TU München
Fakultät für Informatik
PD Dr. Rudolph Triebel
John Chiotellis

Machine Learning for Robotics and Computer Vision
Winter term 2015

Homework Assignment 5
Topic: SVMs and Gaussian Processes
December 22th, 2015

Exercise 1: Support Vector Machines

Consider a dataset with a single feature $x \in \mathbb{R}$ and labels $y \in \{+1, -1\}$. Data points $-3, -2, 3$ have label $+1$ and data points $-1, 0, 1$ have label -1.

a) Is this dataset linearly separable? Why?

b) Find a feature map $\phi(x) \in \mathbb{R}^2$ so that the dataset is linearly separable.
(Drawing the data helps.)

c) Construct a maximum-margin hyperplane and mark the support vectors. Also draw the decision boundary in the original feature space. Is it possible to add another point to the training set so that the hyperplane does not change? Why?

Exercise 2: Gaussian Processes (Regression)

We want to approximate a function and we are given some samples (as training set) with input values $\mathbf{x}$ and outputs $\mathbf{y}$:

$$\mathbf{x} = (-0.8372, -0.4558, 0.6902, 0.1114, -0.4678)$$
$$\mathbf{y} = (-0.6414, -1.0286, -0.6893, -1.4021, -1.0594)$$

Suppose it has zero mean. Consider the kernel:

$$k(x_i, x_j) = \sigma_f^2 \exp(-\frac{1}{2l^2}(x_i - x_j)^2) + \sigma_n^2 \delta_{ij}$$

where $\sigma_f = 1$, $\sigma_n = 0.5$ and $\delta_{ij} = 1$, if $i = j$ and 0 otherwise.

a) Two new points $\mathbf{x}_* = (-0.5, 0.5)$ appear. Compute the mean value $\overline{\mathbf{y}_*}$ for $l = 1$.

b) Try different values for the hyperparameter l. Plot $\mathbf{y}_*$ against $\mathbf{x}_*$ with the confidence intervals (two standard deviations). How does the function change? Why?

Exercise 3: Gaussian Processes (Programming)

Visit `http://gaussianprocess.org/`. You will find a vast amount of resources relevant to Gaussian processes, including research papers and software. For this exercise we will use the *gpml* package for Matlab (written by Rasmussen and Williams). Read through the documentation in `http://www.gaussianprocess.org/gpml/code/matlab/doc/index.html`. Experiment with gpml for classification using the dataset from the previous exercise (banknote_auth). Section 4(b) of the documentation can guide you through the different parameters you can tinker with, like mean, covariance and likelihood functions. How do GPs compare to AdaBoost?

The next exercise class will take place on **January 15th, 2016**.

For downloads of slides and of homework assignments and for further information on the course see

<div align="center">

`https://vision.in.tum.de/teaching/ws2015/mlcv15`

</div>