Project 1 Results

ECE763

I. **Summary:** In this project multiple generative models were built for the purpose of face detection. The dataset was created from the FDDB face dataset.

II. **Data Extraction:** First the data had to be extracted from the FDDB dataset. This dataset provides elliptical facial annotations. First the annotation and image file name text files were concatenated into single files. Then the elliptical annotations were converted into rectangular annotations using the script *convert_annotation.py.* This script created a new text file containing the new rectangular annotations in csv format. The faces were extracted from the images using the *extract_images.py* script. This script creates both face and non-face images by using the annotations to create new images of the faces as well as select regions outside of the annotation as background (non-face) images. The dataset was then split into 1000 training and 100 testing images of each face and non-face class. These images were manually selected out of the extracted images to obtain clean images and ensure no faces are repeated or found both in training and testing sets. The images were preprocessed by converting to 1 channel grayscale and max-normalized between 0 and 1. The images were also resized to 60x60 images using cv2.INTER_AREA scaling.

III. **Utility Functions:** The *utils.py* script contains the utility function shared across all models including for loading the images and plotting the ROC curves.

IV. **Model Visualizations:** The following sections contain the images to visualize the means and covariances generated using the various models. The ROC curves are also shown.

a. **Gaussian Model:** *gaussian_model.py*

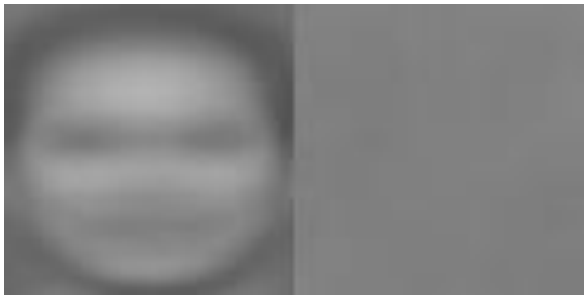

Figure 1: The means of the (left): face and (right): non-face data

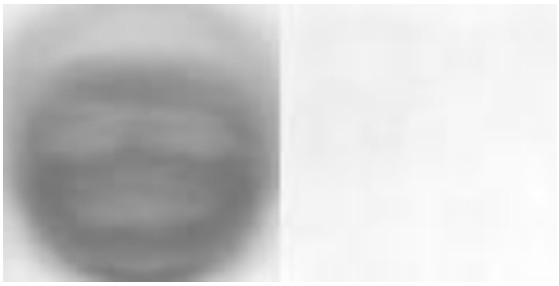

Figure 2: The square root of the diagonal covariance for face and non-face data scaled from 0 to 255.

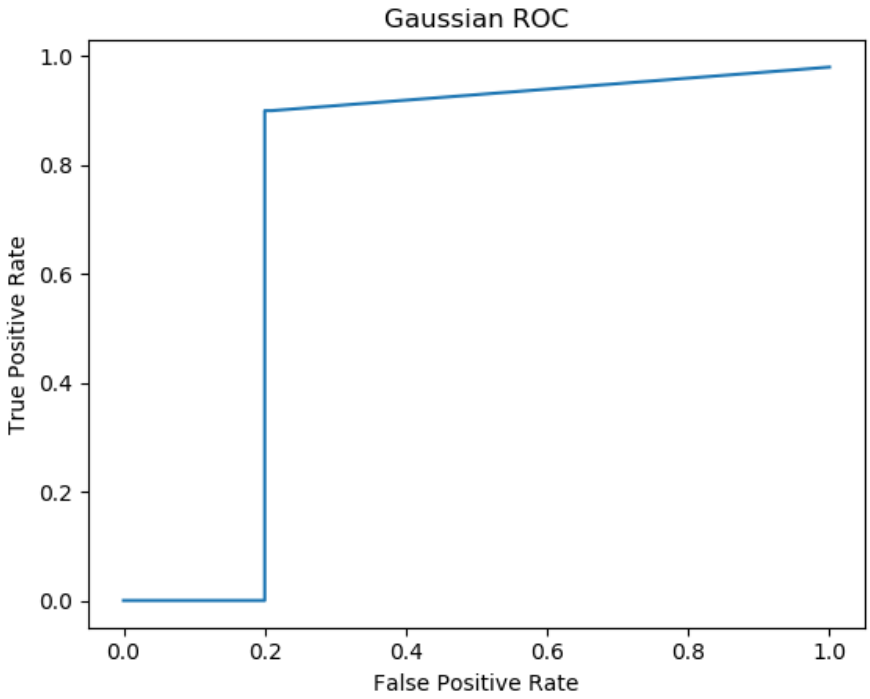

Figure 3: ROC for the Gaussian Model.

b. Mixture of Gaussians: The mixture of Gaussians model uses K = 5 Gaussian components which was found using simple line search to minimize the misclassification rate.

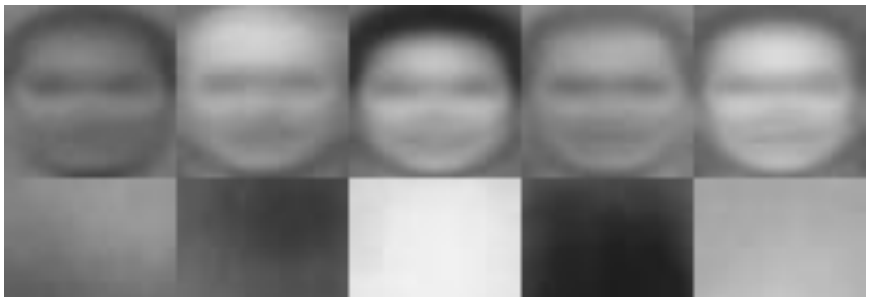

Figure 4: Top: Means of the k face components. Bottom: means of the k non-face components.

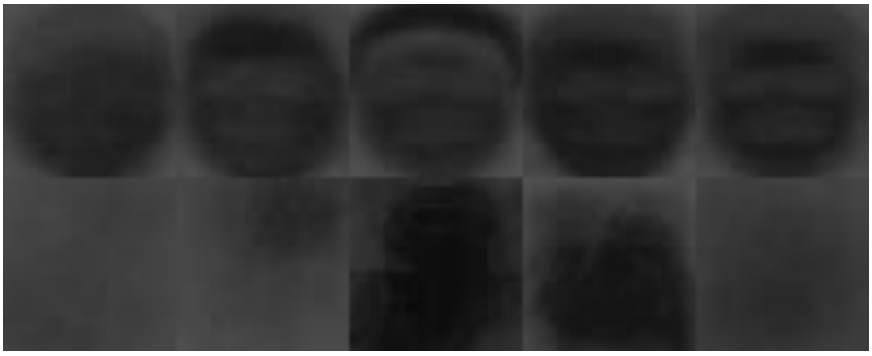

Figure 5: Sqrt diagonal covariance of the gaussian components for face and non face in top and bottom respectively.

It can clearly be seen in the images above that the gaussian components seems to be separating the faces based on skin intensity, hair color, and possibly some facial shape. The non-face images are clustered by intensity.

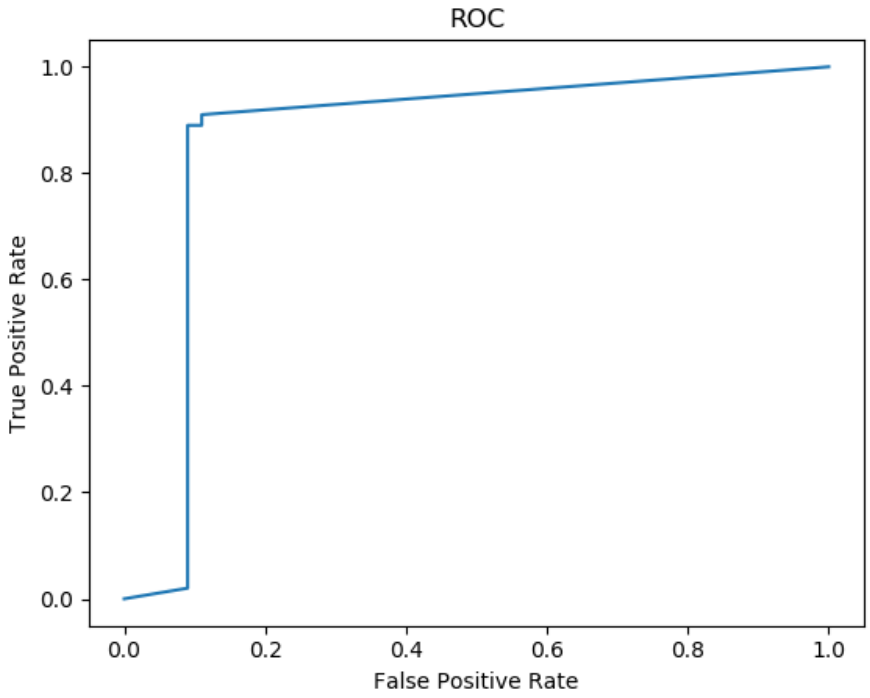

Figure 6: ROC for Mixture of Gaussians Model K=5

c. Student t-distribution: The student t-distribution is implemented in *t_model.py.* The means and covariances for the classes are visualized below.

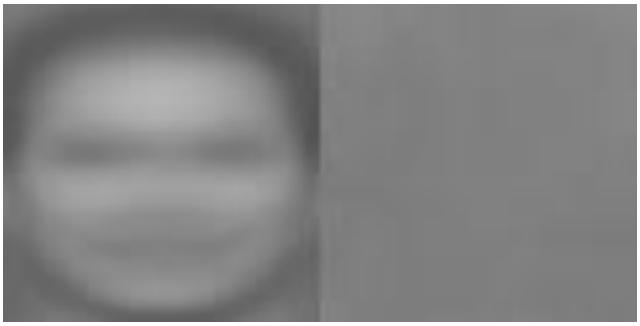

Figure 7: Student t-distribution means for face and non-face.

Figure 8: Student t-dist. covariance images for face and non-face.

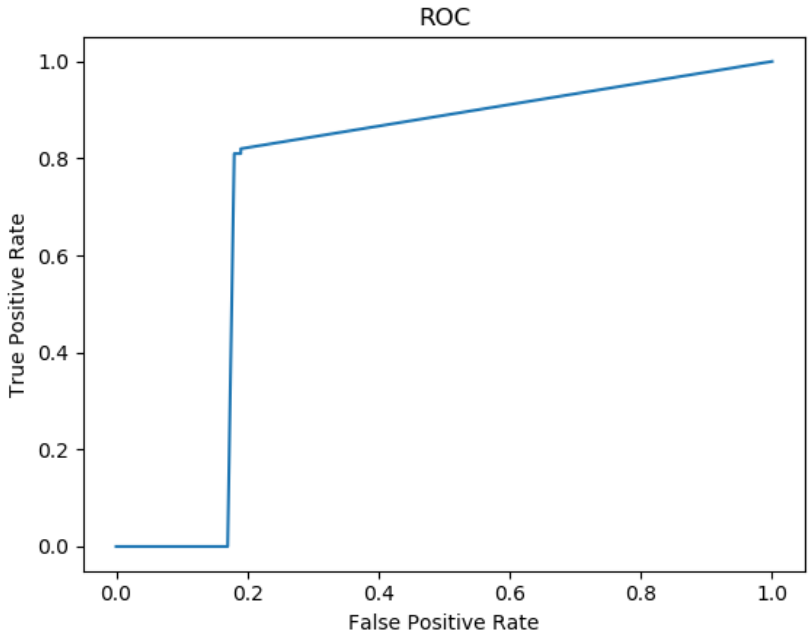

Figure 9: ROC for Student t model.

d. Factor Analyzer: The factor analyzer is implemented in the *factor_analyzer.py* script. The resulting visualizations can be seen below. First the total mean and covariance matrices are shown, followed by the visualization of each individual factor and how it affects the mean. Here, the number of factors was chosen as 5 from a line search between 2 and 5. Due to time constraints and the computational load of this model, the images were resized to 40x40 pixels and full hyperparameter tuning was not feasible (the first choice of 5 factors gave perfect score so further tuning was not necessary). Figure 9 shows the effect of adding each factor to the mean vector. The factors are extracting features such as skin shade, face orientation, and hair color.

Figure 10: The mean of the face and non-face models visualized without factors added.

Figure 11: The covariance of the face and non-face factor models.

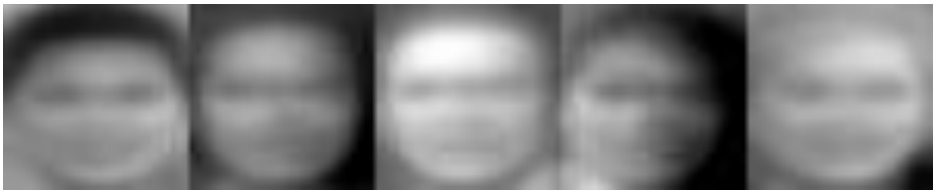

Figure 12: The effect of the factors visualized. The five images represent the mean with each factor added or $\mu+2\varphi_k$

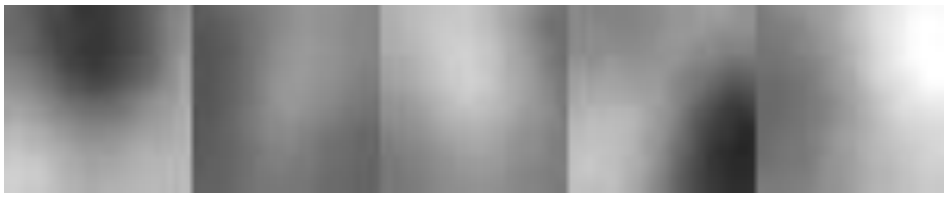

Figure 13: The effect of adding the non-face factors to the non-face mean as in figure 12.

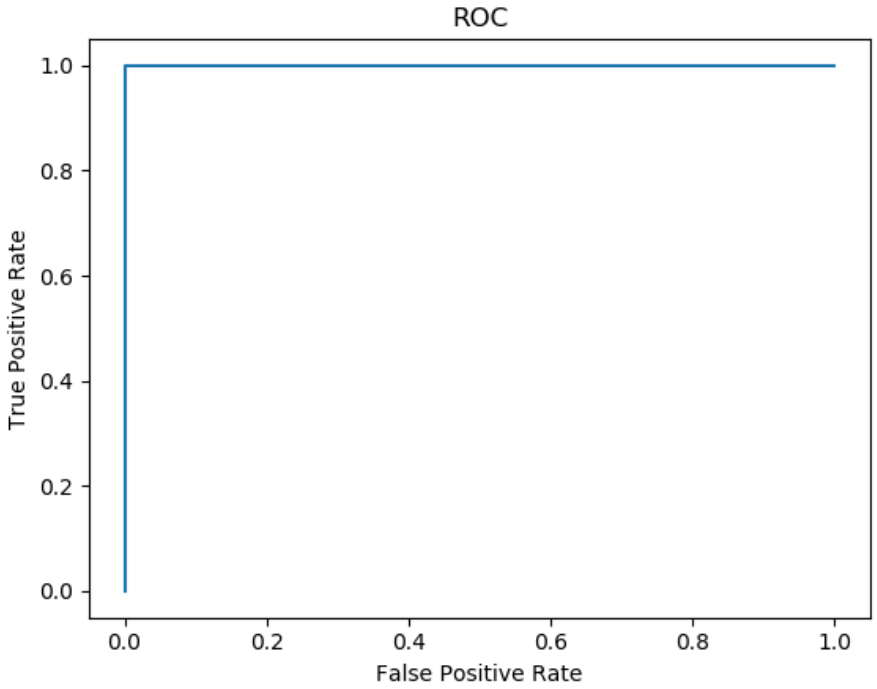

Figure 14: ROC for the FA model. 5 factors

V. Final Testing Results: Table 1 below shows the results for all the models for a threshold of 0.5. The table lists false positive rate, false negative rate, and total misclassification rate. Clearly, the factor analyzer was the superior model.

Model	False Positive Rate (%)	False Negative Rate (%)	Misclassification Rate (%)
Gaussian	20%	10%	15%
MoG	11%	11%	11%
Student t	19%	19%	19%
Factor Analyzer	0%	0%	0%