Computational Intelligence, SS11

http://www.spsc.tugraz.at/courses/computational-intelligence

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4 Homework: Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA)

[Points: 10+3 , Issued: 2011/05/24 , Deadline: 2011/06/10 , Tutor: Georg Kapeller [2]; Infohour: TBA , Room and Date will be posted in the newsgroup , ;

General: Download the given data set from the course homepage, load it into the Matlab workspace and plot it using `plot3()`. The file contains the complete unlabeled dataset in the variable `X` $= \{\mathbf{x}_1, \ldots, \mathbf{x}_N\}$ and the same samples split into the two classes in `X1` and `X2`. The dataset for the homework consists of three-dimensional samples ($\mathbf{x}_n \in \mathbb{R}^3$), the two-dimensional data used in classroom is also available. We denote the dimensionality of the input space as D and that of the output space as M.

For each subtask, provide meaningful plots and discuss your results.

4.1 PCA [4 Points]

1. Transform the data in the space defined by their *principal components*, i.e. the directions of maximum variance. Use $M = D$, i.e. do not perform dimensionality reduction. Plot the data set together with the directions of the principal components (scaled in a meaningful way).

2. What are the statistical properties of the data after applying PCA? Are the dimensions of the transformed data statistically independent?

3. Now project the data points given in $\mathbf{X}$ onto the one-dimensional space ($M = 1$) corresponding to the direction of maximum variance. Plot the transformed data points and histograms of the transformed classes! Select a reasonable threshold value to classify the data and check the classification performance!

4.2 LDA [6 Points]

1. Transform the data to one dimension used both discussed variants of LDA. Again, plot the transformed data points and histograms of the transformed classes! Are the transformed data points well separable?

2. Visualize the transformation vector $\mathbf{w}$ in the data for both LDA variants and discuss the difference to PCA!

3. Again select a reasonable threshold value for classification and report the classification performance!

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4.3 PCA with normalization [3* Points]

1. Transform the data in $\mathbf{X}$ such that the transformed data $\mathbf{x}' = \mathbf{W}\mathbf{x}$ has zero mean and a covariance matrix equal to the identity matrix! For classification, this can be an important pre-processing step when different features are on different scales.