The CGL Support Vector Machine

Theory and Implementation

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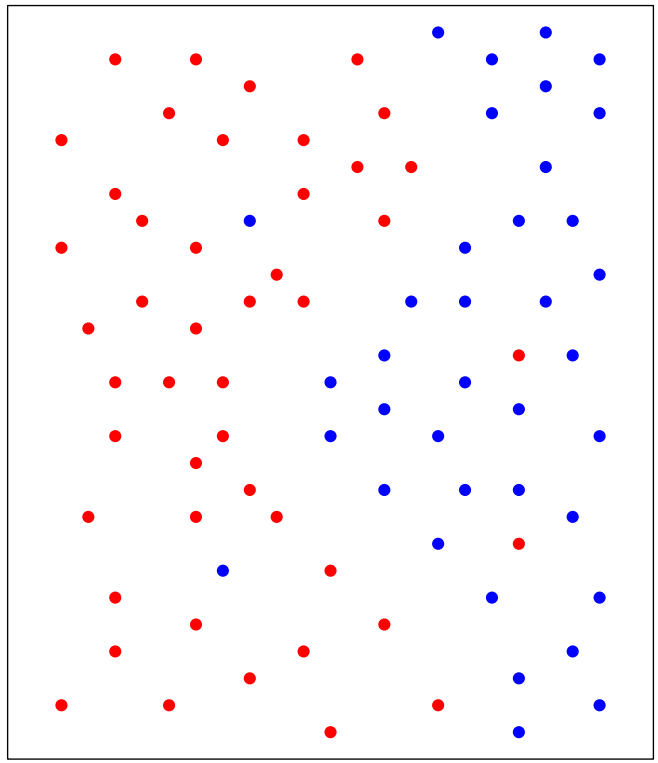
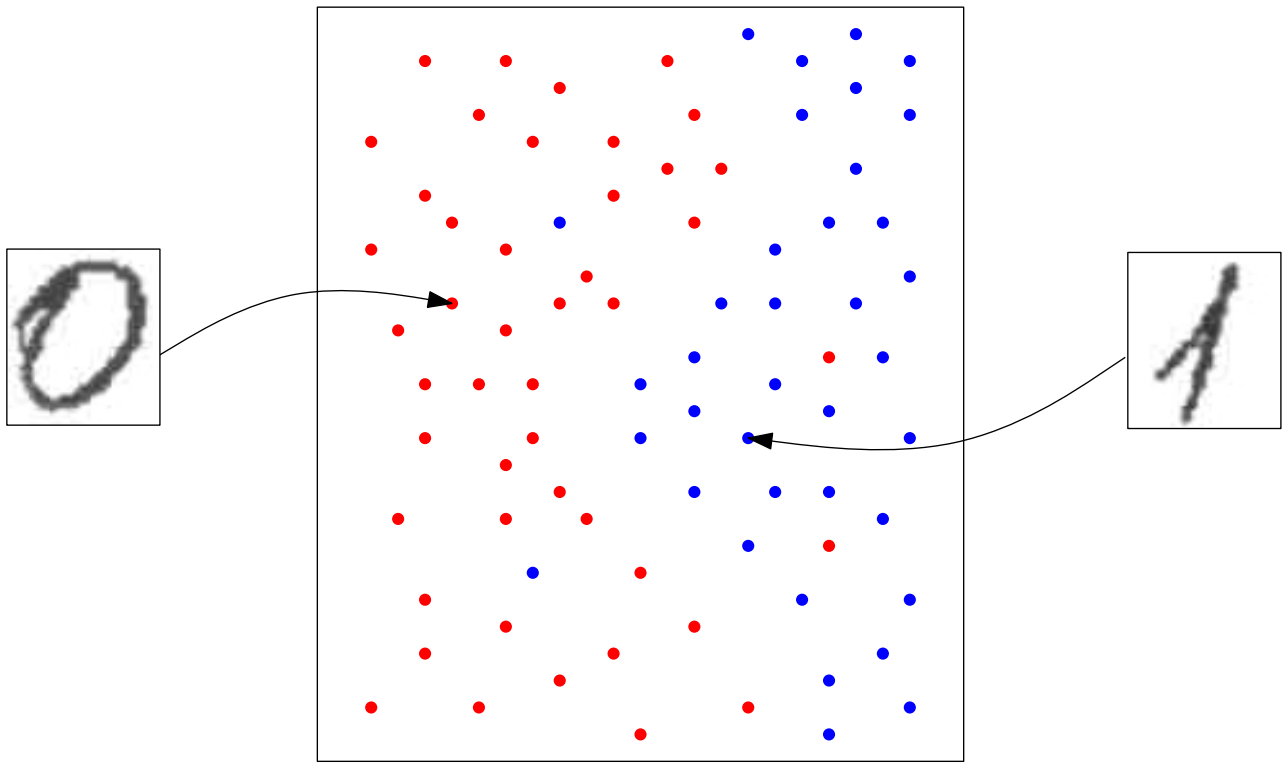
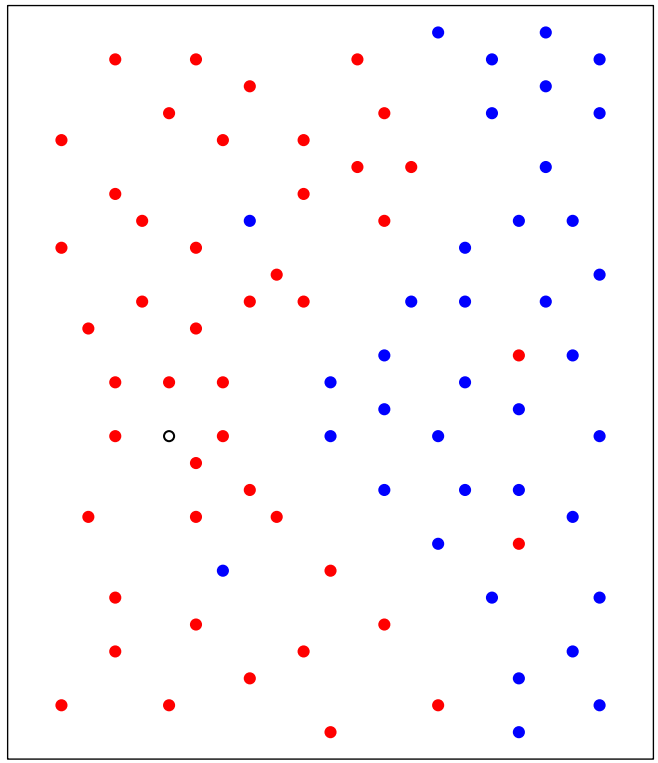
Machine Learning – Classification



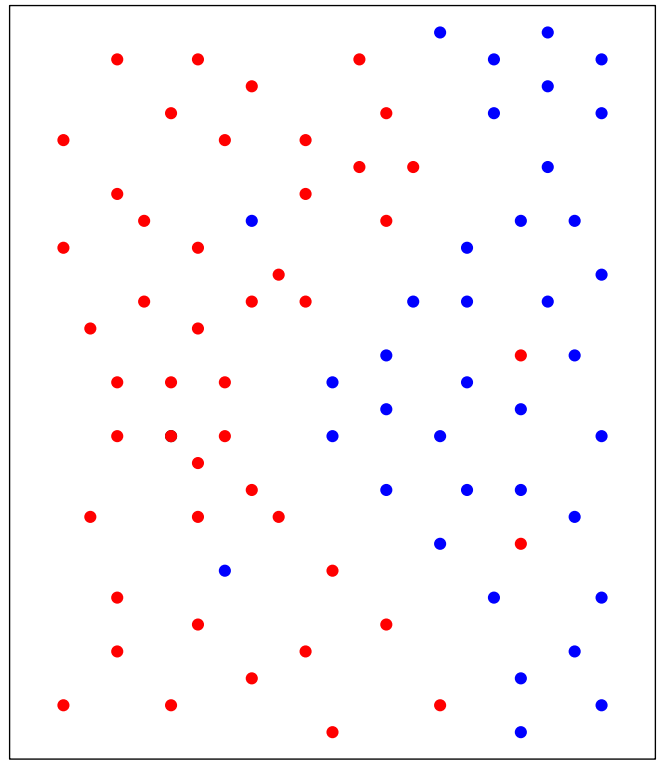
Machine Learning – Classification



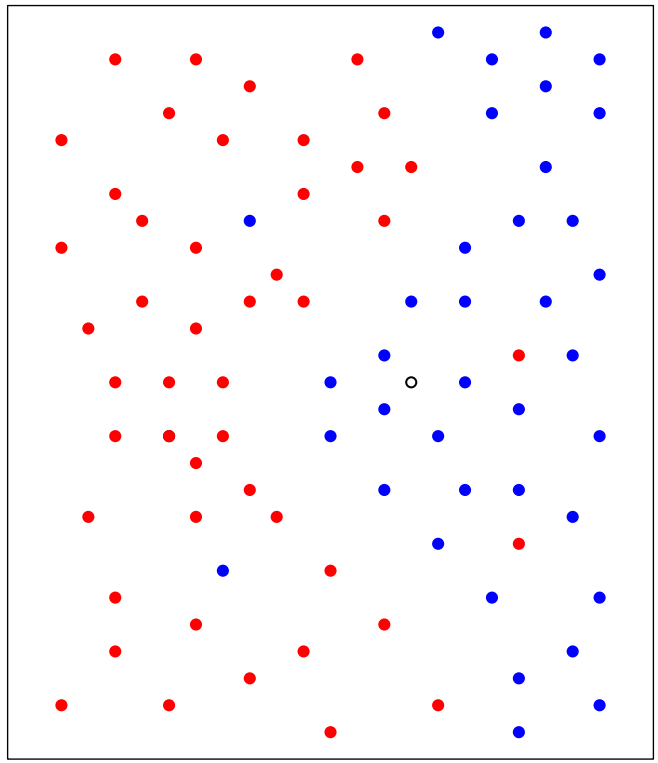
Machine Learning – Classification



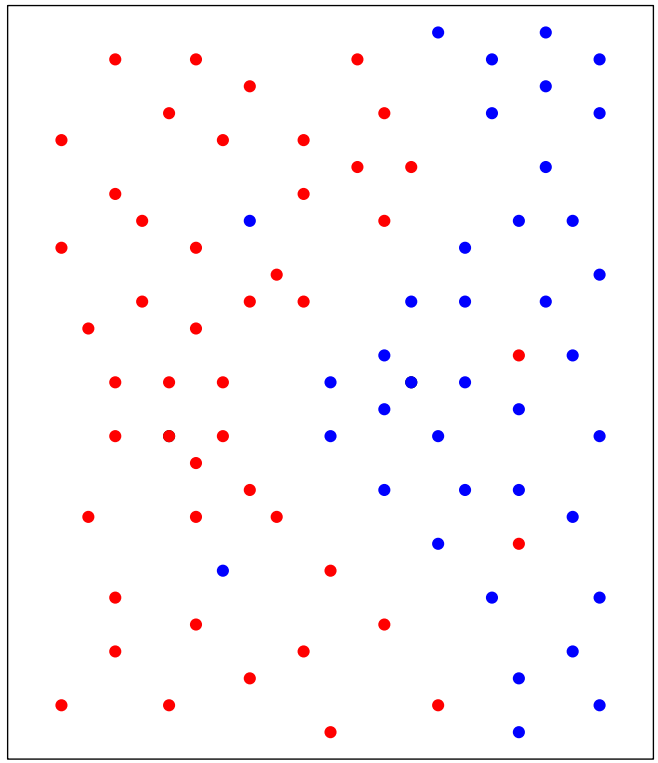
Machine Learning – Classification



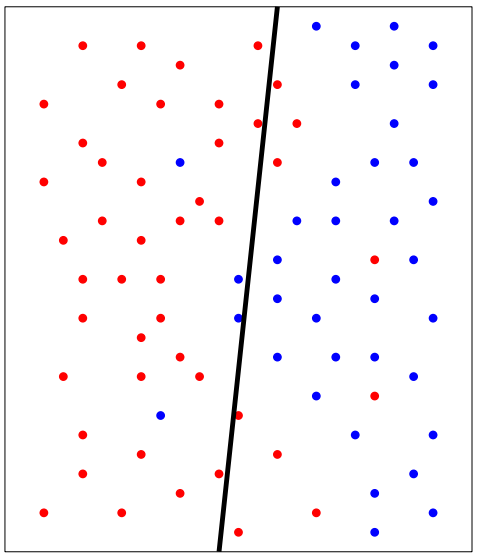
Machine Learning – Classification



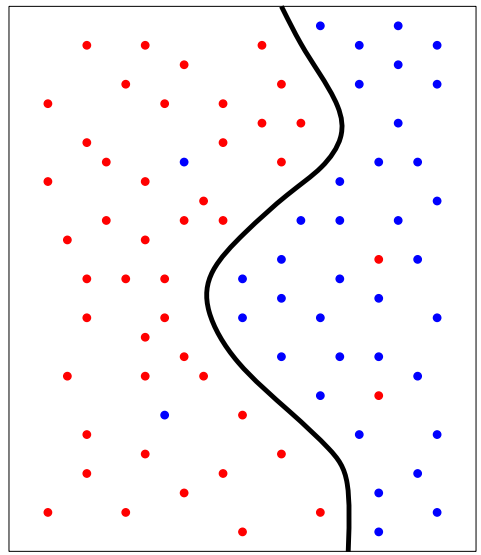
Machine Learning – Classification



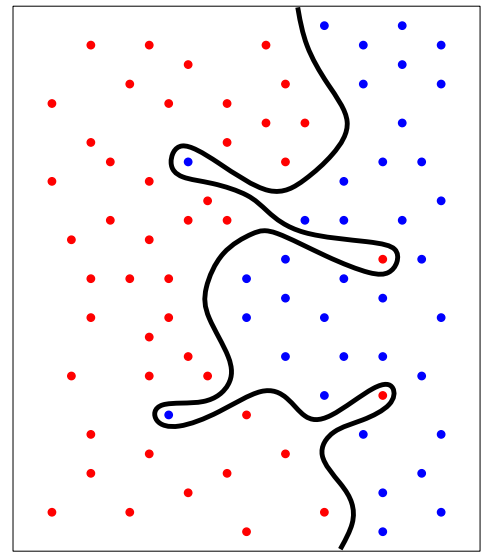
Machine Learning – Classification



underfitting



best classifier



overfitting

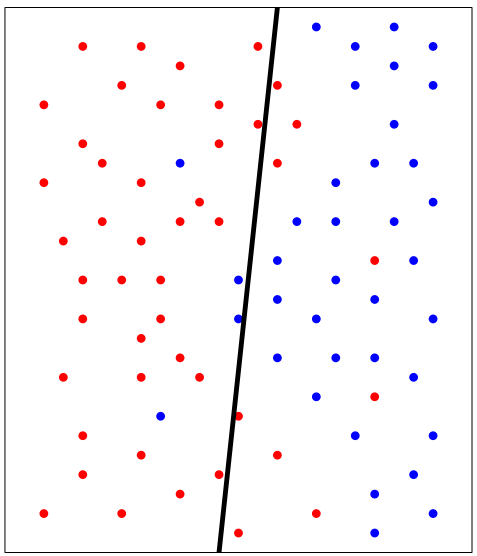
Support Vector Machine (SVM)

Support Vector Machine (SVM)
Primal Formulation

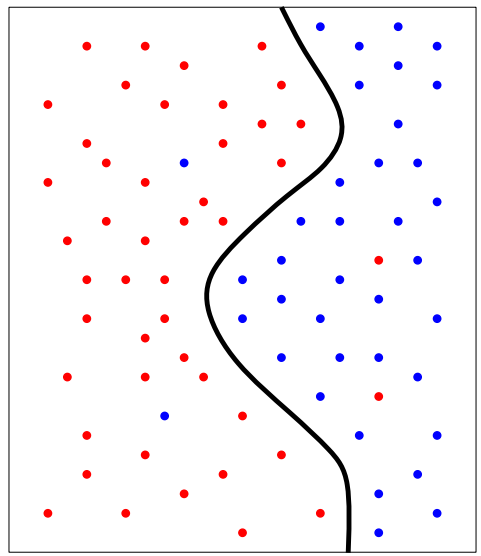
$$\begin{aligned} \min_{w,b,\xi} \quad & \frac{1}{2}\|\phi(w)\|^2 \quad + \quad c \quad \sum_i \xi_i^2 \\ \text{s.t.} \quad & y^{(i)}(\phi(w)^T \phi(x^{(i)}) + b) \geq 1 - \xi_i \end{aligned}$$

$\|w\|^2$ – model complexity
$\sum_i \xi_i^2$ – training error
c – regularization parameter

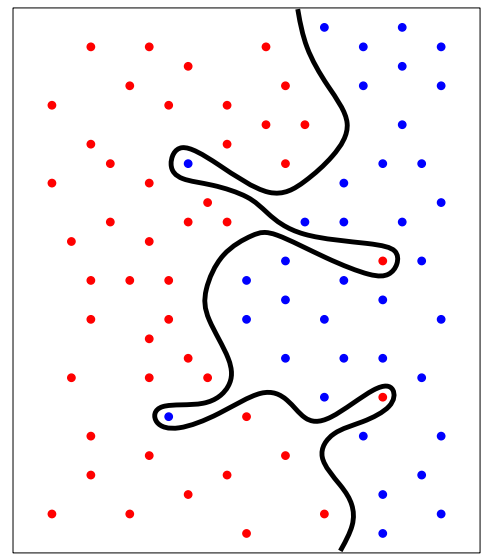
Regularization Parameter



$c = 10^{-3}$



$c = 10$



$c = 10^{4}$

Related SVM Solvers

- LibSVM [1]
- SVM Perf [5]
- Matlab Toolboxes, Weka, PyML, ...

These SVM solvers do not focus on regularization/hyper parameter paths.

CGL-SVM Solver

- Written in portable C++
- Command line interface and C++-API
- Cross platform Windows, Linux, Mac OS X
- Unit testing
- Matrix algebra using Eigen [4]

Capabilities

- Linear kernel, Gaussian kernel, kernel matrix, basis functions
- Efficient handling of linear kernel
- All solved using one primal solver

Joachim Giesen, Sören Laue, and Jens K. Mueller. "Basis Expansions for Support Vector Machines"

First Results

Regularization path for $c \in [2^{-4}, 2^{18}]$ with Gaussian kernel $k(x, y) = \exp(-\gamma \|x - y\|^2)$ for $\gamma = 0.5$

Dataset	#vectors × #features	LibSvm[1]	CGL-SVM
heart	270 × 13 d	2.0	2.1
breast cancer	683 × 10 d	2.4	3.4
w2a	3470 × 300 s	426.6	177.2
ionosphere	351 × 34 d	4.4	1.48
two spirals	400 × 2 d	45.7	3.34
mnist 01	2000 × 256 d	1117.6	374.9
a1a	1605 × 123 s	127.8	82.7

Measured on Intel(R) Core(TM)2 Duo CPU E8200 2.66GHz with 2GB RAM

[1] Version 3.11 (November 2011)

First Results II

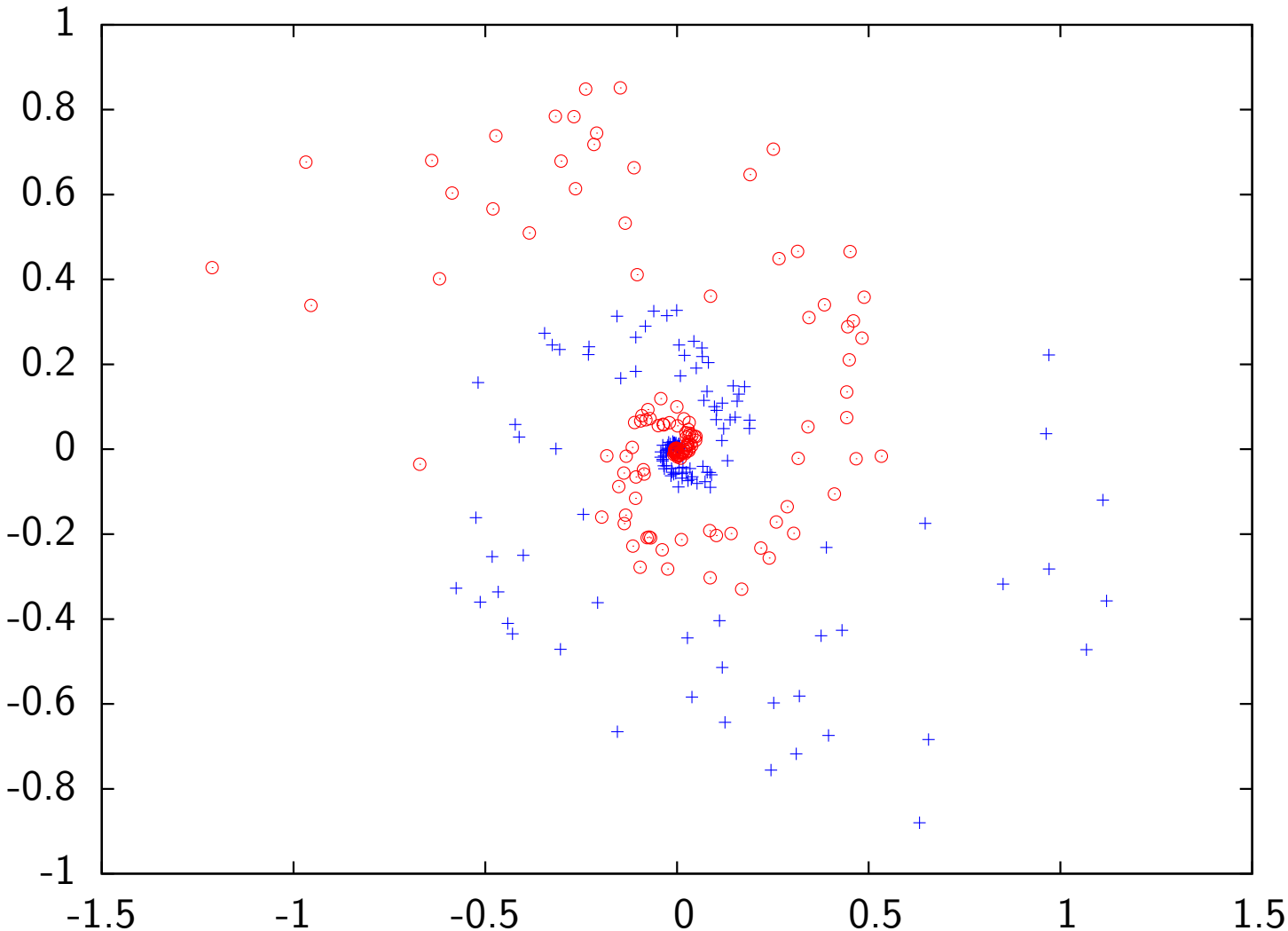
Regularization path for $c \in [2^{-4}, 2^{18}]$ with Gaussian kernel $k(x, y) = \exp(-\gamma \|x - y\|^2)$ for $\gamma = 0.25$

Dataset	#vectors × #features	LibSvm[2]	CGL-SVM
heart	270 × 13 d	1.8	2.9
breast cancer	683 × 10 d	2.2	2.7
w2a	3470 × 300 s	310.7	102.4
ionosphere	351 × 34 d	3.1	1.6
two spirals	400 × 2 d	31.3	1.7
mnist 01	2000 × 256 d	1079.1	125.5
a1a	1605 × 123 s	109.8	214.4

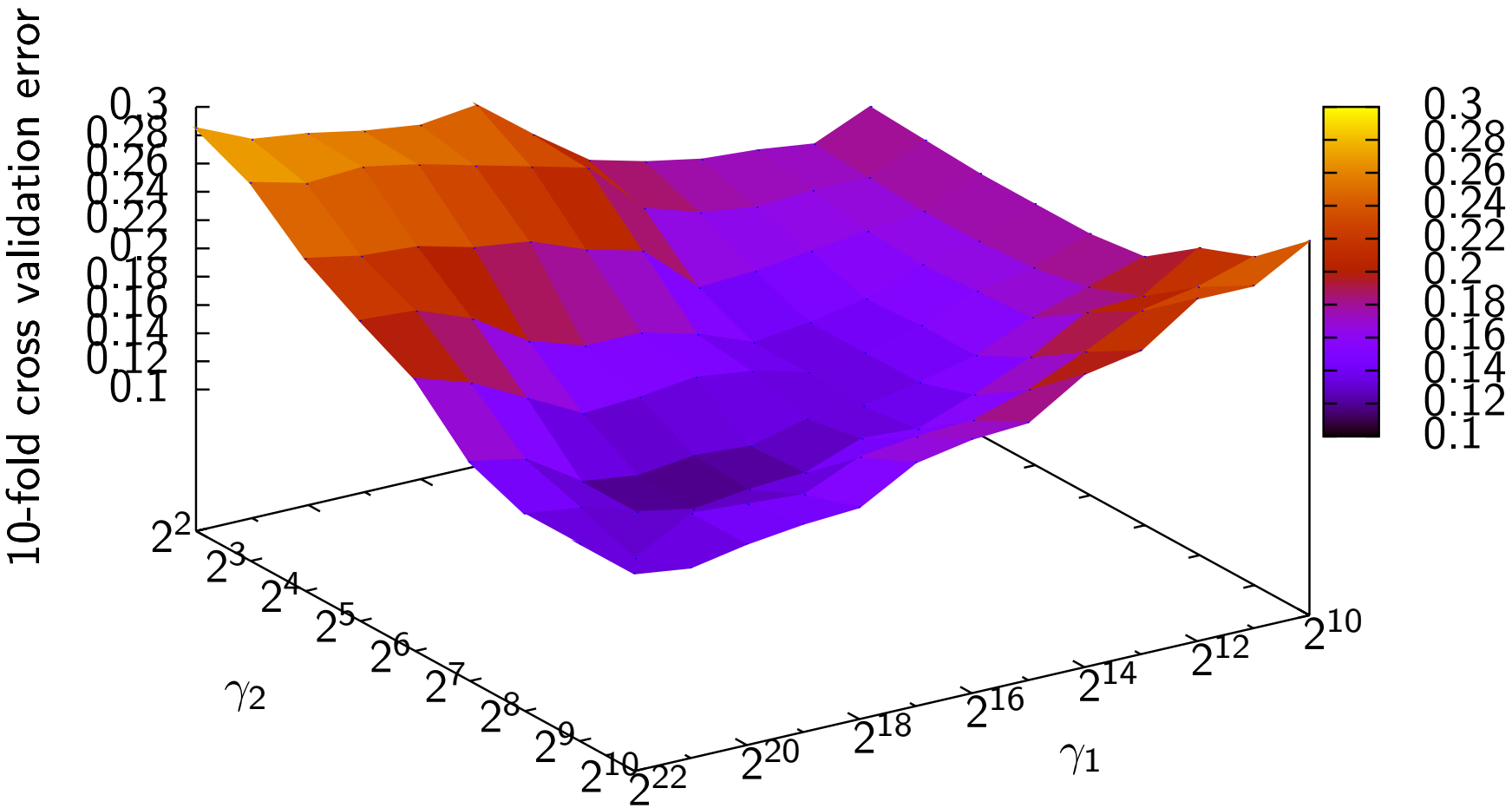
Measured on Intel(R) Core(TM)2 Duo CPU E8200 2.66GHz with 2GB RAM

[2] Version 3.11 (November 2011)

Two confocal spirals



Two Gaussians per data point



Demo

Two dimensional path over the hyper parameter γ and the regularization parameter c

Future and Current Work

- Stabilizing API and command line interface
- Approximate path solver
- Sparse vs. dense dataset
- Matlab Plugin

Joachim Giesen, Martin Jaggi, and Sören Laue. Approximating parameterized convex optimization problems. In: *Transactions on Algorithms* (to appear)

Thank you for your attention.

References

[1] Chih-Chung Chang and Chih-Jen Lin. LIBSVM: A library for support vector machines. In: *ACM Transactions on Intelligent Systems and Technology* 2 (3 2011). Software available at `http://www.csie.ntu.edu.tw/~cjlin/libsvm`, 27:1–27:27 (cit. on p. 11).

[2] Joachim Giesen, Martin Jaggi, and Sören Laue. Approximating parameterized convex optimization problems. In: *Transactions on Algorithms* (to appear) (cit. on p. 19).

[3] Joachim Giesen, Sören Laue, and Jens K. Mueller. "Basis Expansions for Support Vector Machines" (cit. on p. 13).

[4] Benoît Jacob, Gaël Guennebaud, et al. *Eigen*. 2011. URL: `http://eigen.tuxfamily.org` (cit. on p. 12).

[5] Thorsten Joachims. *SVM Perf*. URL: `http://svmlight.joachims.org/svm_perf.html` (cit. on p. 11).