ECE763 Project 01-Face Detection

Department of civil engineering

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-Dataset:

I use the FDDB.Face Detection and Data Set Benchmark. 5k images dataset.

-Data processing stage:

First of all, we download the dataset and then divide them into 1000 training images for face and non-face separately, 100 test images for face and non-face separately. Since the downloaded dataset contains label for each images, so it is easy for us to manipulate data. The same index image for face and non-face came from the same original image.

Each face image will be cut into 60*60, RGB, with face in the center, and for non-face image, we just cut it randomly. The exampled images are shown below:

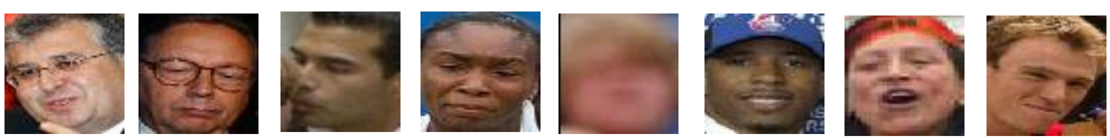


Figure 1. Face images

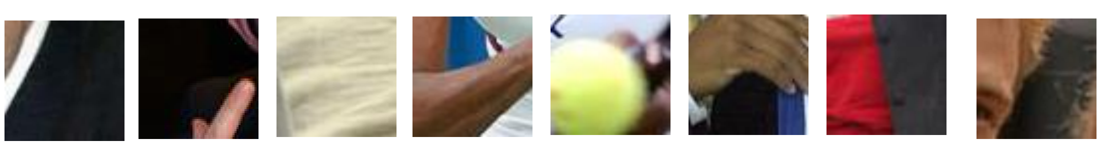


Figure 2. Non-face images

-Mode1: Learn single Gaussian model using training images and report your results

Each training image could be transferred to a single array with 60*60*3 =10800 values, totally we have 1000 face images and 1000 non-face images, so it is easily for us to get a 1000*10800 matrix for face and non-face independently.

$$p(x|w=0) = Norm_x[\mu_0, \sigma_0^2], \qquad p(x|w=1) = Norm_x[\mu_1, \sigma_1^2]$$

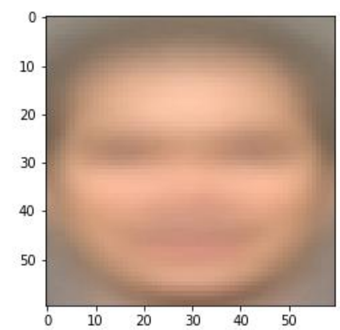
Second step, we calculate the mean over the 1000 training samples, so we could get an array of 1*10800 which represent the average value of 1000 training samples. Similarly for variance. Test data will be setting as a 200*10800 matrix. We use the 200 dataset to fit for our training mean and variance, the results are shown below:

TP= 83 FN= 17 FP= 27 TN= 73

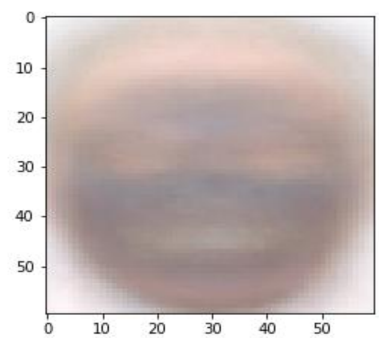
false positive rate: 0.27

false negative rate: 0.17

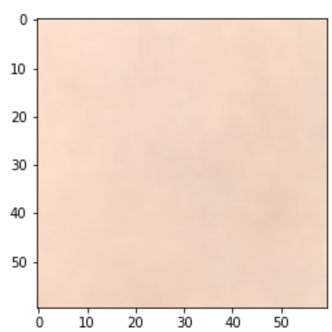
misclassification rate: 0.22



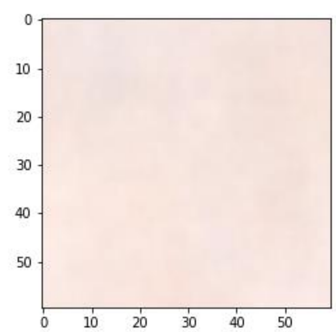
(a).mean_face



(b).sigma_face



(c).mean_nonface



(d).sigma_nonface

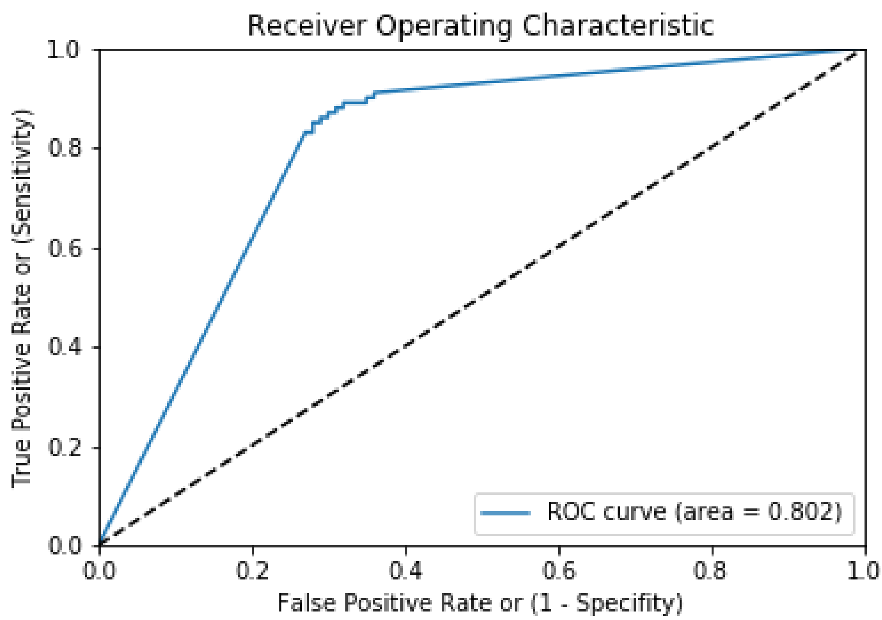


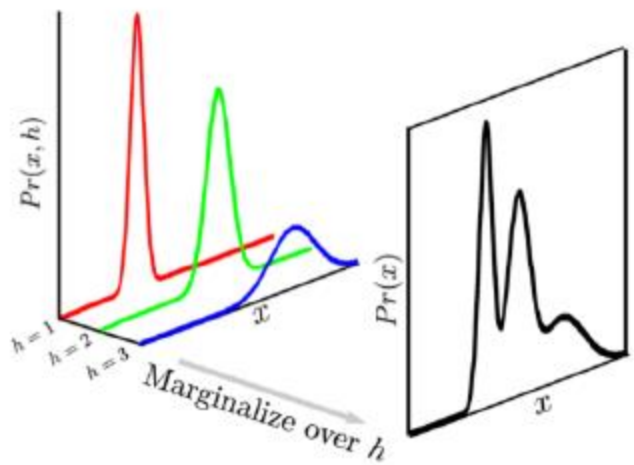
Figure 3. ROC for Single-Gaussian

-Model2:Learn Mixture of Gaussian model using training images and report your results

The setting of training and test data will be the same as stated above, but this model the likehood function is defined as:

$$p(x|w) = \alpha \, Norm_x\left[\mu_{w,1}, \Sigma_{w,1}^2\right] + (1 - \alpha) \, Norm_x[\mu_{w,2}, \Sigma_{w,2}^2]$$

The mix-Gaussian is actually composed of different of normal distribution with different mean and variance for one model, which will be look like as follows:



With different mean and variance, and with log function, the real likelihood function is

$$\log \mathcal{N}(\boldsymbol{x} \mid \boldsymbol{\mu}, \boldsymbol{\Sigma}) = -\frac{D}{2}\log(2\pi) - \frac{1}{2}\log\det(\boldsymbol{\Sigma}) - \frac{1}{2}(\boldsymbol{x}-\boldsymbol{\mu})^\top \boldsymbol{\Sigma}^{-1}(\boldsymbol{x}-\boldsymbol{\mu}). \quad (11.11)$$

Since it is hard to find the closed form for optimal unknown parameters, we are using EM algorithm to find out the optimal mean and covariance. We could assume face distribution and non-face distribution contain different hidden variables, and then we are trying to tune the model. The results are show below:

TP= 97 FN= 3 FP= 42 TN= 58

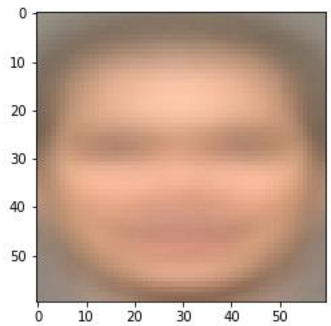
false positive rate: 0.42

false negative rate: 0.03

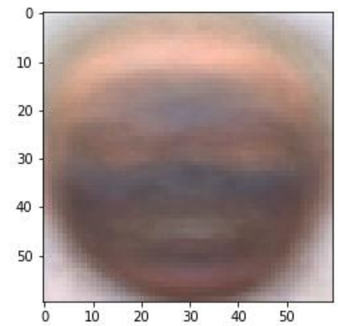
misclassification rate: 0.225

Important to find out that: for non-face distribution, it only has two hidden variables, even we are trying to assume it has 3 or 4 hidden variables, the final results will tell that there are only two hidden parameters will not be zero, others will be close to zero.

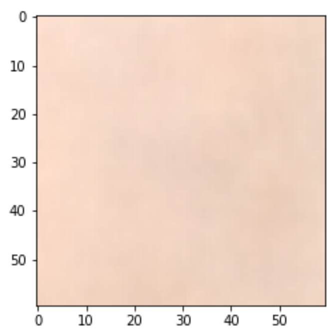
So our results assume that the model is composed of two hidden variables.



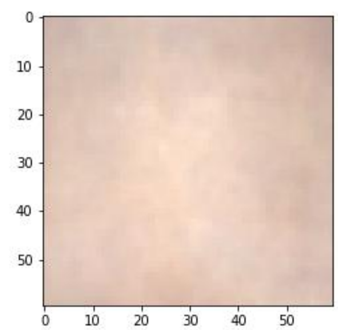
(a).mean_mix_face



(b).sigma_mix_face



(c).mean_mix_nonface



(d).sigma_mix_nonface

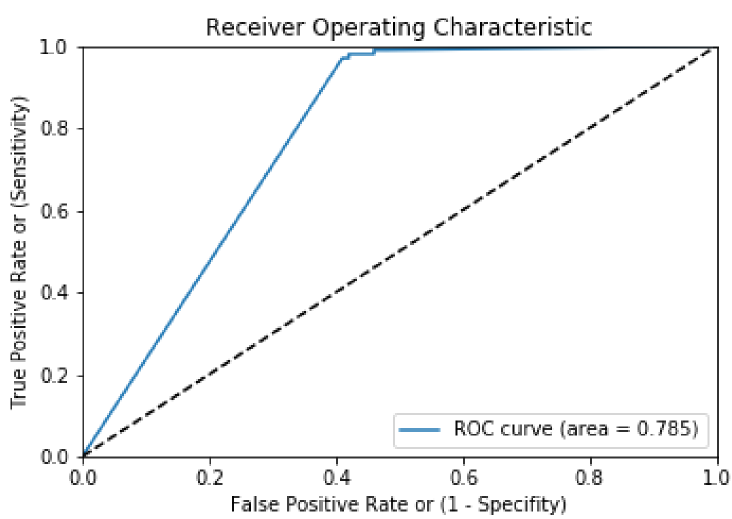
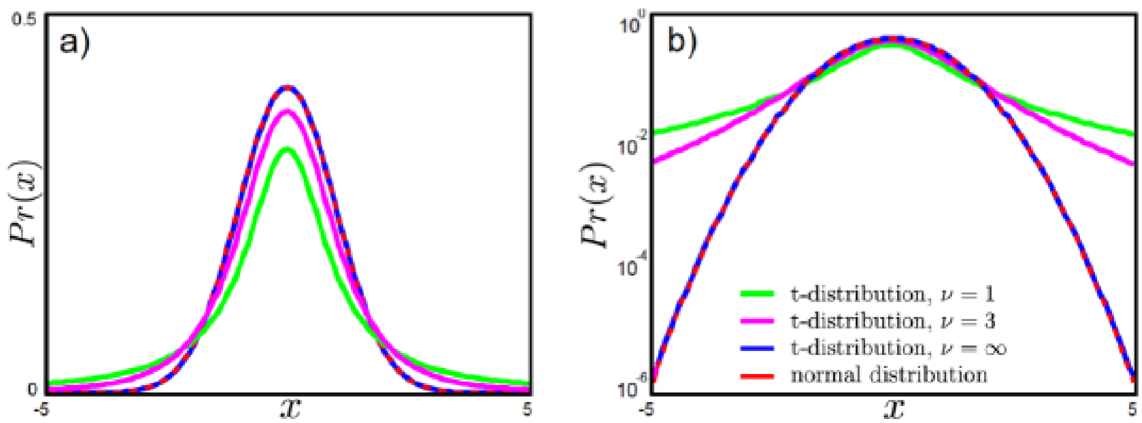


Figure 3. ROC for Mixture-Gaussian

-Model3: Learn t-distribution model using training images and report your results

As well as the mean mu and scaling parameter sigma, the t-distribution has a parameter v which is termed the degrees of freedom. As v decreases, the tails of the distribution become longer and the model becomes more robust. The t-distribution has the following probability densify function and the shapes:

$$\begin{aligned} Pr(\mathbf{x}) &= \text{Stud}_{\mathbf{x}}\left[\boldsymbol{\mu}, \boldsymbol{\Sigma}, \nu\right] \\ &= \frac{\Gamma\left[\frac{\nu+D}{2}\right]}{(\nu\pi)^{D/2}|\boldsymbol{\Sigma}|^{1/2}\Gamma\left[\frac{\nu}{2}\right]}\left(1+\frac{(\mathbf{x}-\boldsymbol{\mu})^T\boldsymbol{\Sigma}^{-1}(\mathbf{x}-\boldsymbol{\mu})}{\nu}\right)^{-\frac{\nu+D}{2}}, \quad (7.21) \end{aligned}$$



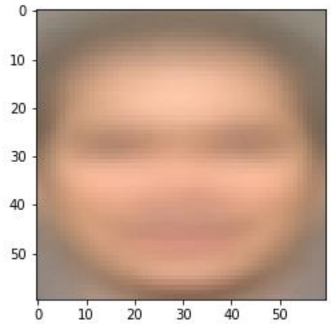
There is no closed form solution for the degrees of freedom &. We hence perform a one-dimensional line search to maximize the objective function with the updated mean and covariance. The optimal result for v is **10** for my model.

TP= 83 FN= 17 FP= 32 TN= 68

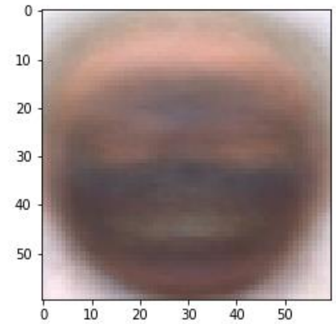
false positive rate: 0.32

false negative rate: 0.17

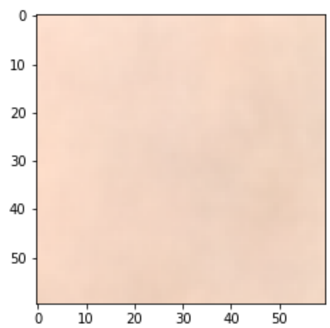
misclassification rate: 0.245



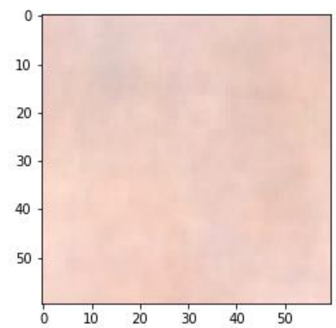
(a).mean_t_face



(b).sigma_t_face



(c).mean_t_nonface



(d).sigma_t_nonface

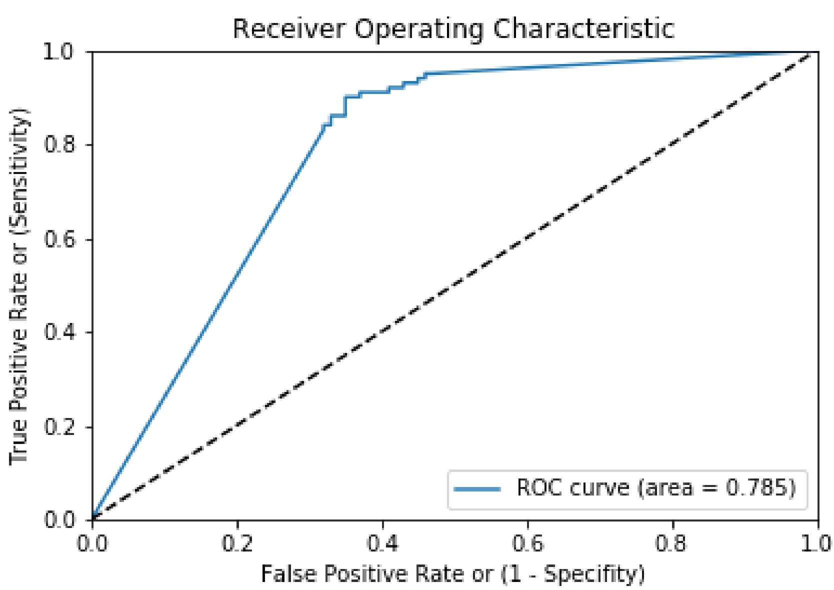


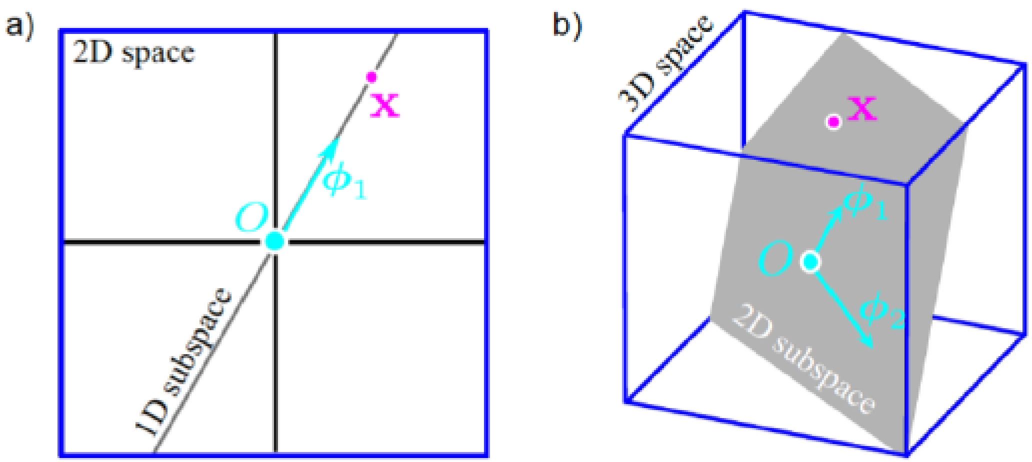
Figure 4. ROC for t-distribution

-Model4: Learn factor analyzer using training images and report your results as stated above. You can tune the dimensionality of the subspace.

Factor analysis: the intuition is to model part of the high-dimensional space with a full model and mops up remaining variation with a diagonal model. Thus, provides a compromise in which the covariance matrix is structured so that it contains fewer unknown parameters than the full matrix but more than the diagonal form.

$$\log[Pr(\mathbf{x}_i|\mathbf{h}_i)] = -\frac{D\log(2\pi) + \log|\boldsymbol{\Sigma}| + (\mathbf{x}_i - \boldsymbol{\mu} - \boldsymbol{\Phi}\mathbf{h}_i)^T\boldsymbol{\Sigma}^{-1}(\mathbf{x}_i - \boldsymbol{\mu} - \boldsymbol{\Phi}\mathbf{h}_i)}{2}$$

It describes a linear subspace with a full covariance model.

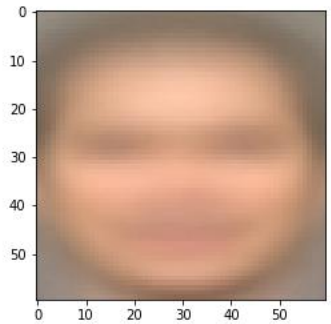


TP= 80 FN= 20 FP= 24 TN= 76

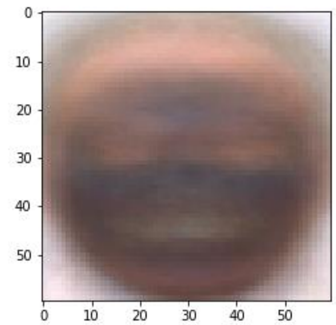
false positive rate: 0.24

false negative rate: 0.2

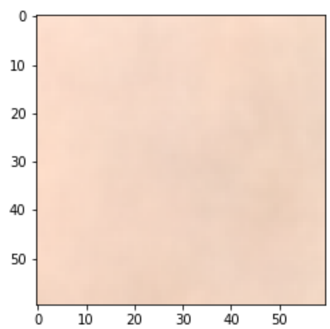
misclassification rate: 0.22



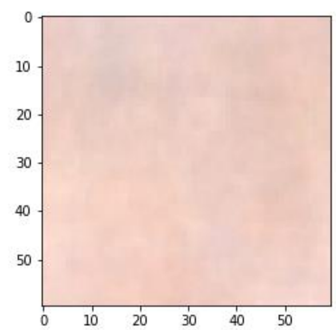
(a). mean_factor analysis_face



(b).sigma_factor analysis_face



(c).mean_factor analysis_nonface



(d).sigma_factor analysis_nonface

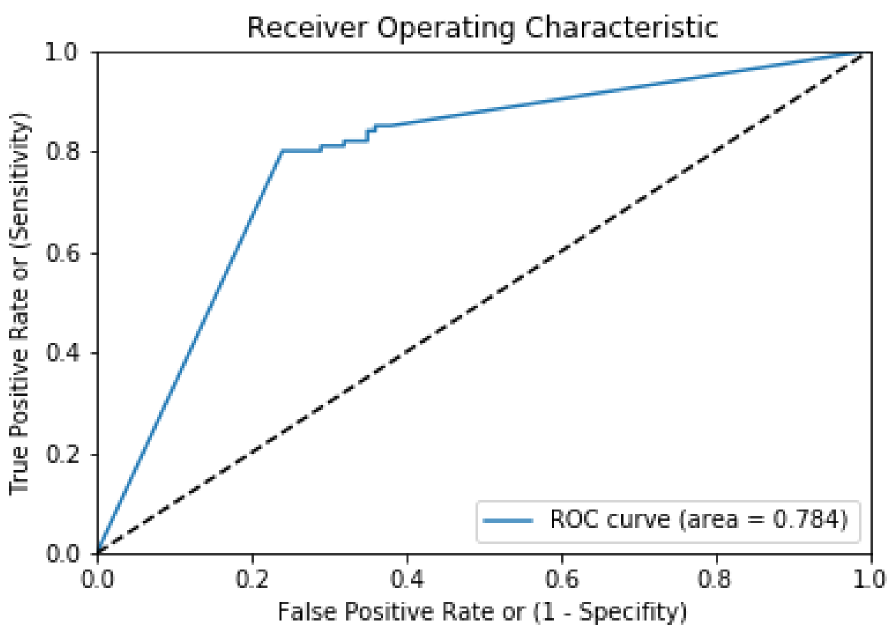


Figure 5. ROC for t-distribution

-Model5: Learn Mixture of t-distribution model using training images and report your results

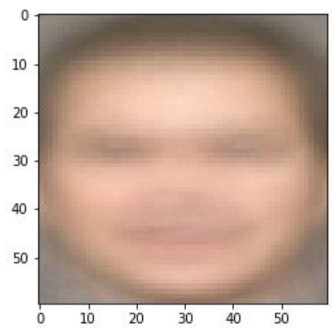
Using mixture of t distributions, actually adding hidden variables that assuming there are different combination of t distribution, each weighted t distribution with the same mean and different variance. We tune the parameters, and finding that with **8** hidden parameters will return the best results.

TP= 89 FN= 11 FP= 13 TN= 87

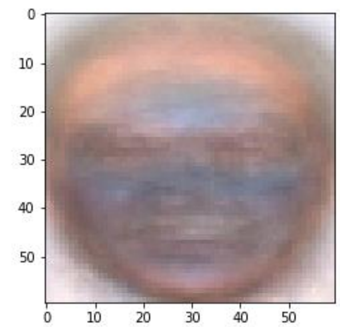
false positive rate: 0.13

false negative rate: 0.11

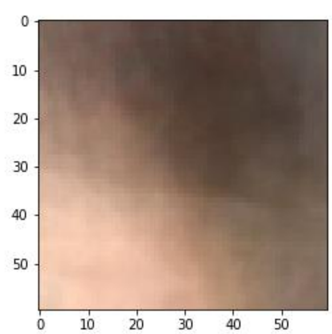
misclassification rate: 0.12



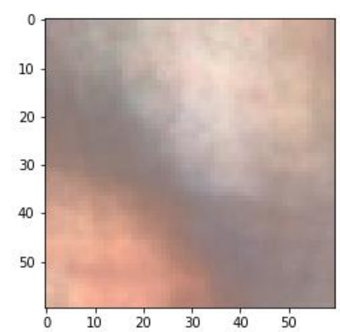
(a). mean_mix-t _face



(b).sigma_mix-t _face



(c). mean_mix-t _nonface



(d).sigma_mix-t _nonface

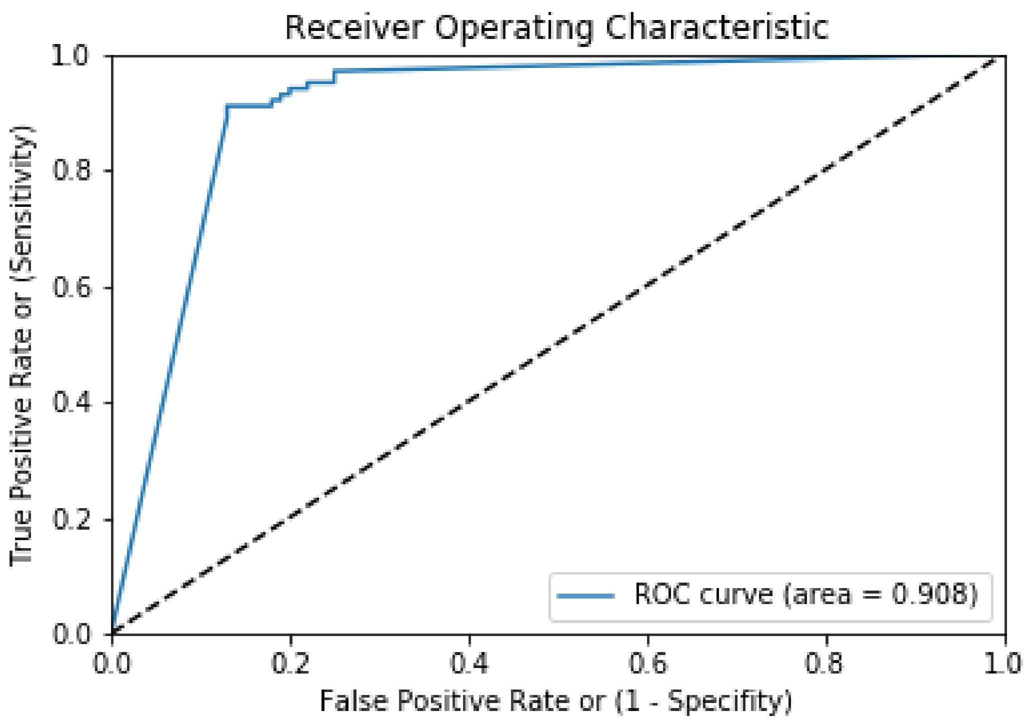


Figure 5. ROC for mix-t distribution