

Exercise Sheet 5: Support Vector Machines

Deadline: See course calendar on the website.

For this problem set please hand in code as well as written solutions. The code and an electronic version of the written solutions should be submitted to PASS (see the link on the website).

Exercises

Part 1: Implementation

Exercise 1 (7 Marks)

Implement the SMO algorithm for SVMs. The signature follows that of Kernel Ridge Regression:

```
C = svm_smo(X, y, kernel, kernelparameter, regularization)
```

with the following kernels (and parameters)

Name	Kernel	Parameter
linear	$k(x, z) = \langle x, z \rangle$	(none)
polynomial	$k(x, z) = (\langle x, z \rangle + 1)^p$	degree $p \in \{1, 2, 3, \dots\}$
gaussian	$k(x, z) = \exp(-\ x - z\ ^2 / 2dw^2)$	kernel width w

Here, d is the dimension of X .

Use the debug-datasets (see below), to test your implementation.

Exercise 2 (3 Marks)

Implement an SVM with help of the function `quadprog` from the Matlab optimization toolbox. The signature and construction is the same as with `svm_smo`.

```
C = svm_quadprog(X, y, kernel, kernelparameter, regularization)
```

Use the debug-datasets (see below), to test your implementation.

Part 2: Application

Use both implementations on the following datasets. If the found solutions differ from each other, visualize both and describe the differences.

Exercise 3 (5 Marks)

- To debug, use the dataset `U05_easy_1d` and `U05_easy_2d` with a linear kernel. Plot the resulting decision hyperplanes and mark the support vectors.
- Use the algorithm on the dataset `U05_spiral` with a Gaussian kernel. Find good settings manually for the kernel width and constant. Plot the decision hyperplanes and report good values for the parameters.

Exercise 4 (5 Marks)

- (USPS-Dataset) We would now like to use the SVM on a 'real' dataset, the USPS dataset, which we saw on sheets 1 and 3. In this case, one trains to classify one digit against the rest of the digits.
 - Use 5-fold Cross Validation (see exercise sheet 4), to find the best kernel and kernel parameters. Report the best kernel and kernel parameter as well as the estimated test error.
 - Plot, for each kernel, 5 randomly chosen Support Vectors from the two classes.