SGN-41006 Signal Interpretation

Exercise Set 4: February 3 - 4, 2016

Exercises consist of both pen&paper and computer assignments. Pen&paper questions are solved at home before exercises, while computer assignments are solved during exercise hours. The computer assignments are marked by text **python** and Pen&paper questions by text **pen&paper**

1. **pen&paper** *Design an LDA classifier manually.*

   A dataset consists of two classes, whose distributions are assumed Gaussian, and whose sample covariances and means are the following:

   $$\boldsymbol{\mu}_1 = \begin{pmatrix} -1 \\ 1 \end{pmatrix} \qquad \boldsymbol{\mu}_2 = \begin{pmatrix} -7 \\ 2 \end{pmatrix}$$
   $$\mathbf{C}_1 = \begin{pmatrix} 2 & 0.1 \\ 0.1 & 0.4 \end{pmatrix} \qquad \mathbf{C}_2 = \begin{pmatrix} 3 & -2 \\ -2 & 2 \end{pmatrix}$$

   Calculate the projection vector $\mathbf{w}$. In order to be fully manual, invert the 2×2 matrix using the rule

   $$\begin{pmatrix} a & b \\ c & d \end{pmatrix}^{-1} = \frac{1}{ad - bc} \begin{pmatrix} d & -b \\ -c & a \end{pmatrix}$$

2. **pen&paper** *Compute the threshold and classify.*

   The LDA decision rule requires a threshold T:

   - Decide class = 1 if $\mathbf{w}^T\mathbf{x} \geq T$.
   - Decide class = 0 if $\mathbf{w}^T\mathbf{x} < T$.

   Compute T by setting it at the center of projected class means, $\boldsymbol{\mu}_1$ and $\boldsymbol{\mu}_2$.

   Which class will be predicted for sample $\mathbf{x} = (1, 2)$?

3. **pen&paper** *Compute the threshold more properly and classify.*

   The previous approach to defining the threshold T did not take into account the fact that the two classes have different spreads, and the threshold should probably not be exactly at the center.

   A more appropriate approach would thus compute the projection of the multivariate Gaussians and set the threshold accordingly. The projected Gaussians are univariate normal: $\mathcal{N}(\mathbf{w}^T\boldsymbol{\mu}_1, \mathbf{w}^T\mathbf{C}_1\mathbf{w})$ and $\mathcal{N}(\mathbf{w}^T\boldsymbol{\mu}_2, \mathbf{w}^T\mathbf{C}_2\mathbf{w})$. Formulate the classification problem as a likelihood ratio test and choose the threshold based on that.

   Which class will be predicted for sample $\mathbf{x} = (1, 2)$?

4. **python** *Extract Local Binary Pattern features for classification.*

   In this exercise we will extract image features for categorization of traffic signs. Download the following file:

   `http://www.cs.tut.fi/courses/SGN-41006/GTSRB_subset.zip`

   If has two folders each containing 100 images from the German Traffic Sign Recognition Benchmark (GTSRB); a competition organized in IJCNN-2011 conference.

   Load all images from the two folders and compute their Local Binary Pattern features using `skimage.feature.local_binary_pattern`.[1] The function returns an image with same size as the original, so you will also have to compute the histogram with `numpy.histogram`. Note that this is a similar task to exercise 4 last week. The result should be a feature matrix `X` and label vector `y`.

5. **python** *Train classifiers for the GTSRB task.*

   Create a list of three classifiers with their default parameters:

   - `sklearn.neighbors.KNeighborsClassifier`
   - `sklearn.lda.LDA`
   - `sklearn.svm.SVC`

   Split your data into two parts—80% for training and 20% for testing—using `sklearn.cross_validation.train_test_split`.

   Train each classifier in a for loop and assess the accuracy in the test set using `sklearn.metrics.accuracy_score`. Which one is the best?

[1] See `http://scikit-image.org/docs/dev/auto_examples/plot_local_binary_pattern.html`