# Homework 4

Machine Learning — 19 November, 2013
1st Semester (FEUP-PDEEC) — 18-782PP CMU-Portugal

Submit by 3 December, 2013, 23h59
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## Problem 1

a) Consider SVMs applied to a generic classification problem. What is the difference in the solutions obtained with kernel $k_1(\mathbf{x}_1;\mathbf{x}_2)$ and $k_2(\mathbf{x}_1;\mathbf{x}_2) = 1 + k_1(\mathbf{x}_1;\mathbf{x}_2)$. Starting from the dual formulation, prove that difference.

b) Let us consider a mapping of a feature $x$ to a feature space $\phi_\infty(x)$ in infinite number of dimensions.

$$\phi_\infty(x) = \{e^{-x^2/2}, e^{-x^2/2}x, \frac{e^{-x^2/2}x^2}{\sqrt{2}}, ..., \frac{e^{-x^2/2}x^i}{\sqrt{i!}}, ...\}$$

We will start by defining inner product between two infinite vectors
$a = \{a_1, ..., a_i, ...\}$, and $b = \{b_1, ..., b_i, ...\}$ as $K(a,b) = a \cdot b = \sum_{i=1}^{\infty} a_i b_i$.

For two scalar numbers $x$ and $y$, Prove the following:

$$K(x,y) = \phi_\infty(x) \cdot \phi_\infty(y) = e^{-\frac{(x-y)^2}{2}}$$

## Problem 2

Starting from the Matlab code provided, implement a basicSVM classifier. Use the Matlab function quadprog to solve the quadratic programming problem.
Set the kernel to $k(\mathbf{x}_1, \mathbf{x}_2) = (1 + \mathbf{x}_1^t.\mathbf{x}_2)^2$

## Problem 3

Starting from the Matlab code provided, implement a multiclass SVM based on DAGs for 4 classes (the code does not need to be generic for any number of classes). You can use your implementation of binary SVM from previous item or from a standard toolbox, as `libsvm` or from Matlab‘s Bioinformatics Toolbox.