A2I2 – Support Vector Machines

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DCT – 1D

For computation of a 1D-DCT the transformation matrix is required.

a) What do these matrices look like, if we want to transform a 1- and 2-dimensional vector, respectively?
b) What is the inverse DCT-matrix in these cases?
c) Apply the transform to the vector $(1\ 2)^T$. Compute the inverse.
d) Compute a 2D-DCT of the "image" $\begin{pmatrix} 1 & 1 \\ 2 & 2 \end{pmatrix}$ by
    a. applying a 1D-DCT to the columns, and then again a 1D-DCT to the transformed rows
    b. vice versa: apply a 1D-DCT to the rows, and then to the transformed columns

Programming Exercise – Python / scikit-learn

We will use the MNIST database (http://yann.lecun.com/exdb/mnist/) in this exercise. It contains (normalized) hand-written digits in images of size 28x28 as well as corresponding labels. The images are separated in training set (60,000) and test set (10,000). Scikit-learn contains a function for loading the data set from OpenML (https://www.openml.org/d/554).

A Python-program training a simple SVM is provided for download in the Learning Campus. You can either run it using a local installation of Python/scikit-learn, or copy/paste the code to an Azure-Python-Notebook. In the latter case, uncomment the "!pip install…" at the beginning. This will install an update of scikit-learn in the Azure-Notebook; the error messages can be ignored.

For faster training when experimenting with the SVM, the number of training images can be reduced by setting the "noTrainSamples" variable (default: 2000). Evaluation is done on the full test set.

Modify the program to achieve better classification. Answer the following questions:

1. What does the parameter "C" do?
2. What does the parameter "gamma" do? Does it have any effect when using a linear kernel?
3. Which other kernels are available? At least try a radial basis function kernel.
4. Digit classification requires a multi-class SVM. An SVM is a binary classifier. How does scikit-learn handle multiple classes with SVMs?
5. The provided program uses the image pixels as features directly (28x28 = 784 dimensional feature vectors). Now, we will use the first coefficients (zi-zag-scan) of a 2D-DCT as features. The program already contains a function for DCT-computation (compute_dct_features_2d).
    a. Implement the code to call this function and compute DCT-features for the complete data set (in the "if"-statement). Set "useDCT" to "True"; the variable "noDCTCoeffs" contains the desired number of DCT-features to use.
    b. How many DCT-features are required to get a result comparable to using the pixel values?