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ENEE436: Foundations of Machine Learning
Project 1

Facial Recognition

OVERVIEW

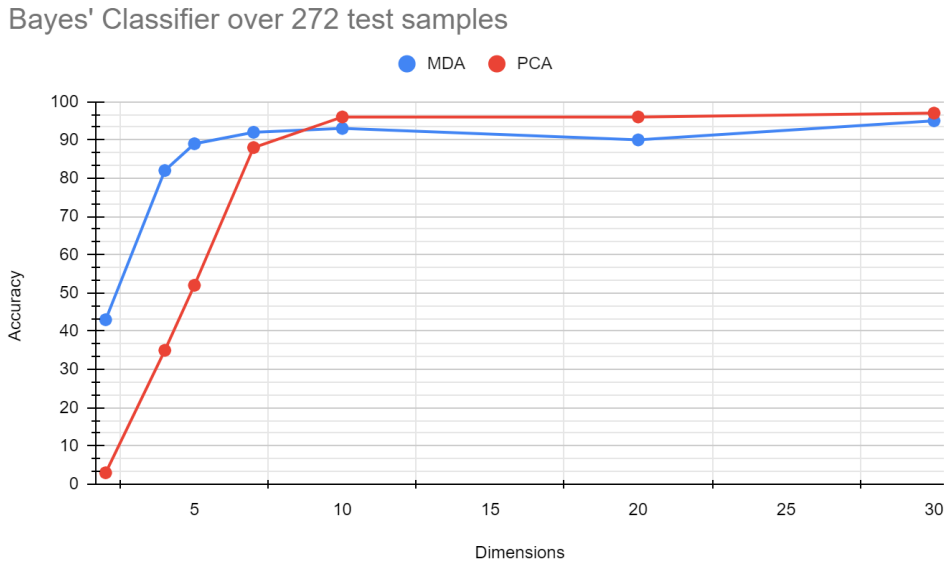
This project is comprised of implementing Bayes' Classifier and the k-NN rule for facial classification. Additionally, before any classification we implement Principal Component Analysis (PCA) or Multiple Discriminant Analysis (MDA). In this report, a combination of each classifier and dimension reduction technique is assessed with two different datasets.

Data Sets

Two data sets are used for the experiments. The first is data.mat, which contains images of 200 subjects with a size of 24x21. This data set is used for neutral vs facial expression classification. Training data and testing data are both comprised of a neutral and expression face per subject. The training data set is default larger than the testing set, but no subjects overlap the sets. The second is illumination.mat, comprised of 68 subjects, each with 21 different illuminations, with a size of 48x40. This data set is used for identifying a subject from among the training set. The training data is comprised of a random 17 illuminations per subject and the testing data is the remaining 4 images per subject.

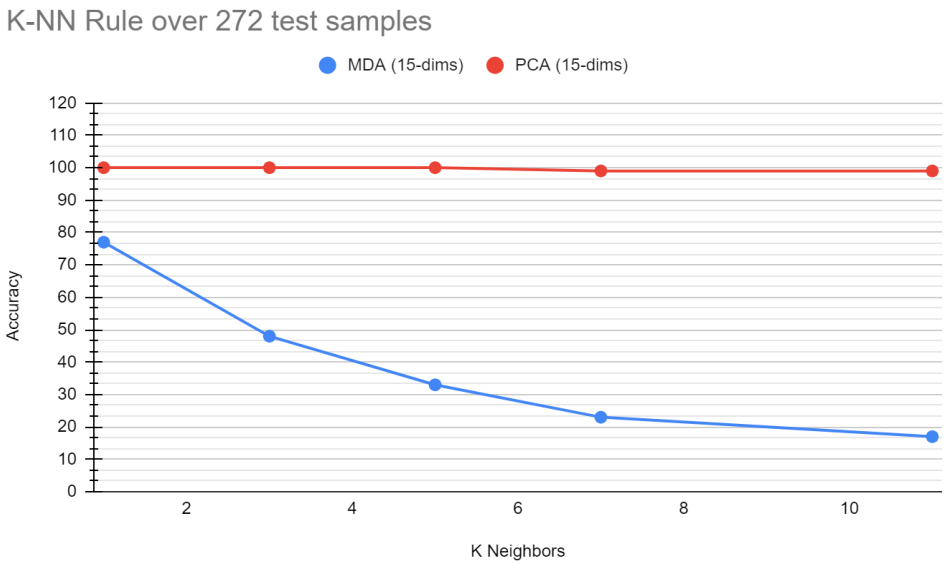
Task 1: Subject Identification

Due to a much longer run-time, the following accuracies are the average over 4 independent runs, this includes a new split of training and test samples, PCA and MDA projections. In the subject identification task we have 68 subjects, each with 21 samples of different illumination. Immediately we notice the extremely low accuracy when PCA reduces to the just 1 dimension, where our classifier is wrong almost everytime. MDA however is not as bad, but is still wrong a majority of the time. There is a quick growth of accuracy which levels off at around 10 dimensions. We see that MDA performs better than PCA for lower dimensions whereas PCA is marginally better for higher dimensions.



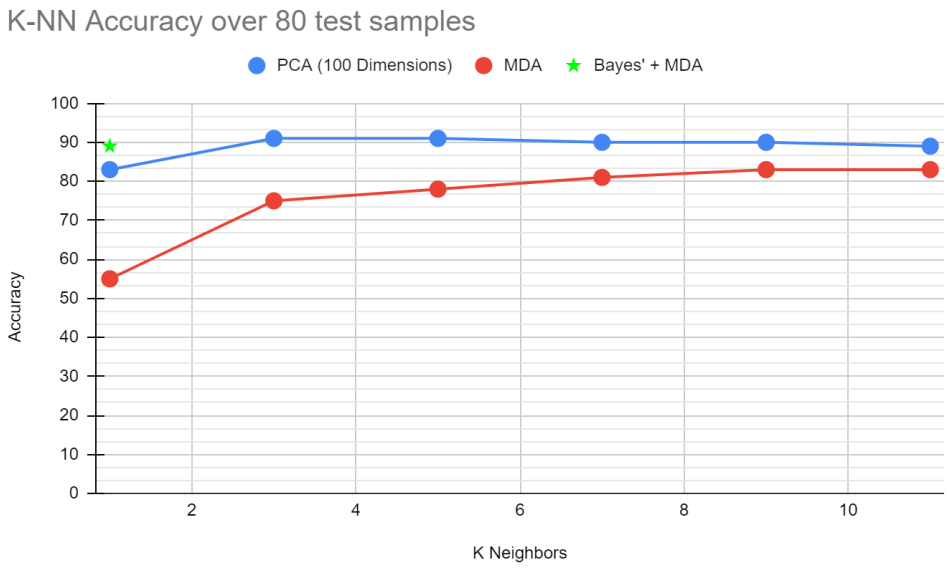
Note that 240/272, 250/272, 260/272 correct classifications yield accuracies of 88%, 92%, 96% respectively.

Here we analyze the impact of the number of neighbors with the K-NN rule for both MDA and PCA projections to 15 dimensions. We notice the same trend in MDA vs PCA as above that with 15 dimensions MDA performs worse. It seems that a PCA reduction to 15 dimension yields the highest accuracy and does not differ based on the number of neigbors. This makes sense because the PCA seeks to preserve the variance in the data. It seems the optimal k for an MDA projection is 1.



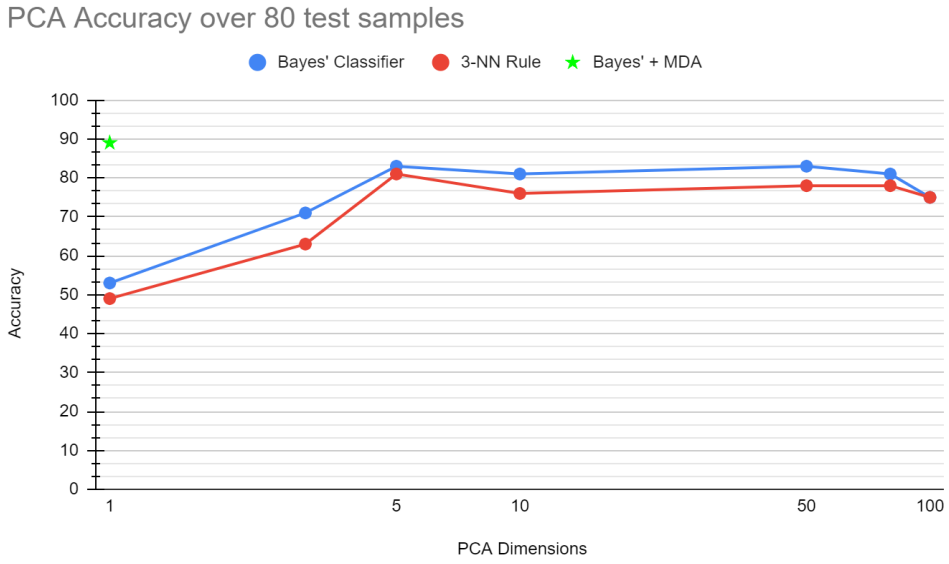
Task 2: Neutral vs. Facial Expression

The following accuracies are the average over seven independent runs, this includes a new split of training and test samples, PCA and MDA projections. It's important to note that there are only two classes here, a neutral face and expression face. We check the accuracy of classification based on the number of nearest neighbors analyzed. Thus our MDA projects our data down to one dimension. Our PCA however, projects our data down to 100 dimensions. This is why our accuracy tended to be higher while using the PCA. Also note the singular data point of Bayes' Classifier and MDA projection for comparison, which yielded a higher accuracy than any other MDA tests for K-NN. For both PCA and MDA we notice the largest improvement in accuracy when we got from 1-NN to 3-NN. After 3-NN and beyond there isn't much improvement in the accuracy.



Note that 70/80, 68/80, 66/80 correct classifications yield accuracies of 87.5%, 85%, 82.5% respectively.

Here we are anaylzing the accuracy of using both Bayes' Classifier and the K-NN neighbor rule with constant K of 3 based on the number of dimensions reduced to with a PCA. Immediately we see a poor accuracy of 50% for both classification when PCA projects our data to one dimension. Since our samples are low quality (low pixels) there isn't much deviation except for a specific area per image. This allows the accuracy to increase drastically when we increase to only 5 dimensions. Again we notice our accuracy almost levels off at this 5-dimension bound.



Conclusion

In this project we got to experiment with two types of classifiers: Bayes' and Nearest Neighbor. Compounded with two dimension reduction techniques: Principal Component Analysis (PCA) or Multiple Discriminant Analysis (MDA). It seems that in Task 2 Bayes' Classifier outperformed the K-NN rule, whereas in Task 1, K-NN performed better. In both cases, our tests showed that PCA yielded better results.