ELEC-E9111 - Mathematical computing

Machine learning

24 October 2024

The deadline has been extended due to the exam week! When submitting the homework, please include all your code as `.m` or `mlx` files, excluding the files that are provided for the exercises.

1 Axel Net (2 pts)

Take two photos by yourself. Select first one object that should be easy for the algorithm to recognize it. Then choose something that for example consists of many individual things (in lecture slides I used a basket of mushrooms) or is something that should be a very rare thing and difficult to recognize. Run AlexNet from `alexnetDemo.m` in Mycourses. Record the results and comment with a few lines how successful the analysis was.

2 Clustering cars (6 pts)

a)

The table `cardata` in the file `cars.mat` has five numerical and one categorical attributes. Extract the numerical data from the table and z-score normalize it to acquire an array of size 392x5. Do PCA for this array and visualize the pca scores with a scatter plot using the two first principal components. How many clusters you detect visually in the plot and how much of the total variance is explained by the two first principal components?
Use `evalclusters()` on the normalized numerical data [not PCA scores!] to evaluate how many clusters there seems to be in case of hierarchical ('linkage') clustering.

b)

Generate a hierarchical clustering model for the normalized data using `linkage()` with the 'ward' method. Use `cluster()` on the hierarchical model to group the data into clusters. Create a scatter plot of the PCA results like in part a), but use the groups given by `cluster()` for coloring to visualize the achieved cluster divisions. Create one more plot of the pca values, this time colored by the origin of the car. Is there any correlation between the clusters and the car's origins?

3 Classifying satellite data (6 pts)

The file `sat.trn` contains measurementd data from a Landsat satellite. Each row describes one datapoint measured from a 3x3 pixel area, on four different wavelengths. Therefore, the total amount of variables measured for each datapoint is 36. The last column contains the class of the datapoint:

1 red soil
2 cotton crop
3 grey soil
4 damp grey soil
5 soil with vegetation stubble
6 mixture class (all types present)
7 very damp grey soil

Note: in this specific dataset there are no instances of class 6.

a)

Use `fitcknn()` with default options to create a k-nearest neighbour classifier for the data. Use the classifier to predict the classes for the test set in `sat.tst` and compare the predictions to the actual classes. Finally, draw a confusion plot of the test set results. How does the classifier perform?

b)

Use `patternnet()` to create and train a pattern recognition neural network using the training data. Compare the test set confusion plot to part a). How well does the trained net perform in predicting the test data compared to the knn classifier?

Detailed dataset description can be found in `sat.doc` and in
https://archive.ics.uci.edu/ml/datasets/Statlog+(Landsat+Satellite)

4 Concrete factory regression (6 pts)

The compressive strength of concrete depends on its age and the ingredients used to manufacture the concrete. The file `concrete_Data.xls` contains data on the amounts of various ingredients used in the manufacturing process, the age of the concrete and the measured compressive strength.

a)

Fit a linear regression model that predicts the compressive strength from the age and ingredients. What is the MSE (Mean Squared Error) for the linear model?

b)

Use `fitnet()` to create and train a neural network to fit the same data. The default performance function used by the network is `'mse'`, how does the fitnet performance compare to the linear model? Finally, plot both results using `plotregression`.

Detailed dataset description can be found in `Concrete_readme.txt` and in
https://archive.ics.uci.edu/ml/datasets/concrete+compressive+strength

Original research article:
I-Cheng Yeh, "Modeling of strength of high performance concrete using artificial neural networks," Cement and Concrete Research, Vol. 28, No. 12, pp. 1797-1808 (1998).