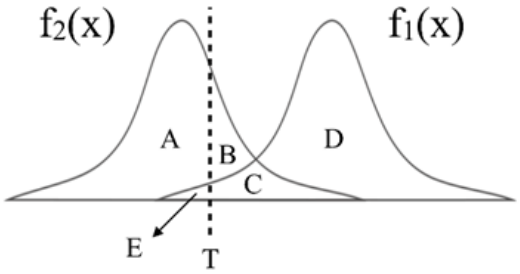
# Computer Vision HW2 Report

B04901147 電機四 黃健祐

**Problem 1**

Assume $X$ is a continuous random variable that denotes the estimated probability of a binary classifier. The instance is classified as positive if $X > T$ and negative otherwise. When the instance is positive, $X$ follows a PDF $f_1(x)$. When the instance is negative, $X$ follows a PDF $f_2(x)$. Please specify which regions (A ~ E) represent the cases of *False Positive* and *False Negative*, respectively. Clearly explain why.



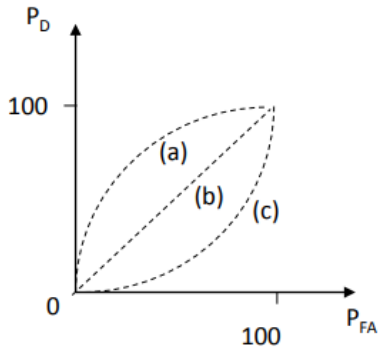

False Positive: B and C.

They are classified to be negative while they are in fact positive.

False Negative: E

It is classified to be positive while it is in fact negative.

There are three ROC curves in the plot below. Please specify which ROC curves are considered to have reasonable discriminating ability, and which are not. Also, please answer that under what circumstances will the ROC curve fall on curve (b)?




(a) and (b) have reasonable discriminating ability as their $P_D$ are always greater than or equal to $P_{FA}$ while (c) does not.

When two classes follow identical distribution, the ROC curve falls on (b).

## Problem 2

### PCA

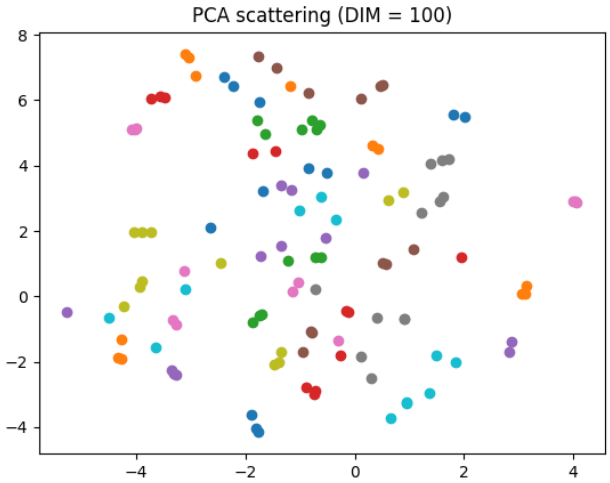
Perform PCA on the training data. Plot the mean face and the first five eigenfaces and show them in the report.

| mean face | eigenface 1 | eigenface 2 | eigenface 3 | eigenface 4 | eigenface 5 |
|---|---|---|---|---|---|
|  |  |  |  |  |  |

Take $\boldsymbol{person_8\_image_6}$, and project it onto the above PCA eigenspace. Reconstruct this image using the first n = { 5, 50, 150, all } eigenfaces. For each n, compute the mean square error (MSE) between the reconstructed face image and the original $\boldsymbol{person_8\_image_6}$. Plot reconstructed images with the corresponding MSE values in the report.

| n | 5 | 50 | 150 | 279 |
|---|---|---|---|---|
| images |  |  |  |  |
| MSE | 694.02 | 119.45 | 38.78 | 0 |

Reduce the dimension of the image in testing set to dim = 100. Use t-SNE to visualize the distribution of test images.

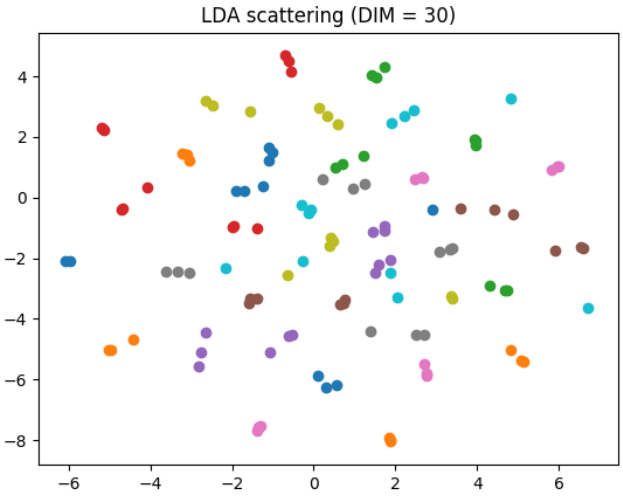


**LDA**

Implement LDA and plot first 5 Fisherfaces.

| Fisherface 1 | Fisherface 2 | Fisherface 3 | Fisherface 4 | Fisherface 5 |
|---|---|---|---|---|
|  |  |  |  |  |

Use t-SNE to visualize the distribution of the projected testing data, which has the dimension of 30.




**KNN**

**Validation Accuracy of PCA**

| k \ n | 3 | 10 | 39 |
|---|---|---|---|
| 1 | 0.736 | 0.946 | 0.950 |
| 3 | 0.618 | 0.814 | 0.857 |
| 5 | 0.589 | 0.732 | 0.818 |

**Validation Accuracy of LDA**

| k \ n | 3 | 10 | 39 |
|---|---|---|---|
| 1 | 0.425 | 0.850 | 0.933 |
| 3 | 0.442 | 0.800 | 0.879 |
| 5 | 0.425 | 0.771 | 0.854 |

According to the validation accuracy above, $(k, n) = (1,39)$ is selected to evaluate accuracy on testing set. The result is shown below.

**Accuracy on Testing Set**

| | |
|---|---|
| PCA | 0.958 |
| LDA | 0.917 |

Theoretically, LDA should have better performance than PCA since it takes labels into consideration. However, in this test, PCA surpassed LDA. The reason may be that the training data is insufficient (7 images for each person).

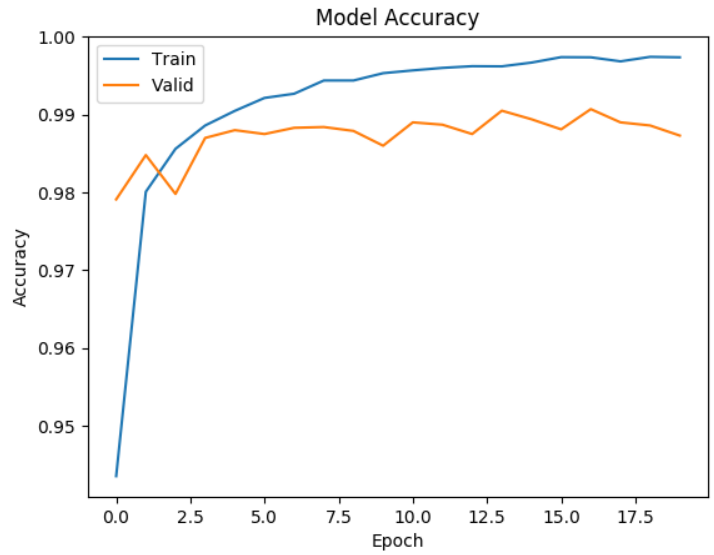
## Problem 3

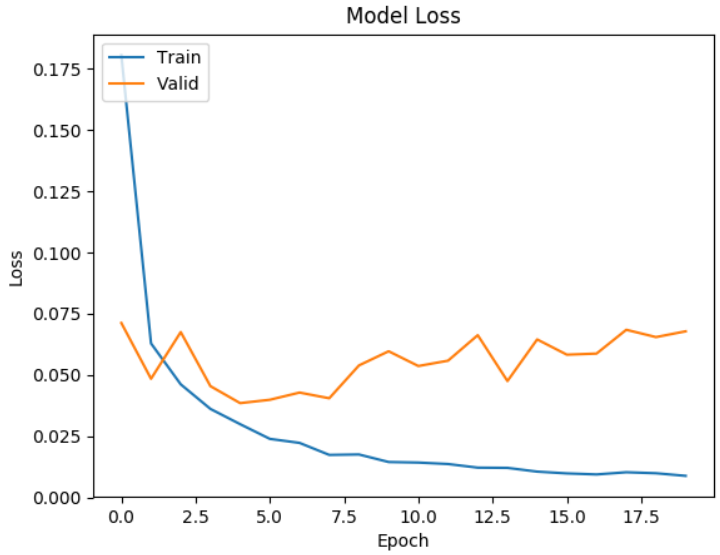
Build a CNN model and train it on the given dataset. Show the architecture of your model in the report.

| Layer (Type) | Output Shape | Number of Parameters |
|---|---|---|
| Conv2D | (None,24,24,6) | 156 |
| MaxPooling2D | (None,12,12,6) | 0 |
| Conv2D | (None,8,8,16) | 2416 |
| MaxPooling2D | (None,4,4,16) | 0 |
| Flatten | (None,256) | 0 |
| Dense | (None,120) | 30840 |
| Dense | (None,84) | 10164 |
| Dense | (None,10) | 850 |

Report your training / validation accuracy, and plot the learning curve (loss, accuracy) of the training process.

| | Accuracy | Loss |
|---|---|---|
| Training | 0.9974 | 0.0088 |
| Validation | 0.9873 | 0.0678 |




Visualize at least 6 filters on both the first and the last convolutional layers.

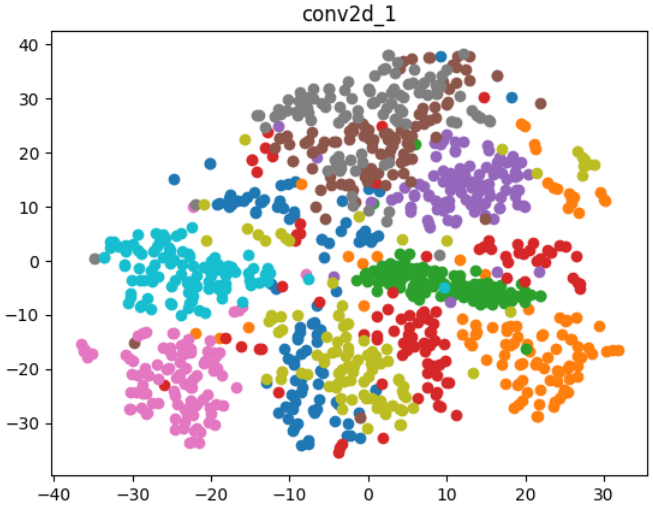
conv2d_1

| Filter 1 | Filter 2 | Filter 3 | Filter 4 | Filter 5 | Filter 6 |
|---|---|---|---|---|---|
|  |  |  |  |  |  |

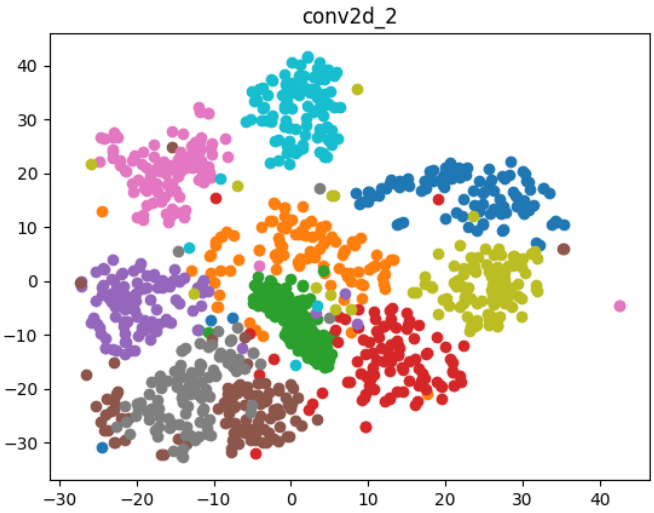
conv2d_2

| Filter 1 | Filter 2 | Filter 3 | Filter 4 | Filter 5 | Filter 6 |
|---|---|---|---|---|---|
|  |  |  |  |  |  |

Visualize high-level and low-level features of 1000 validation data (100 for each class) extracted from different layers, and explain what you have observed from the two t-SNE plots.




➢ Low-level Features




➢ High-Level Features

From the two plots we can observe that in the first convolution layer, the images are preliminarily classified (with some basic features) while in the second convolution layer, the images are further clearly classified with more specific features.