609.8507837
    viii. -3620540.41662508
d. Distances d_i
    i. 138234145.354257
    ii. 192445966.605726
    iii. 148453735.146490
    iv. 230798092.580242
    v. 99293271.5935073
    vi. 329170947.041930
    vii. 29288864.5383487
    viii. 241921419.359326
e. Classification Result : Subject 14 - Normal

17. Subject 15 - Normal

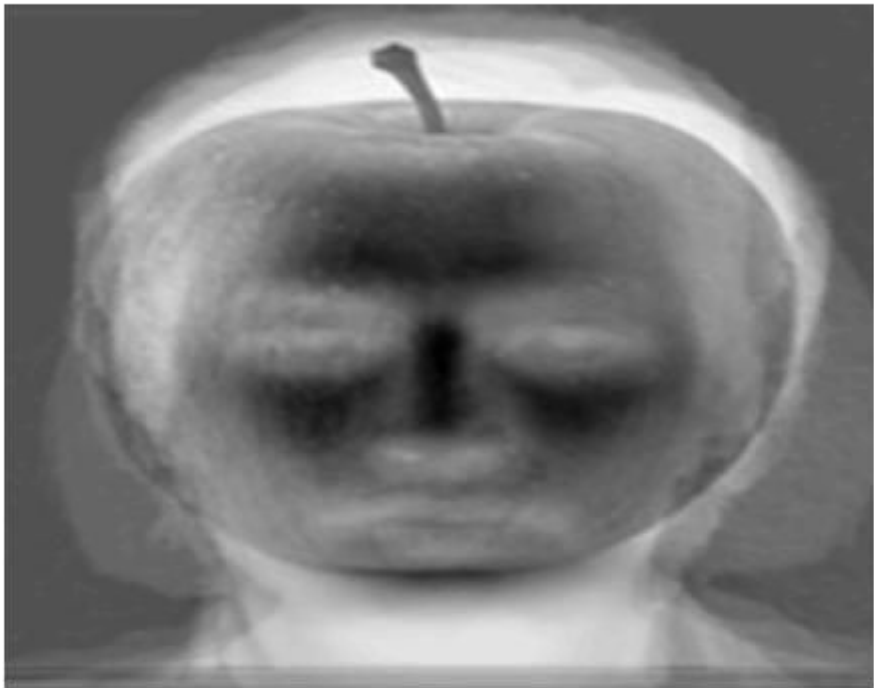
a. Test Image after Subtracting Mean Face

b. Reconstructed Face Image

c. PCA Coefficients
   i. 77244599.2710244
   ii. 17640895.6125729
   iii. -54141773.6274766
   iv. 57060235.0263369
   v. 61453761.2969176
   vi. 76770356.5110417
   vii. 26276446.8252656
   viii. 86877911.5329249

d. Distances d_i
    i. 277663944.426984
    ii. 139435953.876930
    iii. 152707730.057506
    iv. 122825753.492711
    v. 243532387.903863
    vi. 471070915.788474
    vii. 265375190.467984
    viii. 0
e. Classification Result : Subject 15 - Normal

18. Apple
    a. Test Image after Subtracting Mean Face



b. Reconstructed Face Image

c. PCA Coefficients
    i. -22220126.8239289
    ii. -4924421.59330461
    iii. 18942914.3514933
    iv. -2786227.22914090
    v. 22107423.0506407
    vi. -52091944.5531915
    vii. -19572059.6835171
    viii. 33874108.7029032
d. Distances d_i
    i. 99528430.7367422
    ii. 168246897.546787
    iii. 135436880.947719
    iv. 221067105.390168
    v. 159725879.166500
    vi. 318046174.251508
    vii. 118544264.239992
    viii. 205889561.589982
e. Classification Result : Non Face Image

Threshold :

T0 = 9.0000e+10;
When I apply this threshold I am getting apple as a non face image, as it is satisfying the condition d0>t0.