**North Carolina State University**

**ECE 763 Computer Vision**

**Project Report:**

# Face Image Classification

**Author: Adarsh Puri (200324466)**

**Instructor: Dr. Tianfu Wu**

## Objective:

In face detection, we attempt to infer a discrete label ω ε {0, 1} indicating whether a face is present or not based on observed image data. Through this project I aim to achieve face image classification using Gaussian model, Mixture of Gaussian model, t-distribution, Mixture of t-distribution, and Factor Analysis. For each classification model the results are reported as follows:

1. Visualization of the estimated mean(s) and covariance matrix for face and non-face respectively.
2. Evaluation of the learned model on the testing images using 0.5 as threshold for the posterior by computing the false positive rate, false negative rate and the misclassification rate.
3. Plot of the Receiver Operating Characteristic Curve (ROC Curve) to evaluate the diagnostic ability of the binary classifier

## Data Set Preparation:

The Image Database used for this project is a subset of the Face Detection and Data Set Benchmark (FDDB) http://vis-www.cs.umass.edu/fddb/. The Database consists of RGB images with annotations for the face bounding boxes. I extracted 1000 training images and 100 testing images from the dataset through careful filtering to avoid anomalies such as spectacles. The annotations provided in the form of rectangular coordinates are used for the extraction of the face boundary from the images. The non-face image data set is created using the same extracted images by carefully cropping the background while ensuring no or minimal overlap exists between the annotated face and background section. All the testing and training images are resized to a 20 x 20 dimension. Ensuring the separation between the training face images and testing face images, i.e., no face testing images are from the same person in the training set of face images. The resulting dataset consists of 2000 training and 200 test images. A sampling of the dataset is depicted below. To recognize if a provided image patch contains a face or not face we first concatenate the RGB values to form a 1 x 1200 vector x.

**Sample:**

a) *Sample image from fddb dataset*

*b) Extracted image patch from annotation.*

**RESULTS:**

## Model 1: Single Gaussian Model:

Visualize the estimated mean(s) and covariance matrix for face and non-face:

a) Mean from face data b) Covariance from face data c) Mean from non-face data d) Covariance from non-face data.

**a)**

**b)**

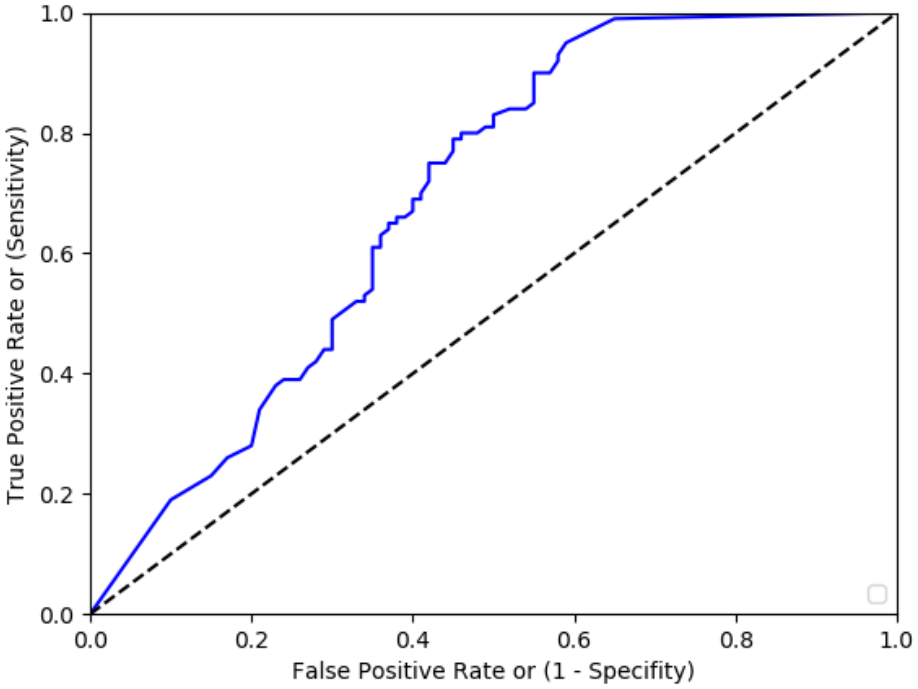
**c)**



**d)**

| Evaluation Criteria | |
|---|---|
| False Positive Rate | 0.47 |
| False Negative Rate | 0.37 |
| Misclassification Rate | 0.35 |

**The blue line is the Gaussian Model ROC curve and the dotted black line is Random Guess curve.**




## Model 2: Mixture of Gaussian Model:

## Visualize the estimated mean(s) and covariance matrix for face and non-face for 3 iterations:

## Iterate 1

a) **Mean from face data b) Covariance from face data c) Mean from non-face data d) Covariance from non-face data**

**a)**

**b)**

**c)**



**d)**

**Iteration 2:**

**a)**

**b)**

**c)**

**d)**

**Iteration 3:**

**a)**

**b)**

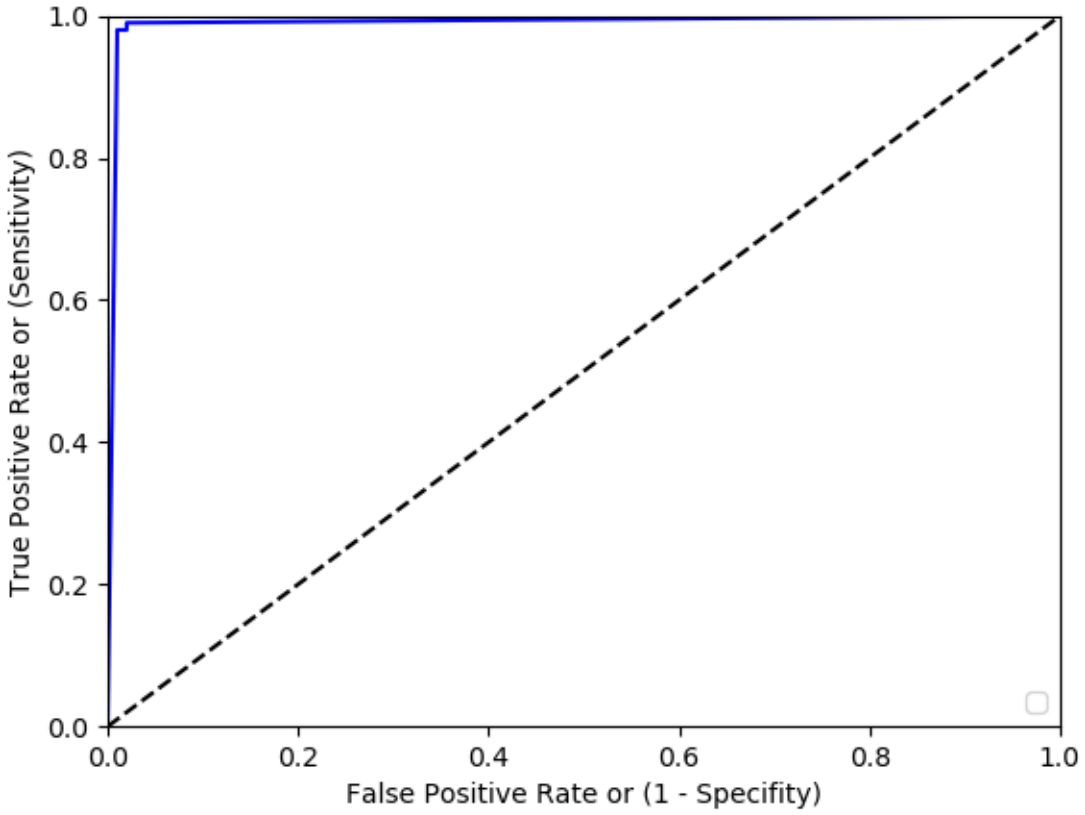
**c)**



**d)**

| Evaluation Criteria | |
|---|---|
| False Positive Rate | 0.25 |
| False Negative Rate | 0.03 |
| Misclassification Rate | 0.02 |

The Blue line is the Mixture of Gaussian Model ROC curve and the dotted black line is Random Guess curve



## Model 3: T - Distribution Model:

**a) Mean from face data b) Covariance from face data c) Mean from non-face data d) Covariance from non-face data**

**a)**

**b)**

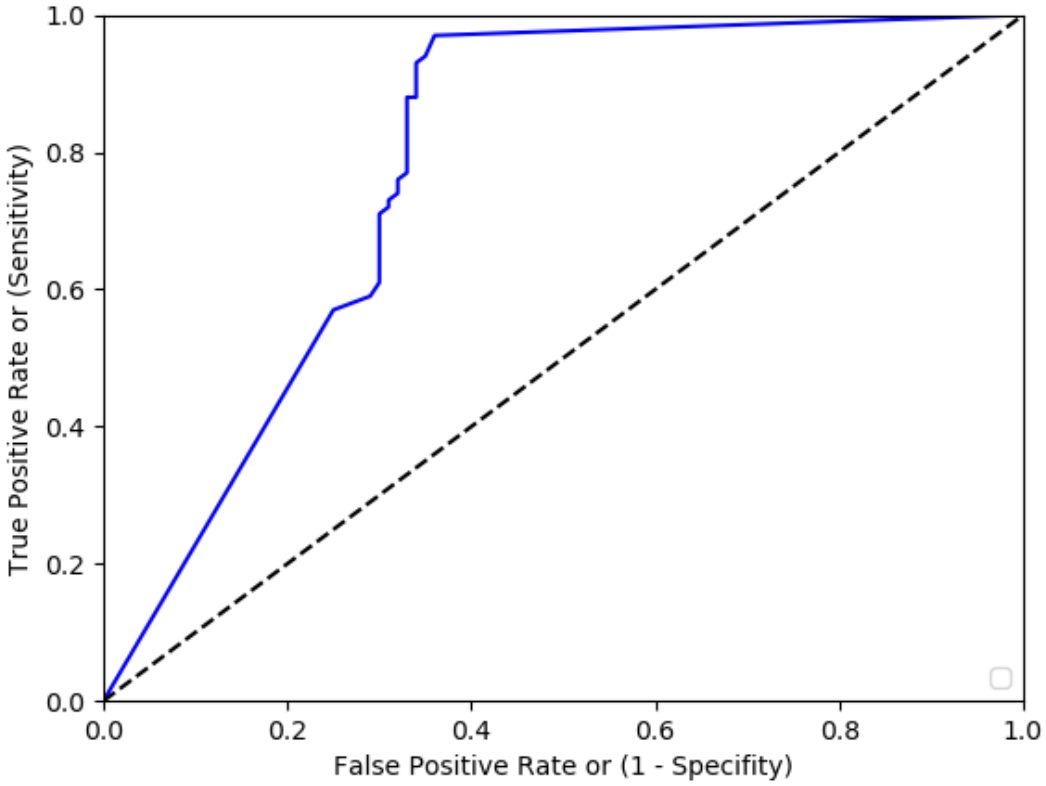
**c)**



**d)**

| Evaluation Criteria | |
|---|---|
| False Positive Rate | 0.70 |
| False Negative Rate | 0.13 |
| Misclassification Rate | 0.23 |

The blue line is the Student T distribution Model ROC curve and the dotted black line is Random Guess curve

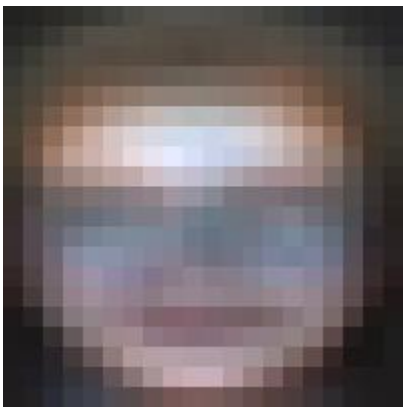



## Model 4: Factor Analysis Model:

**a) Mean from face data b) Covariance from face data c) Mean from non-face data d) Covariance from non-face data**

**a)**

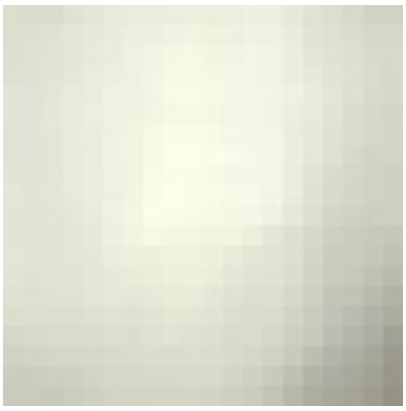
**b)**



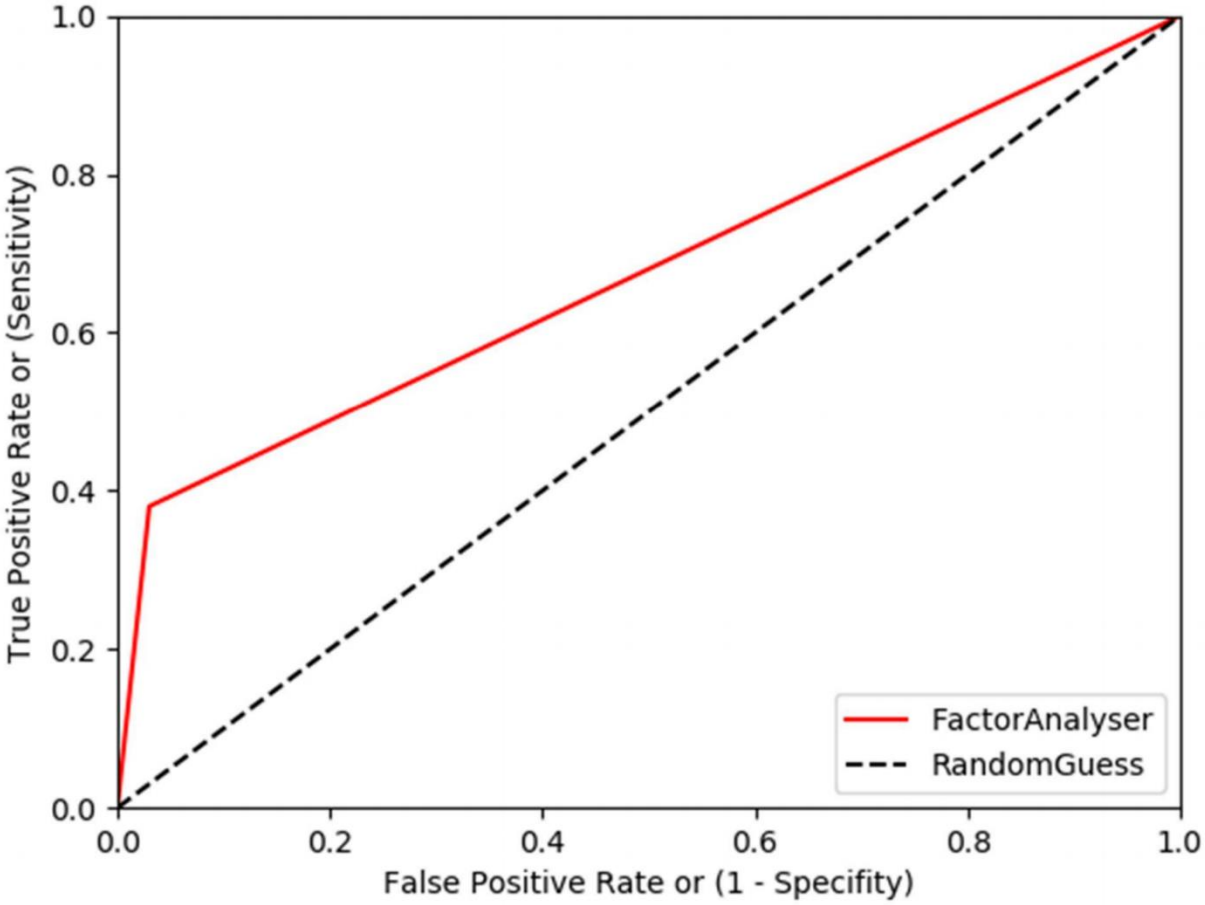
**c)**



**d)**



| **Evaluation Criteria** | |
|---|---|
| False Positive Rate | 0.048 |
| False Negative Rate | 0.45 |
| Misclassification Rate | 0.35 |


1.0
0.8
0.6
0.4
0.2
0.0
True Positive Rate or (Sensitivity)
0.0
0.2
0.4
0.6
0.8
1.0
False Positive Rate or (1 - Specifity)
FactorAnalyser
RandomGuess

**Model 5: Mixture of T - Distribution:**

| Evaluation Criteria | |
|---|---|
| False Positive Rate | 0. |
| False Negative Rate | 0.27 |
| Misclassification Rate | 0.15 |

**Appendix:**

To reproduce the results, run models_main.py (inside /apuri3_code)

in the command prompt with the following arguments.

1. '—inputcheck' to make sure the data is loaded properly

2. '--trainmodel' to reproduce the results of gaussian model

3. '—trainmog' to reproduce the results of Mixture of Gaussian

4. '--trainstud' to reproduce the result of T

5. '--trainfactor' to reproduce the result of Factor Analysis

6. '—trainmixoft' to reproduce the result of mixture of T Note:(for Mixture of T, the roc is not complete but attempt is made in the right direction, results are hard coded)

In addition to basic python libraries the code requires numpy, scipy, Pandas and

OpenCv for execution.

**References:**

1. Vuong Le, Jonathan Brandt, Lubomir Boudev, Zhe Lin, Thomas S. Huang, Interactive Facial Feature Localization, European conference on computer vision ECCV 2012.

2. Cambridge University Press 978-1-107-01179-3 - Computer Vision: Models, Learning, and Inference Simon J. D. Prince.
3. McLachlan, GJ and Peel, D. (2000) Robust mixture modelling using the t distribution. Statistics and Computing, 10 4: 335-344