Image Analysis

Optimization and Data Analytics mini-project

Morten Lyng Rosenquist
Faculty of Technical Sciences
Aarhus University
Aarhus, Denmark
201706031

Write abstract

***Abstract*—**

***Index Terms*— component, formatting, style, styling, insert**

Insert keywords

Introduction to the Image Classification problem and description of the basic and more advanced approaches.

Description of the classification schemes used in your experiments.

I. Introduction

A. Nearest class Centroid

B. Nearest sub-class Centroid

C. Nearest Neighbor

D. Perceptron using Backpropagation

E. Perceptron using MSE

F. Principal component analysis

II. Databases

The data sets that are analyzed in this paper are MNIST and ORL.

A. ORL

The ORL data set contains 400 vectorized images. The images are of size 40x30 and depict a persons face in an upright position in a frontal view[1]. There is 10 images of 40 different persons. Examples of the images can be seen on Figure 1.

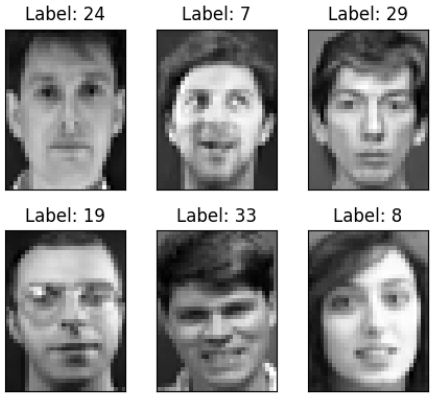


Fig. 1: ORL example images

B. MNIST

The MNIST dataset is larger with 70,000 vectorized images. The images depict handwritten digits and are of size 28x28. Differing from the ORL data set, the set is already split in training and test data. Leading to 60,000 images for training and 10,000 for testing. Examples from the MNIST data set can be seen on Figure 2.

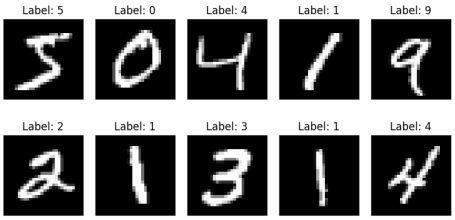


Fig. 2: MNIST example images

III. Methods

Write methods

IV. Results

The performance of each classifier for both datasets will in this section be covered.

A. PCA impact on data

Classification is performed both on the original data and on the data reduced to two dimensions using PCA. Illustrations of the data lost by reducing the dimensions can be seen on Figure 3 for ORL and Figure 4 for MNIST. These figures are the same images illustrated on Figure 1 and Figure2, but where PCA has been applied and thereafter retransformed to their original dimensionality.

Having the dimensions reduced to two, makes it easy to visualize the data. On Figure 5 can a scatter plot for the MNIST test data be seen.

As for the ORL data set there is 40 classes, which is hard to illustrate in a single scatter plot. Therefore Figure 6 contains the first 20 classes while Figure 7 contains the other 20 classes.

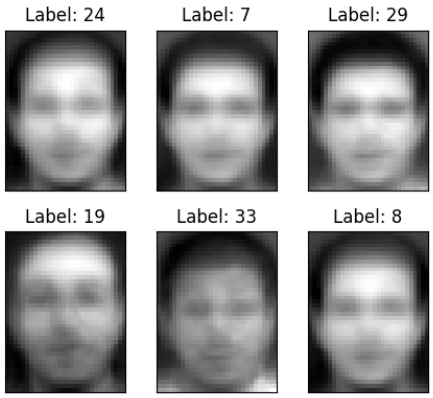


Fig. 3: ORL images reconstructed after PCA

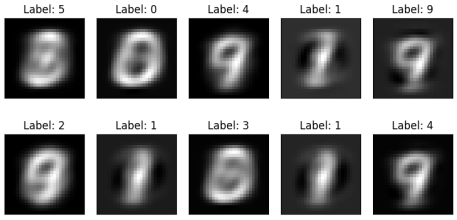


Fig. 4: MNIST images reconstructed after PCA

B. Classification

Each classifier, for both the original data and the PCA version of the data, have their hyperparameters tuned if relevant. Afterwards the classification is performed. The accuracy of class predictions of the test data can be seen on Table I. Measurements of the time spent both training and testing can be seen for certain classifiers.

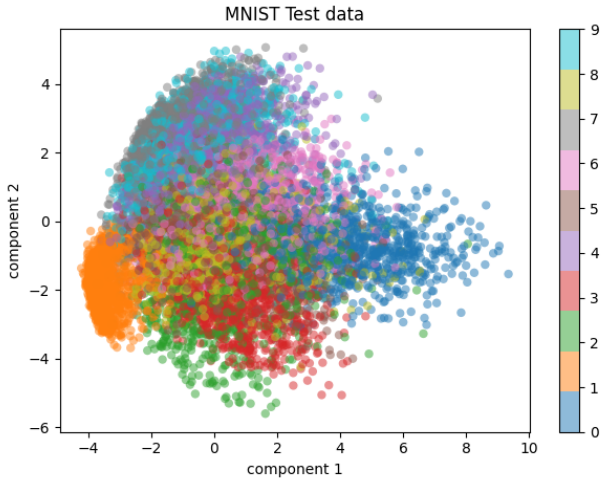


Fig. 5: MNIST test PCA images scatter plot

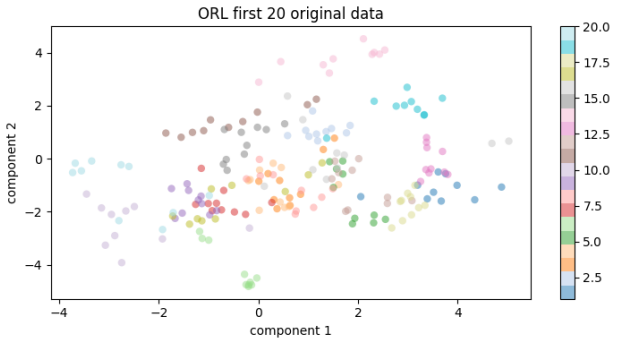


Fig. 6: ORL original PCA images first 20 classes

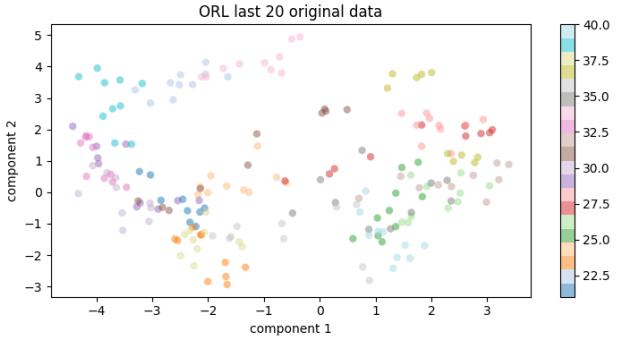


Fig. 7: ORL original PCA images last 20 classes

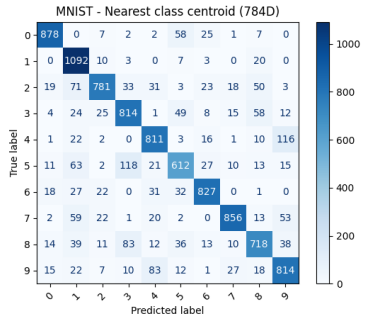
C. Visualization

V. Discussion

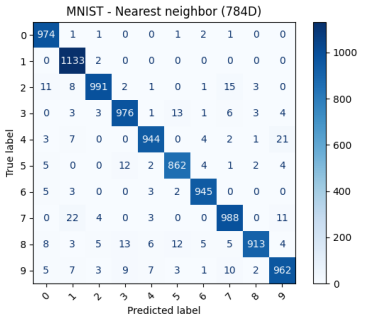
Write discussion

VI. Conclusion

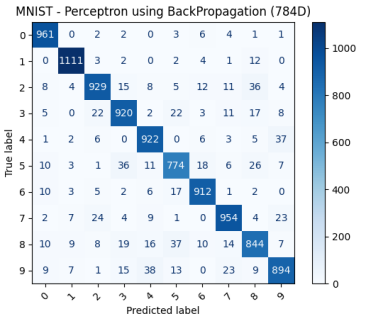
Write conclusion



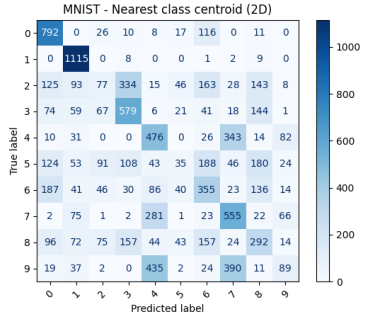
(a) Nearest class centroid (784D)



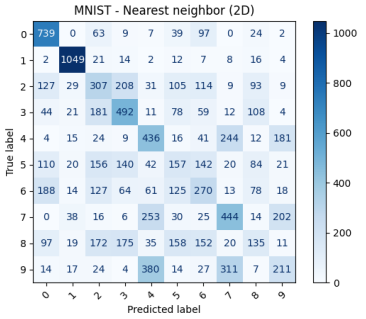
(b) Nearest 5 neighbors (784D)



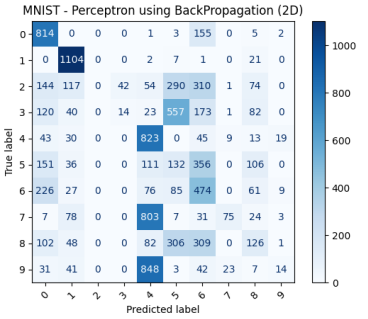
(c) Perceptron using BP (784D)



(d) Nearest class centroid (2D)

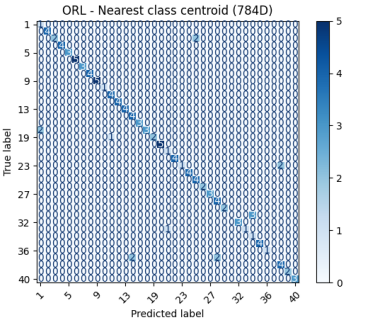


(e) Nearest 5 neighbors (2D)

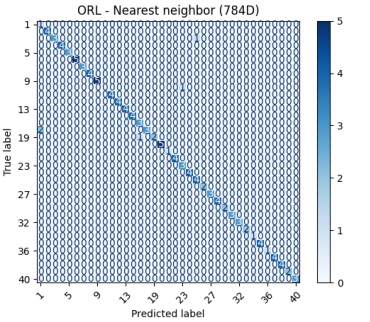


(f) Perceptron using BP (2D)

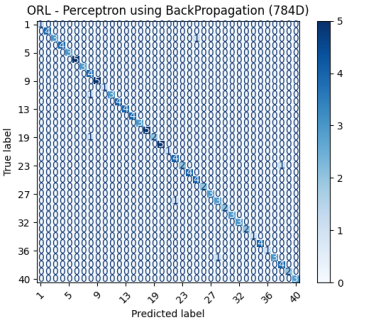
Fig. 8: Confusion Matrices - MNIST



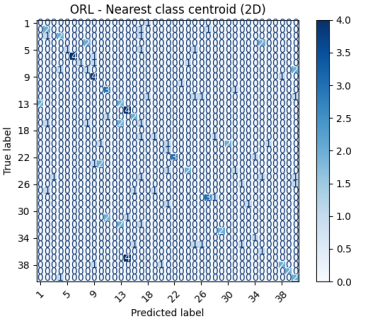
(a) Nearest class centroid (784D)



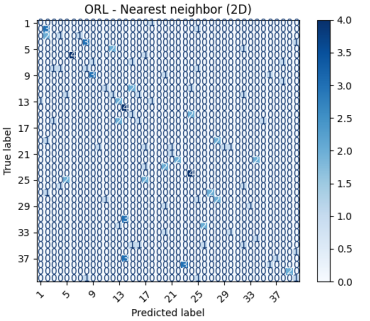
(b) Nearest 5 neighbors (784D)



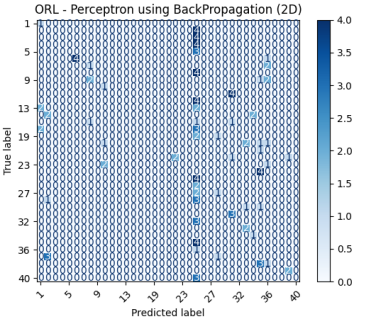
(c) Perceptron using BP (784D)



(d) Nearest class centroid (2D)



(e) Nearest 5 neighbors (2D)



(f) Perceptron using BP (2D)

Fig. 9: Confusion Matrices - ORL

Dataset	Classifier	Accuracy (Raw)	Accuracy (2d)	Time (Raw)	Time (2d)
MNIST					
	Nearest Class Centroid	82.03%	43.65%	0.702 s	0.016 s
	Nearest 2 Sub-Class Centroid	86.07%	43.07%	5.049 s	1.197 s
	Nearest 3 Sub-Class Centroid	88.24%	42.39%	7.918 s	1.918 s
	Nearest 5 Sub-Class Centroid	90.27%	41.81%	12.513 s	3.308 s
	Nearest Neighbor	96.88%	42.43%	14.173 s	0.207 s
	Perceptron with Backpropagation	92.20%	39.36%	5.812 s	0.090 s
	Perceptron with MSE	86.08%	32.79%	5.923 s	0.128 s
ORL					
	Nearest Class Centroid	87.50%	33.33%	0.005 s	0.001 s
	Nearest 2 Sub-Class Centroid	94.17%	40.00%	0.602 s	0.548 s
	Nearest 3 Sub-Class Centroid	96.67%	35.83%	0.666 s	0.613 s
	Nearest 5 Sub-Class Centroid	96.67%	34.17%	0.828 s	0.748 s
	Nearest Neighbor	95.83%	30.83%	0.013 s	0.006 s
	Perceptron with Backpropagation	95.83%	13.33%	0.073 s	0.015 s
	Perceptron with MSE	95.83%	13.33%	0.165 s	0.015 s

TABLE I: Performance of each classifier for both datasets

References

[1] Nimfa. *ORL Images*. URL: https://nimfa.biolab.si/nimfa.examples.orl_images.html. (accessed: 10.11.2021).

NOTES