ECE763 - Computer Vision - Project 1

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PROBLEM RESTATEMENT

Classify the images in the test data set as faces/ non-faces based on the learned models which are learned using the training data. The models used are - Simple Gaussian model, Mixture of Gaussians, t-distribution, Factor Analyzer. The following metrics and visualizations are reported for each model.

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 the threshold for the posterior by computing the false positive rate, false negative rate, and the misclassification rate.
3) Plotting the ROC curve where x-axis is the false positive rate and y-axis is the true positive rate.

DATA SET PREPARATION

The Widerface dataset was used - WIDER FACE: A Face Detection Benchmark Multimedia Laboratory, Department of Information Engineering, The Chinese University of Hong Kong

- The data was annotated with the bounding box data provided in a text file. The file was parsed and the images having 1 face were used to crop the face and non-face data from them.
- 1000 training images and 100 test images were read for face and non-face data respectively. The non-face images were cropped from the face images using the intersection over union criterion by keeping a low permissible IoU score of around 0.3-0.4.
- The images were then resized to 10x10 image size to reduce the dimensionality and then dumped using pickle so that they can be loaded quickly to run the algorithm anytime after the first execution of the code.
- Another dataset from CBCL was tested and the images were stored in different pickle dumps as well.

RESULTS

A. Single Gaussian model

The simpleGaussian.py file can be used to test out the model. The data can be read from the pickle dumps. This is the most basic model where the entire training data is fitted on a single Multivariate Gaussian Function.
The mean and the covariance learned from this fitting is then used to characterize the model.
In our case we prepared two Gaussians for the face and non-face data based on the face and non-face training examples. (1000 each) and then used the models to test unknown test-data.
As the covariance matrix has a large number of parameters D(D+1)/2, we use the diagonal form of the covariance matrix by setting the rest of the elements to zero to avoid any matrix singularity errors. (The covariance matrix, if singular leads to an infinite likelihood value)
On evaluating the learned model on a 0.5 threshold we got the following results.

Evaluation Criterion	Value
False Positive Rate	0.45
False Negative Rate	0.48
Misclassification Rate	0.465

TABLE I

The visualizations for the mean and covariance for the face and non-face data is as follows.

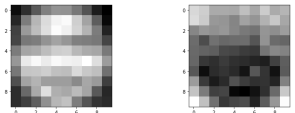

Fig. 1: Mean and Covariance for Face Data

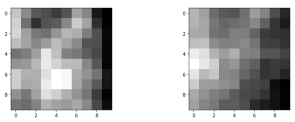

Fig. 2: Mean and Covariance for Non Face Data

The ROC curve for the Gaussian model is as below. It shows the ability of the model to distinguish between the two classes. It's a plot between the false positives and true positives at different thresholds.

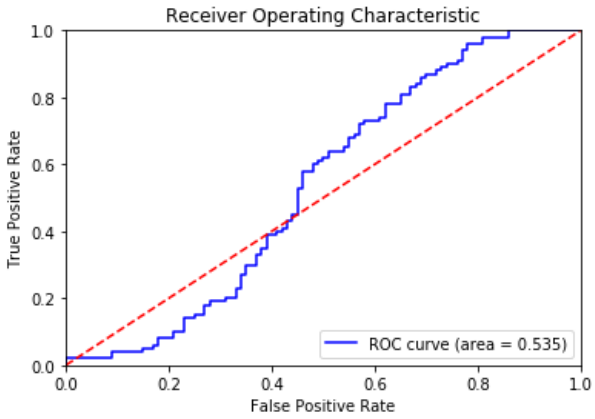

Fig. 3: RoC Curve - Simple Gaussian

B. Mixture of Gaussians model

For the Mixture model, I chose to give 10x10 images as the input as well. K = 3 was chosen to model both the facec and non-face data. The weights and the mean and covariance are updated with the EM algorithm ('learning' from the training data).
On evaluating the learned model on a 0.5 threshold we got the following results.

Evaluation Criterion	**Value**
False Positive Rate	0.24
False Negative Rate	0.68
Misclassification Rate	0.46

TABLE II

The visualizations for the mean and covariance for the face and non-face data is as follows. I have visualized the mean and covariance for all the weights in the Gaussian which are shown as below.

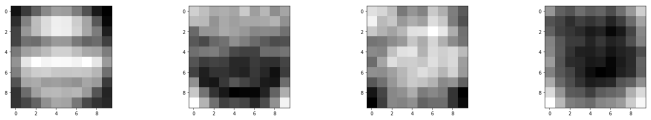

Fig. 4: Mean and Covariance for Face and Non Face Data - Weight - 0.294(Face) and 0.268(Non Face)

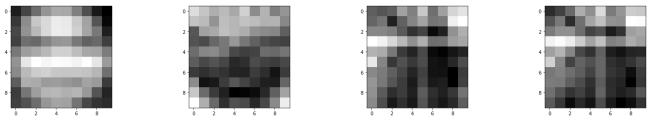

Fig. 5: Mean and Covariance for Face and Non Face Data - Weight - 0.232(Face) and 0.216(Non Face)

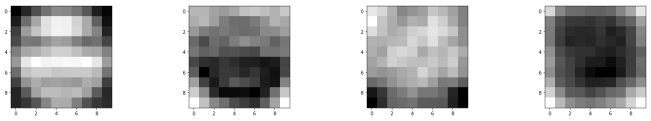

Fig. 6: Mean and Covariance for Face and Non Face Data - Weight - 0.473(Face) and 0.515(Non Face)

The ROC curve for the Mixture Gaussian model is as below. We can see it is a slight improvement over Simple Gaussian model.

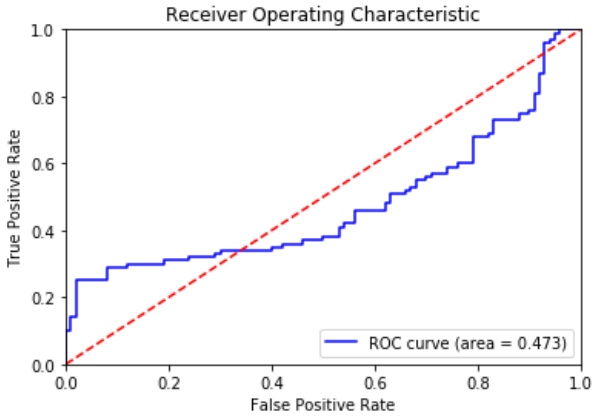

Fig. 7: RoC Curve - Mixture of Gaussian

C. t-Distribution model

The t-Distribution is an improvement as it is more robust to outliers. On evaluating the learned model on a 0.5 threshold we got the following results.

Evaluation Criterion	**Value**
False Positive Rate	0.22
False Negative Rate	0.85
Misclassification Rate	0.465

TABLE III

The visualizations for the mean and covariance for the face and non-face data is as follows.

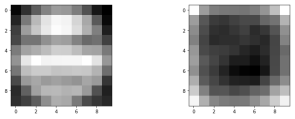

Fig. 8: Mean and Covariance for Face Data

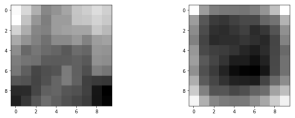

Fig. 9: Mean and Covariance for Non Face Data

The ROC curve for the Gaussian model is as below. It shows the ability of the model to distinguish between the two classes. It's a plot between the false positives and true positives at different thresholds.

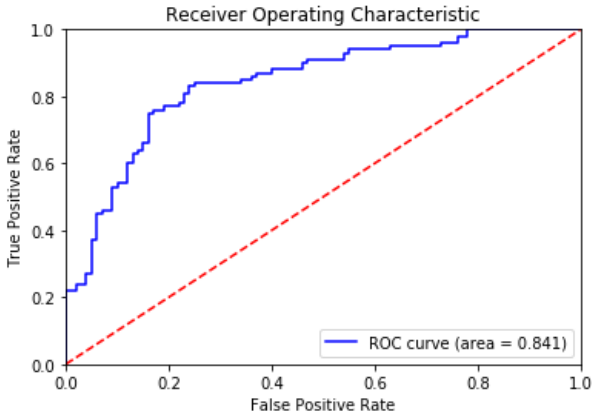

Fig. 10: RoC Curve - t-Distribution

D. Factor Analyzer model

On evaluating the learned model on a 0.5 threshold we got the following results.

Evaluation Criterion	Value
False Positive Rate	0.7
False Negative Rate	0.09
Misclassification Rate	0.395

TABLE IV

The visualizations for the mean and covariance for the face and non-face data is as follows.

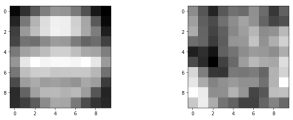

Fig. 11: Mean and Covariance for Face Data

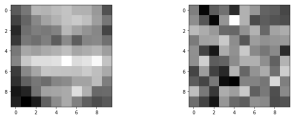

Fig. 12: Mean and Covariance for Non Face Data

The ROC curve for the Gaussian model is as below. It shows the ability of the model to distinguish between the two classes. It's a plot between the false positives and true positives at different thresholds.

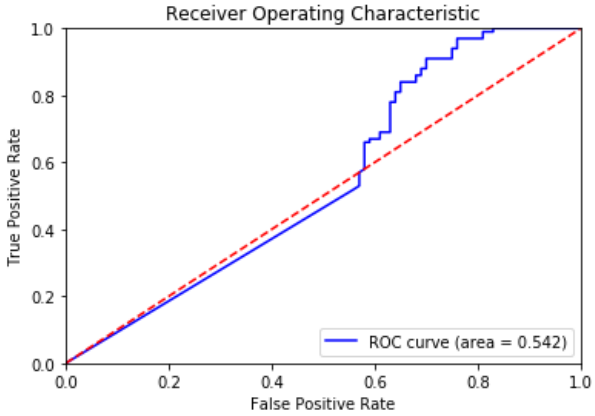

Fig. 13: RoC Curve - Factor Analyzer