Stastical Pattern Recognotion Project 1

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Introduction

The aim of this project is to classify images to a) identify a person i.e face recognition and b) gesture detection. We are given 3 datasets namely data.mat, pose. mat and illumination. mat. We are to use any one of them to perform these classification tasks. I will be using data. mat for facial recognition as well as gesture detection. The data contain 200 classes i.e people with neutral, smile, and illumination changes images. Thus a total of 3 images per class dataset with a total of 600 images of resolution 24,21.

First dimensional reduction is done via PCA(Principal Component Analysis) and MDA(Multiple Discriminant Analysis). and then Bayes Classifier and K-Nearest Neighbors Classifier is done for both classification tasks while Kernel SVM (with RBF and Polynomial) and Boosted SVM are trained for only classifying facial expression.

Data Split

I split the data into two parts train and test. For classifying the face I took one image from set of three images at random for each class.So training set has 400 images and test set has 200 images. For classifying facial expression our classes are neutral and smile so faces are kind of irrelevant. Here i have just split train and test data in the ration 75:25 from data.mat. Smile has label -1 and neutral has label 1. For second data set first image of each class corresponds to neutral face and second image corresponds to facial expression. so removing third image from each class is necessary. Thus 400 data points are left splitted in shape of (24,21,400) which can be reshape into (504,1,400)

PCA and MDA

PCA and MDA are done to reduce the dimensions of the data. The below figure shows original image , PCA reconstucted image and MDA reconstructed image.

1 Classifiers

Bayes Classifier

Bayes Classifier finds maximum of posterior i.e sum of log likelyhood and log of priors. The class for which the sample has maximum log of posterior is predicted to that class. There is no hyper paramater tuning for this classifier.

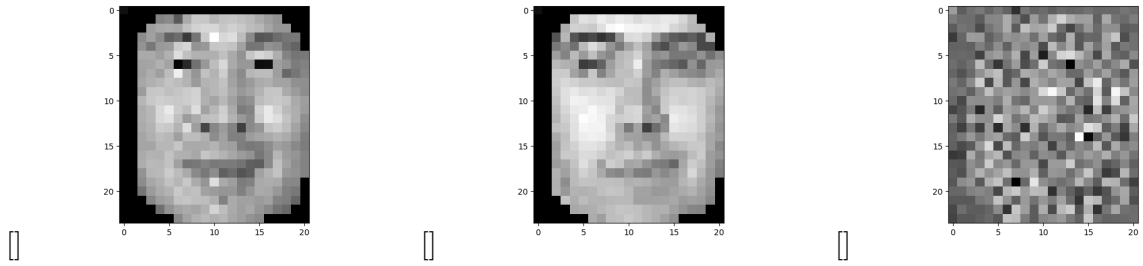

Figure 1: (a) Original Image, (b) PCA Reconstruction, (c) MDA Reconstruction

KNN

KNN classifies data based on labels of k nearest neighbours of the data. Here hyper parameters is k. For different values of k we get different test accuracies. For our case 1NN gives best test accuracy for PCA prepossessing while 3NN for MDA prepossessing.

Kernel SVM

For Kernel SVM problem we try to solve the dual optimization problem given below.

$$\max_{\underline{\mu}} \sum_{n=1}^{N} \mu_n - 12 \sum_{n=1}^{N} \sum_{m=1}^{N} \mu_n \mu_m y_n y_m K(\underline{x_m}, \underline{x_n}),\ subject\ to\ \underline{\mu} \geq 0 \tag{1}$$

$$f(.) = \sum_{n=1}^{N} \mu_n y_n K(., \underline{x_n}) If\ \mu_k \neq 0,\ \theta_0 = y_k - f(\underline{x_k}),\ where,\ \underline{x_k}\ is\ a\ training\ sample Predicted\ Label,\ y_{pred} = \theta_0 + f(\tag{2}$$

We use 2 types of Kernels:

- RBF Kernel $\left(K(x,y) = e^{-||x-y||^2\sigma^2}\right)$ with hyperparameter σ
- Polynomial Kernel $(K(x,y) = (x^T y + 1)^r)$ with hyperparameter r

Here hyper parameters are sigma for RBF and r for Polynomial Kernel.

Boosting

Boosting uses linear SVM using subset of training example to create a week classifier and using that we perform adaboost. Here K i.e number of parameters is hyper-parameter for boosting.

1.1 Task 1: Facial recognition

1.1.1 Analysis

We can see that Bayes Classifier performs better for data prepossessed with MDA than PCA for the face classification task. From Table 1, the accuracy of Bayes classifier with PCA is around 34.5% whereas with MDA is around 64%.

KNN work better for MDA a weel than PCA. From Table 1, the accuracy of kNN classifier with PCA is around 34.5% whereas with MDA is around 64%. We can see the best k is found to be $k = 1$ for PCA and $k = 1, 2, 3$ for MDA among choices $k = 1, 2, 3, 4, 5$. Here value KNN results(accuracy) vary after every iterations.

Table 1: Results for Task 1: Facial Recognition

Classifier	Dimensionality Reduction	Hyperparameter ranges	Best hyperparameter values	Best Test Accu
Bayes	PCA	None	None	40
Bayes	MDA	None	None	66.5
kNN	PCA	$k = [1, 2, 3, 4, 5]$	$k = 1$	34.5
kNN	MDA	$k = [1, 2, 3, 4, 5]$	$k = 2$	64

1.2 Task 2: Neutral v/s Facial Expression Classification

Table 2: Results for Task 2: Neutral v/s Facial Expression Classification

Classifier	Hyperparameter ranges	Best hyperparameter values	Best Test Accuracy (%)
Bayes(PCA)	None	None	88
Bayes(MDA)	None	None	50
kNN (PCA)	$k = [1, 2, 3, 4, 5]$	$k = 4$	83
kNN (MDA)	$k = [1, 2, 3, 4, 5]$	$k = 1$	53
Kernel SVM (PCA)(RBF)	$\sigma = [10, 15, 20, 25]$	$\sigma = 10$	89
Kernel SVM (PCA) (Polynomial)	$r = [1, 2, 3, 4, 5]$	$r = 4$	89
Kernel SVM (MDA) (RBF)	$\sigma = [10, 15, 20, 25]$	No solution Dual Optimization Failed	
Kernel SVM (MDA) (Polynomial)	$r = [1, 2, 3, 4, 5]$	$r = 1$	50
Boosted SVM (PCA)	$K = [5, 10, 15, 20]$	$K = 10$	89
Boosted SVM (MDA)	$K = [5, 10, 15, 20]$	No optimal solution	

1.2.1 Bayes

For facial expression recogmition,PCA works fine for Bayes classifier with accuracy 89% while MDa gives 50% accuracy meaning all data points are classified in one class.

1.2.2 kNN

For KNN, PCA works better than MDA with accuracy of 83% vs 53%.

1.2.3 Kernel SVM

For kernel SVM MDA either does not work or works with 50% accuracy while PCA gives nice results.

1.2.4 Boosted SVM

MDA for Boosted SVM does not work wile PCA gives 89% accuracy eith K = 10

2 Conclusion

- For Bayes and KNN classifiers MDA works better than PCA for face recognition and vice versa for facial expression classification.
- For Kernel SVM with PCA give best results
- Boosted SVM works well with PCA
- MDA is not a good dimension reduction method when your clusters are very big i.e class has large number of samples.