Can Support Vector Machine be a Major Classification Method ?

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Motivation

- SVM: a hot machine learning issue
- However, not a major classification method yet

  KDNuggets 2002 Poll: Neural Networks, Decision trees remain main tools
- How to make SVM a major one ?

The Potential of SVM

- In my opinion, after careful data pre-processing

  Appropriately use NN or SVM $\Rightarrow$ similar accuracy

- But, users may not use them properly

- The chance of SVM

  Easier for users to appropriately use it

  The ambition: replacing NN on some applications

What Many Users are Doing Now

- Transfer data to the format of an SVM software
- May not conduct scaling
- Randomly try few parameters and kernels without validation
- Default parameters are surprisingly important
- If most users doing so, accuracy may not be satisfactory

We Hope Users At Least Do

- The following procedure
  1. Simple scaling (training and testing)
  2. Consider the RBF kernel

$$K(x, y) = e^{-\gamma \|x-y\|^2} = e^{-\|x-y\|^2/(2\sigma^2)}$$

     and find the best C and γ (or σ^2)

- Why RBF:
  - Linear kernel: special case of RBF [Keerthi and Lin 2003]
  - Polynomial: numerical difficulties
    $(< 1)^d \to 0, (> 1)^d \to \infty$
  - tanh: still a mystery
    In general not PD

In a coming paper [Lin and Lin 2003], for certain parameters, it behaves like RBF

Examples of the Proposed Procedure

- User 1:

  `I am using libsvm in a astroparticle physics application (AMANDA experiment). First, let me congratulate you to a really easy to use and nice package.`

  `Unfortunately, it gives me astonishingly bad results...`

- Answer:

  What is your procedure ?

- User 1:

  `I do for example the following steps (here for classification):`

  `./svm-scale -l -1. -u +1. TRAINING.DAT`

```
>TRAINING.SCALE.DAT
./svm-train -s 0 -t 2 -c 10 TRAINING.SCALE.DAT
./svm-predict TESTING_SIGNAL.SCALE.DAT
TRAINING.SCALE.DAT.model s_0_2_10.out
Accuracy = 75.2%
```

- Answer:

  OK. Send me the data

- Answer:

```
First I scale the training and testing TOGETHER:
/mnt/professor/cjlin/tmp% libsvm-2.36/svm-scale
total > total.scale
Then separate them again.
Using the model selection tool (cross validation) to
find out the best parameter:
/mnt/professor/cjlin/tmp%python grid.py train
```

```
sort the results:  (find the best cv accuracy)
/mnt/professor/cjlin/tmp% sort -k 3 train.out
.
2 1 96.9569
8 1 96.9569
so c = 4 and g = 1 might be the best.
Train the training data again:
/mnt/professor/cjlin/tmp/libsvm-2.36%./svm-train -m
300 -c 4 -g 2 ../train
Finally test the independent data:
/mnt/professor/cjlin/tmp/libsvm-2.36%./svm-predict
../testdata train.model o Accuracy = 97.3
```

- User 1:

  ```
  You earned a copy of my PhD thesis
  ```

- User 2:

I am a developer in a bioinformatics laboratory at ... We would like to use LIBSVM in a project ... The datasets are reasonable unbalanced - there are 221 examples in the first set, 117 in the second set and 53 in the third set.

But results not good

- Answer:

  Have you scaled the data ? What is your accuracy ?

- User 2: Yes, to [0,1]. 36%

- Answer:

  OK. Send me the data

- Answer:

  I am able to give 83.88% cv accuracy. Is that good enough for you ?

- User 2:

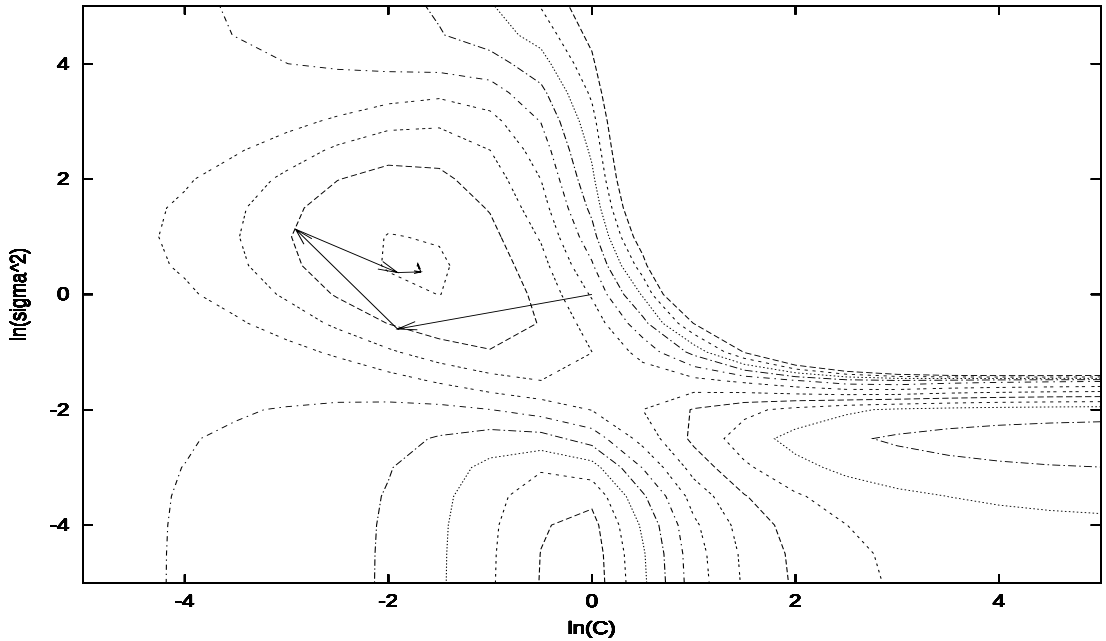
  83.88% accuracy would be excellent...

Model Selection is Important

- In fact, two-parameter search
- By bounds of loo
- By two line search
- By grid search

Bound of loo

- Many loo bounds
- Main reason: save computational cost
- Bounds where a path may be found



  - Radius margin bound
  - Span bound

- A recent paper [Chung et al. 2002] on radius margin bound
  - Minima in a good region more important than tightness

    Good bound should avoid that minima happen at the boundary (i.e., too small or too large C and σ^2)
  - Modification for L1-SVM
  - Differentiability

$$\min_{C,\sigma^2} f(\alpha(C, \sigma^2))$$

  - Reliable Implementation

	L1-SVM			L2-SVM		
	#fun	#grad	accuracy	#fun	#grad	accuracy
banana	9	6	88.96	8	5	88.53
image	17	13	96.24	11	6	97.03
splice	13	12	89.84	21	19	89.84
tree	8	8	86.50	8	8	86.54
waveform	16	13	88.57	8	7	89.83
ijcnn1	9	9	97.09	7	7	97.83

- A coming paper [Chang and Lin 2003]: non-smooth optimization techniques for bounds
  - Allow us to use more (i.e. non-differentiable) bounds
  - Sensitive analysis
  - Nonsmooth Optimization

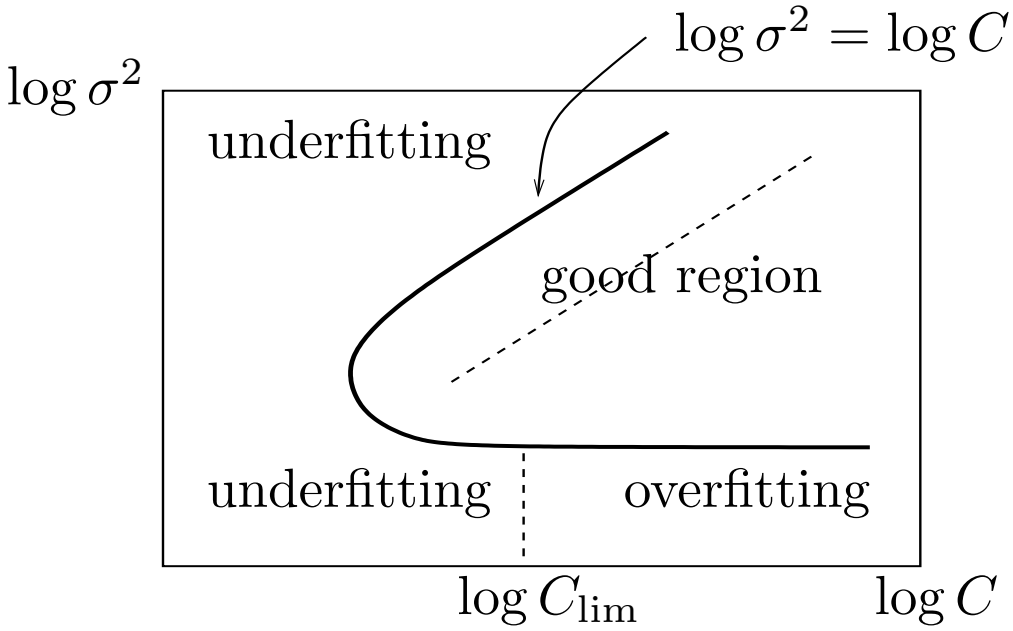
– Boundle (cutting plane) methods

Piecewise diff. $\rightarrow$ Semi-smooth $\nearrow$ Directionally diff.

$\searrow$ Locally Lipschitz cont.

Two Line Searches

- CV (loo) contour of RBF kernel [Keerthi and Lin 2003]:



- When σ^2 large

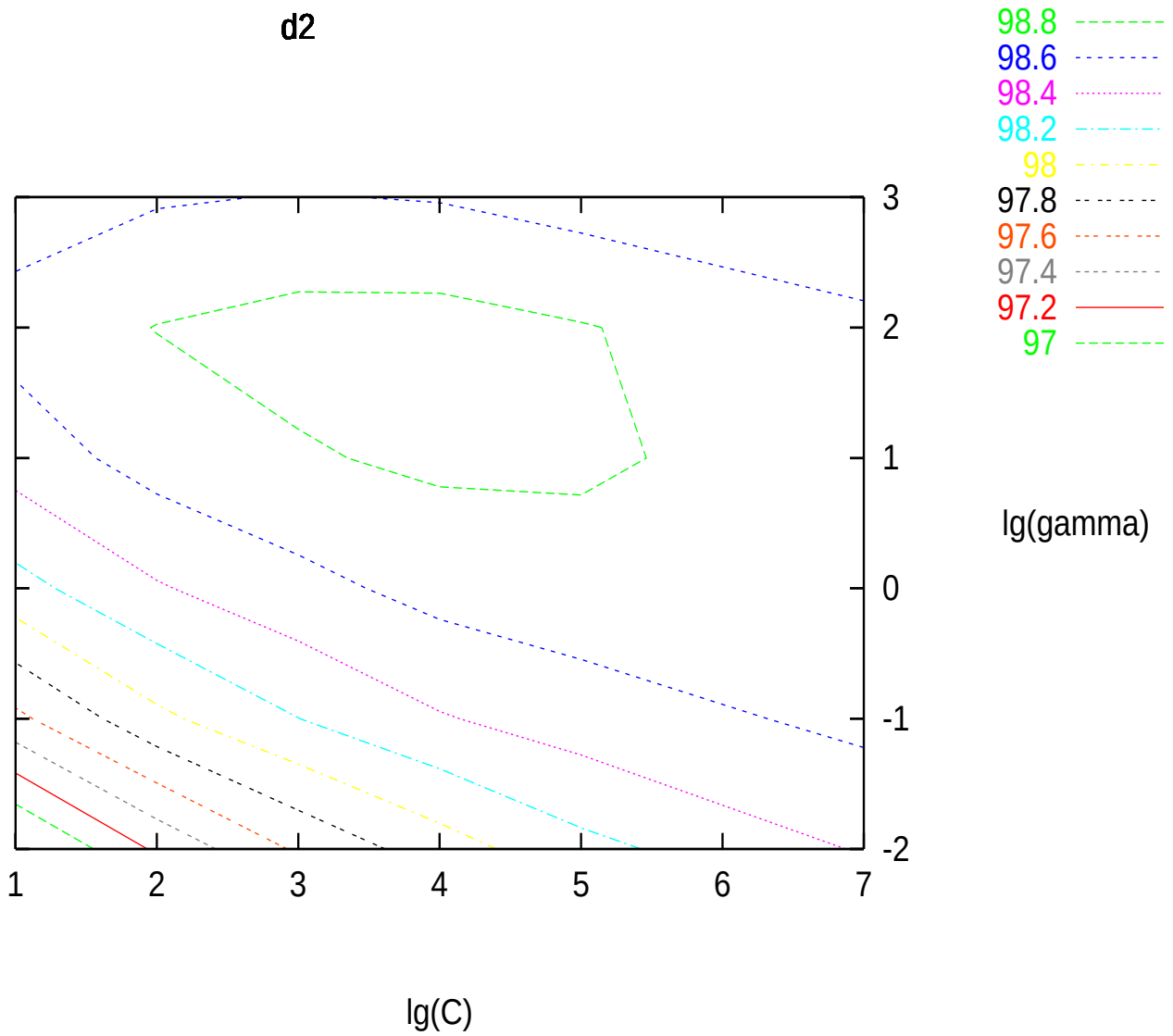
$$(C, \sigma^2) \text{ of RBF} \equiv C/\sigma^2 \text{ of linear}$$

- A heuristic for model selection
  1. Search for the best C of Linear SVM and call it $\tilde{C}$.

2. Fix $\tilde{C}$ and search for the best (C, σ^2) satisfying $\log \sigma^2 = \log C - \log \tilde{C}$ using RBF

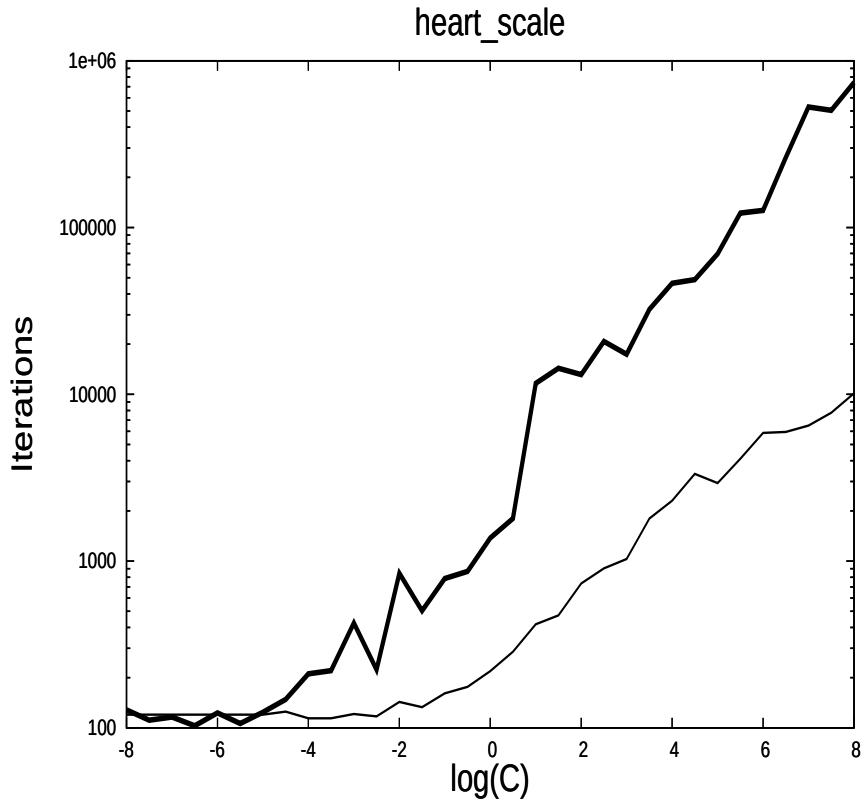
Problem	n	#test	Test error of grid method	Test error of new method
banana	400	4900	0.1235 (6,-0)	0.1178 (-2,-2)
image	1300	1010	0.02475 (9,4)	0.02475 (1,0.5)
splice	1000	2175	0.09701 (1,4)	0.1011 (0,4)
ringnorm	400	7000	0.01429(-2,2)	0.018 (-3,2)
twonorm	400	7000	0.031 (1,3)	0.02914 (1,4)
tree	700	11692	0.1132 (8,4)	0.1246 (2,2)
adult	1605	29589	0.1614 (5,6)	0.1614 (5,6)
web	2477	38994	0.02223 (5,5)	0.02223 (5,5)

- 441 verses 54 SVMs


d2
98.8
98.6
98.4
98.2
98
97.8
97.6
97.4
97.2
97
3
2
1
0
-1
-2
1
2
3
4
5
6
7
lg(gamma)
lg(C)

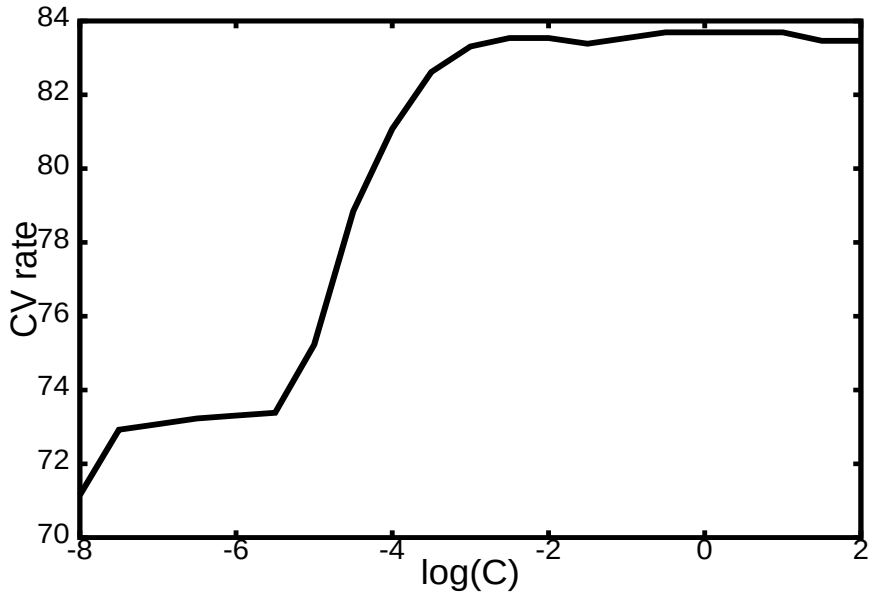
However, I Prefer Simple Grid Search

- Reasons for not using bounds (if two parameters)
  - Psychologically, not feel safe
  - In practice: IJCNN competition:
    97.09% and 97.83% using RM bounds for L1 and L2-SVM
    98.59% using 25-point grid
    2668, 1990, and 1293 testing errors
  - Useful if more than 2 parameters
- About two-line search:
  - Solving linear not as easy as we thought:



– A paper [Chung et al. 2003]: efficient decomposition methods for linear SVMs

– Decision of the best C for linear SVMs sometimes ambiguous



  - After $C \geq C^*$, everything is the same

- We propose that users do
  - Start from a loose grid
  - Identify good regions and finer grid
- The grid search tool in libsvm
- Easy parallelization

  Every problem is independent

loo bounds: 20 steps $\Rightarrow$ more time than 10×10 grids with five computers

Automatic load balancing

- No need for α-seeding, passing cache etc.
- This simple tool
  - Enough for median-sized problems
  - Advantage of having only one figure for multi-class problems
- Further improvement

  Possible but many considerations

Challenges

- Using this, if for enough problems, satisfactory results obtained

  $\Rightarrow$ then SVM can be a major method eventually

  How do we ask users to at least do this ?

  How do we know if it is or not ?

- If not

  What is the next general thing to be added for users ?