



# NUS

National University  
of Singapore

## PATTERN RECOGNITION

(EE5907R)

PROJECT II

REPORT

SUBMITTED BY

VIGNESH PRAKASAM (A0120541Y)

DATE OF SUBMISSION

02.05.2014

## **ACADEMIC INTEGRITY**

“This report and the work reported therein represent my own intellectual efforts, and I confirm that I have not received help or given help to anybody, and that I have not used any unacknowledged sources”

- VIGNESH PRAKASAM

# CROSS - AGE FACE RECOGNITION

EE5907R - PATTERN RECOGNITION — PROJECT II

VIGNESH PRAKASAM | AO120541Y | AY 2013-14 — SEMESTER II

## ABSTRACT:

In this project of cross age recognition, a person's random age photo is given cross his present age or random age photo to determine how accurately the person is predicted as himself/herself. Different feature extraction and classification methods are followed to perform the above task of classification (Cross age detection). PCA, NMF, LDA and GMM learning methods are adopted and classification is performed using K-nearest neighbour classifier on dimension-reduced versions of data generated using PCA and LDA.

## INTRODUCTION:

Dataset contains 2543 images from 285 potential subjects in which 1342 images were considered for training and 1201 images for testing. Different feature extraction algorithms learned were implemented to enhance the classification process of cross age recognition. Among them Principal component analysis (PCA) is a major method to obtain the dimension reduced versions of the data generated. LDA (Linear discriminant analysis) feature extraction method is used to calculate the face recognition accuracy of testing set over different dimension-reduced feature dimension. Non negative matrix factorization is learned for the whole database and GMM (Gaussian Mixture Model) is learned with component number set as 8.

## DATA SET ORDERING:

Initially in order to separate the train and test data, script file: **orgScript.m** has to be run. This separates the data and puts them in the desired test/train folder created by the user. These two folders are kept in the working folder to run all the below implementation scripts.

**Note:** Make sure that before run, **orgScript.m** file is present inside the entire dataset folder.

## METHOD AND IMPLEMENTATION:

### I. PRINCIPAL COMPONENT ANALYSIS (PCA) :

Feature extraction refers to the mapping of the original high dimension data into a low dimensional space and PCA comes in an unsupervised setting.

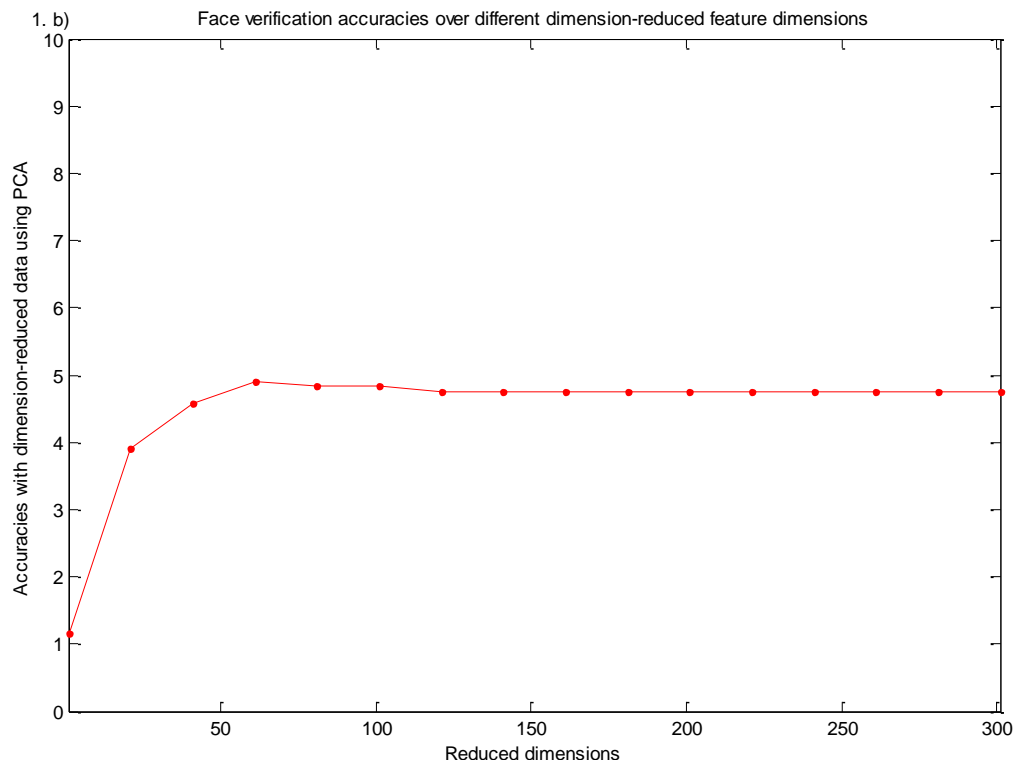
PCA algorithm is represented in the Matlab file source : '**mainPCA.m**'

- This script generates principal components and mean vector from the training data along with the classification of testing data.
- First 10 Eigen faces are displayed.
- SVD has been used for speed up.
- Accuracy over the testing data is plotted for different dimension-reduced feature dimensions (1-286) using nearest neighbour(KNN) approach for classification. With K value equal to 3.

### FIRST 10 EIGEN FACES:



## FACE RECOGNITION ACCURACY OVER DIFFERENT DIMENSION-REDUCED FEATURES:



### OBSERVATIONS AND RESULTS:

Best Accuracy was 4.913% with PCA. By using the pixel grey values for feature extraction classification is not good enough.

Eigen faces are displayed and classification accuracy is plotted for 1-286 reduced dimensions.

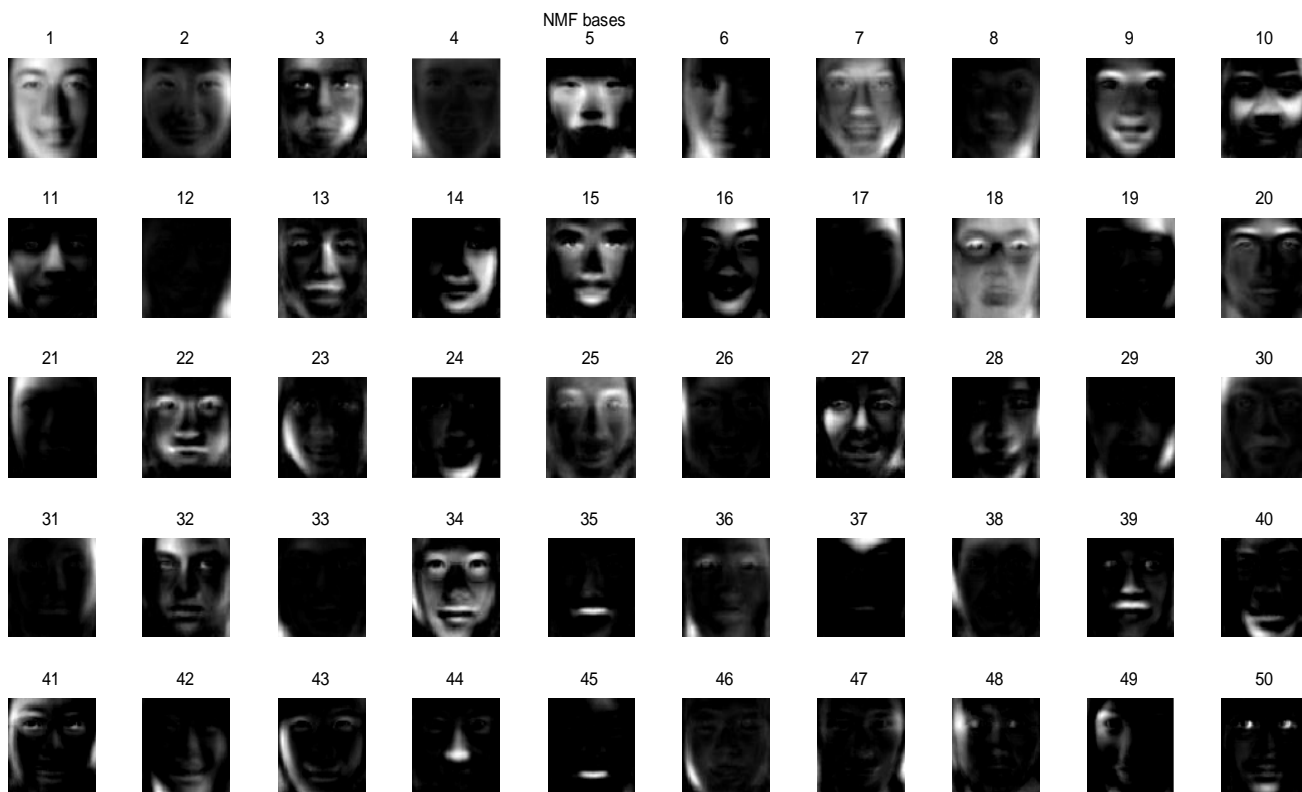
### II. NON NEGATIVE MATRIX FACTORIZATION (NMF) :

Forcing the reconstruction coefficients to be non-negative makes leads to nice basis vectors. It is exactly like the PCA except that the coefficients in linear combinations cannot be negative. Consider a matrix  $\mathbf{V}$  which is factorized into (usually) two matrices  $\mathbf{W}$  and  $\mathbf{H}$ , with the property that all three matrices have no negative elements. This non-negativity makes the resulting matrices easier to inspect. Since the problem is not exactly solvable in general, it is commonly approximated numerically.

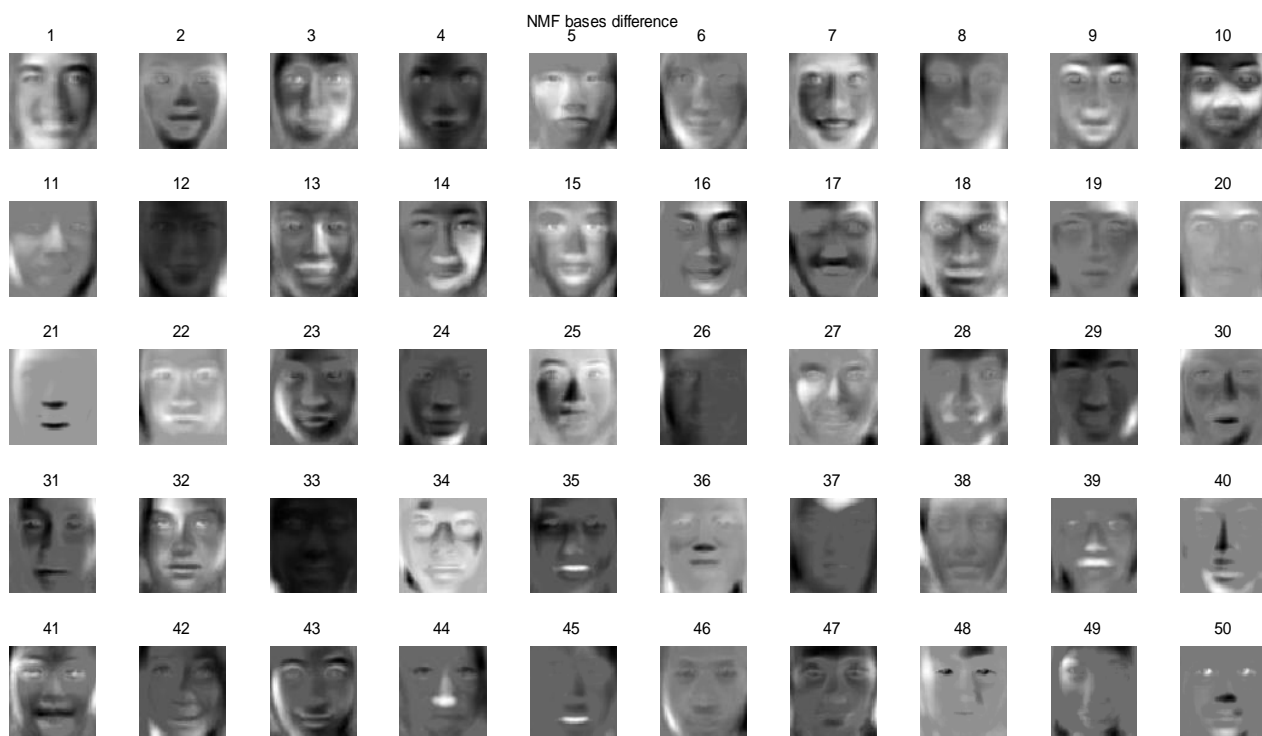
Script file for NMF is '**mainNMF.m**'

- Algorithm has been written to study the bases for the whole database.
- With two more random initializations the bases are found out and a comparative study is performed.

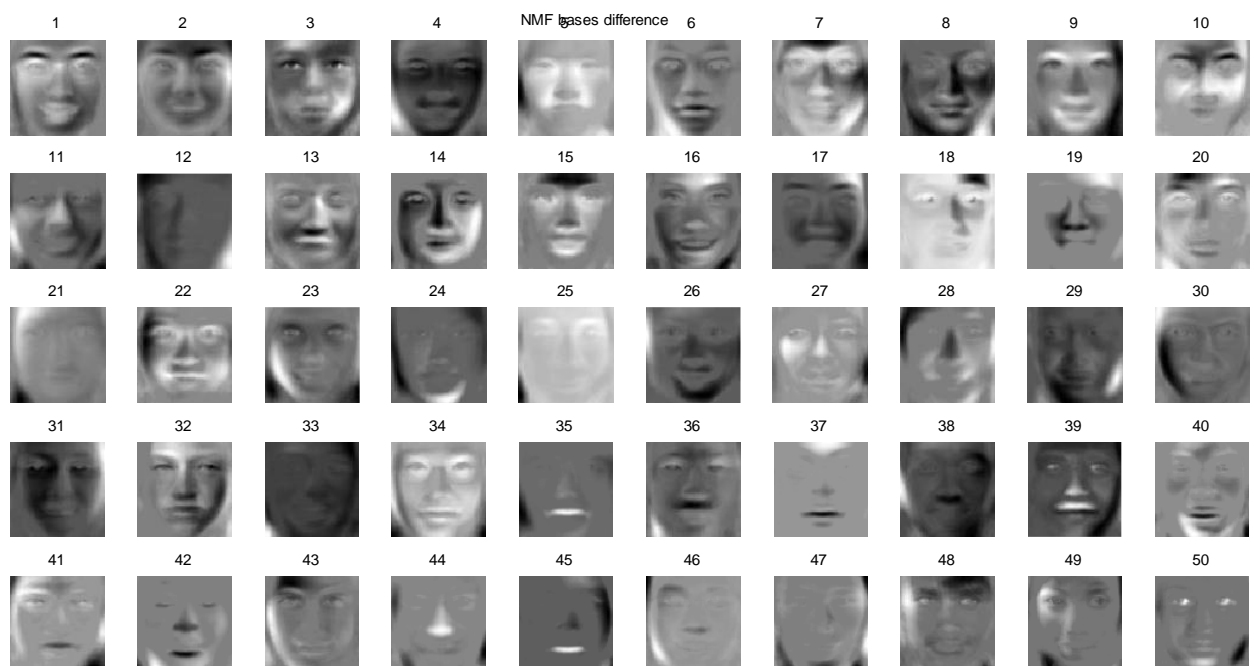
2. a)



1<sup>ST</sup> ITERATION:



## 2ND ITERATION:



## COMPARISON STUDY:

NMF is learnt with 2 different initializations. Strong black and white indicates that there is a significant difference in bases between different initialisations. NMF procedure converges to a local minimum. Hence different initializations may lead to convergence at different local minima. This results in different bases being produced for different initializations. The difference is scaled to 0-255 range. Significant difference is observable in last 20 images from image number 30 to 50.

### III. LINEAR DISCRIMINANT ANALYSIS (LDA):

LDA is a supervised feature extraction algorithm. LDA seeks to reduce the dimensionality while preserving as much of the class discriminatory information as possible. In order to find a good projection vector, we need to define a measure of separation. LDA finds most discriminative projection by maximizing the between class scatter and minimizing the within class scatter.

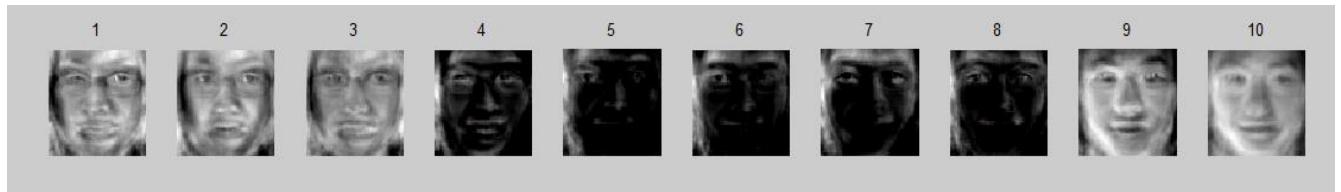
Developed Matlab Script file for LDA is '**mainLDA.m**'

- First 10 fisher faces are displayed.
- LDA produces the transformation matrix for conversion to LDA space.
- It uses reduced dimension data from PCA as input.
- Face recognition accuracy of testing set over different dimension-reduced feature dimensions based on K-NN approach is determined.

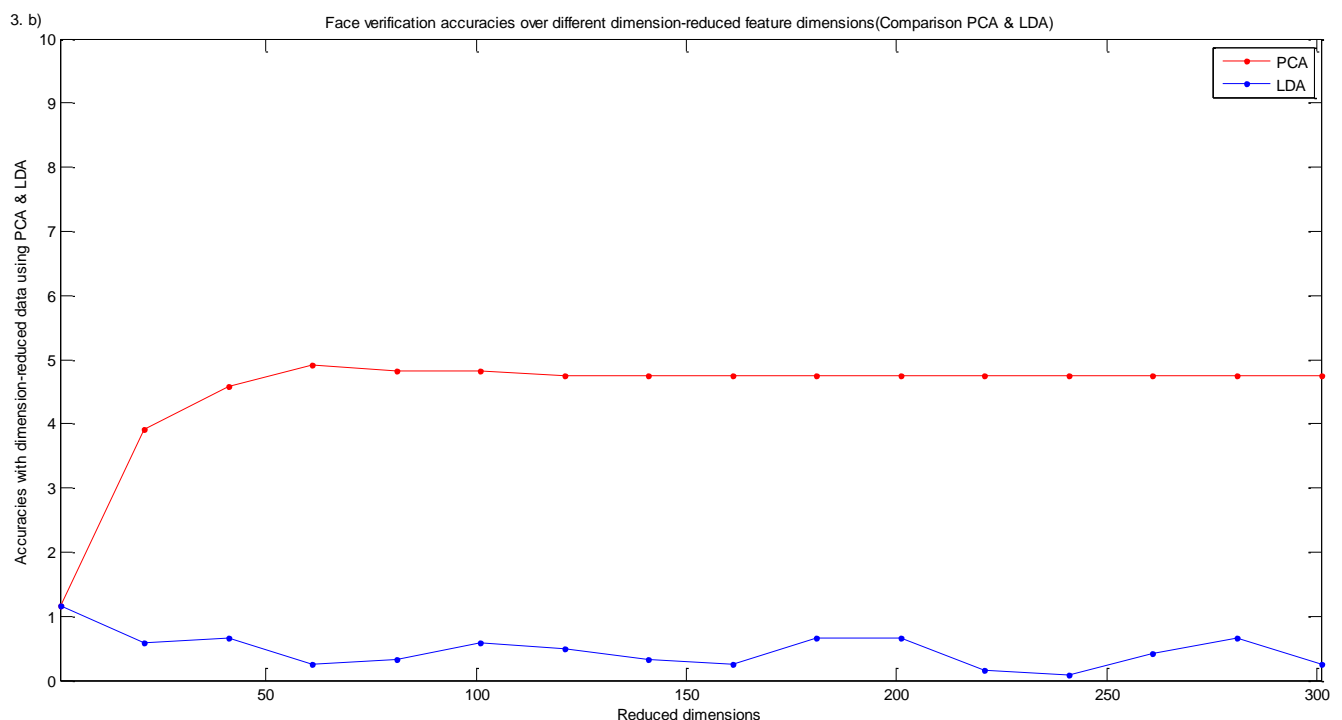
- PCA and LDA accuracies are compared over the different dimensions and plotted as a graph too.

LDA for multiclass was quite challenging to implement. Accuracy turned out to be very poor as there are many classes. Comparison study has been done between PCA and LDA.

### FIRST 10 FISHER FACES:



### FACE RECOGNITION ACCURACY OVER DIFFERENT DIMENSION-REDUCED FEATURES FOR BOTH LDA AND PCA:



Accuracy for PCA is 4.913% and for LDA it is 1.166%. PCA gives slightly better accuracy than LDA because LDA for multiple class is quite uncertain in terms of nearest neighbourhood classification. From the above accuracy over a different dimension reduced feature extraction



through LDA projects that there is a highly significant overlap between the datasets that we wish to operate.

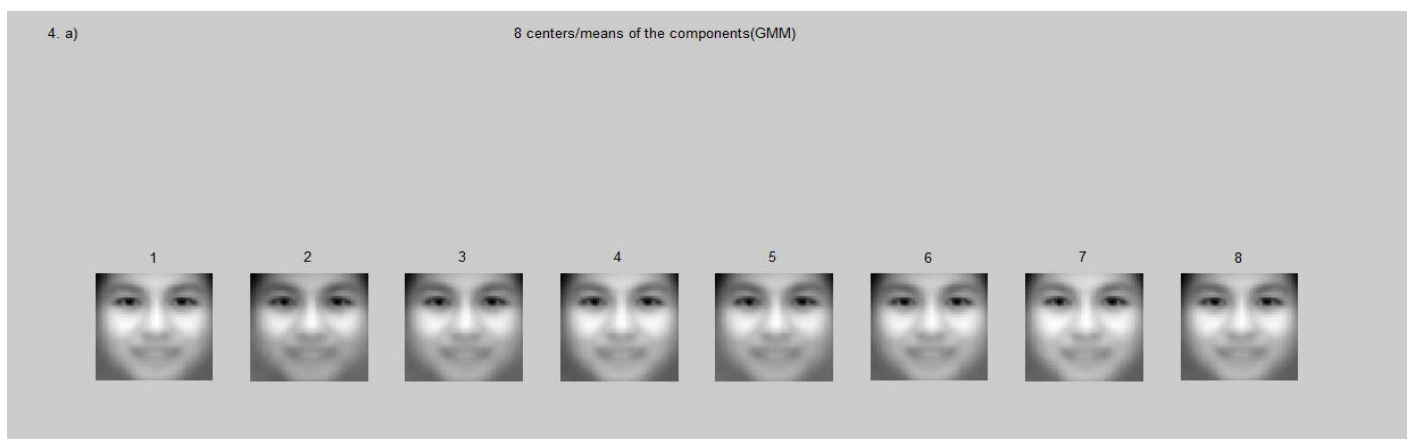
If we use PCA to differentiate the data it projects the data in the direction of maximum variation. Thus it can be seen is a bit hard to define a good classifier due to high degree of overlap.

If we LDA, classification boundary is defined so that there is maximum separation between classes. Because of the large overlap between data of all the classes classification boundary tend to worse than that of PCA.

#### IV. GAUSSIAN MIXTURE MODEL (GMM)

A Gaussian mixture model is a probabilistic model that assumes all the data points are generated from a mixture of a finite number of Gaussian distributions with unknown parameters. One can think of mixture models as generalizing k-means clustering to incorporate information about the covariance structure of the data as well as the centers of the latent Gaussians.

GMM is learned for the whole database with component number set as 8. Mean/centers of the 8 components are shown in the figure. The means are transformed back to original vector from the PCA reduced space. They are reconstructed in 64X64 images.



#### OBSERVATION:

It can be observed that there is not much significant difference between the means of 8 components. This indicates that the data is centered or clustered in a single dense area. Not much variation is present between the images in the PCA reduced-dimension space and hence the 8 centers of components tend to be close to each other.

**Files: mainGMM.m**

- This file contains PCA on input data to reduce data to low dimension space.
- Reduced dimension components are used to calculate the mean and covariance matrices for 8 components. It classifies the input data into 8 classes.
- 

## CONCLUSIONS:

Performing PCA and LDA for feature extraction and classification of the cross age face specifies that grey values does not provide good enough features. Best accuracy for PCA and LDA is

NMF produce different set of bases for different initializations and they are displayed as results.

GMM learning produces 8 mean components which does not have a significant difference because the data does not have a significant variation.

## REFERENCES:

1. Lecture notes: Pattern Recognition (EE5907R)
2. Tao Li, Shengzou et al. "Using Discriminant analysis for multi class classification: An experimental investigation".
3. Hyunsoo Kim, Barry et.al," Multiclass classifiers Based on dimension reduction with generalized LDA".