# libSVM

LING572

Fei Xia

# Documentation

- http://www.csie.ntu.edu.tw/~cjlin/libsvm/

- The libSVM directory on Patas:
  /NLP_TOOLS/ml_tools/svm/libsvm/latest/
  - README
  - FAQ.html
  - svm-train, svm-predict, etc.

- More info:
  - A practical guide to support vector classification
  - LIBSVM : a library for support vector machines

# Steps for using libSVM

- Define features in the input space (if use one of the pre-defined kernel functions)
- Scale the data before training/test
- Choose a kernel function
- Tune parameters using cross-validation

# Main commands

- svm-scale: scaling the data
- svm-train: training
- svm-predict: decoding

# Scaling the data

- To avoid features with larger variance to dominate those with smaller variance.

- Scale each feature to the range [-1,+1] or [0,1].
  - [0,1] is faster than [-1,1]

# svm-scale

- svm-scale -l -1 -u 1 -s range_file  training_data > training_data.scale
- svm-scale -r  range_file test_data >  test_data.scale
- Scale feature values to [-1, 1] or [0,1]
- No need to scale the data for Hw8.

# svm-train

- svm-train [options] training_data model_file

- Options:
  -t [0-3]: kernel type
  -g gamma: used in polynomial, RBF, sigmoid
  -d degree: used in polynomial
  -r coef0: used in polynomial, sigmoid

- Type “svm-train” to see options

# Kernel functions

-t kernel_type : set type of kernel function (default 2)

0: linear: u'*v

1: polynomial: (gamma*u'*v + coef0)^degree

2: RBF: exp(-gamma*|u-v|^2)

3: sigmoid: tanh(gamma*u'*v + coef0)

# svm-predict

- svm-predict test_data model_file output_file
- svm-predict produces only the system prediction in output_file.
- You will implement your own decoder in Hw8.

# The format of training/test data

- Sparse format: no need to include features with value zero.

- Mallet format:

  truelabel f1: v1 f2: v2 …..

- libSVM format:

  truelabel_idx feat_idx1:v1 feat_idx2:v2 ….

  (feat_idx, v) is sorted according to feat_idx in ascending order.

  Ex: 1 20:1 23:0.5 34:-1 …

# When there are two classes

# The format of the model file

svm_type c_svc
kernel_type rbf
gamma 0.5
nr_class 2
total_sv 535
rho 0.281122
label 0 1
nr_sv 272 263
SV
0.98836 0:1 1:1 2:1 3:1 4:1 5:1 ...
...

This is weight for the support vector, which is equal to $\alpha_i y_i$.

This is a support vector with the format f1:v1 f2:v2 ...

# Classifying an instance x

$$f(x) = \sum_i \alpha_i y_i K(x_i, x) - \rho$$
$$= \sum_i weight_i \, K(x_i, x) - \rho$$

where $y_i$ (i.e., $x_i$'s label) is +1 ("$c_0$") or -1 ("$c_1$").

if $f(x) > 0$

then label it with $c_0$

else label it with $c_1$

# Notation differences

| | In SVM paper | In libSVM |
|---|---|---|
| Model | $x_i$, $y_i$, $\alpha_i$<br>$b$ | $weight_i$, $x_i$<br>$\rho$ |
| Prediction | $\sum_i \alpha_i y_i K(x_i, x) + b$ | $\sum_i weight_i K(x_i, x) - \rho$ |
| Representing $y_i$ in training/test/output | +1<br>-1 | 0<br>1 |

# System output of svm-predict

0 $\#\# \ c_0$

0

1 $\#\# \ c_1$

1

0

0

1

0

# Additional slides

# When there are C classes

# Handling a multi-class task

- All-pair
- Build a classifier for every ($c_m$, $c_n$) pairs
  - There are C(C-1)/2 classifiers
- The classifiers are stored in a compact format.

# The format of the model file (when there are C>2 classes)

svm_type c_svc
kernel_type rbf
gamma 0.5
nr_class 3
total_sv 2698
rho -0.0111642 -0.00216906 0.00951624
label 0 1 2
nr_sv 900 898 900
SV
0.98836 0.9975 0:1 1:1 2:1 3:1 4:1 5:1 …
…

# The rho array

It contains C(C-1)/2 elements, one per classifier

0 vs. 1, 0 vs. 2, …, 0 vs. C-1,

1 vs. 2, 1 vs. 3, …, 1 vs. C-1

2 vs. 3, …, 2 vs. C-1

…

C-2 vs. C-1

# The format of the SV line

Each line includes C-1 weights (i.e., $y_i \ \alpha_i$) followed by the vector.

w1 w2 … $w_{C-1}$ f1:v1 f2:v2 ….

Suppose the current vector belongs to the i-th class, the weights are ordered as follows:

0 vs. i  1 vs. i  2 vs i  ….  i-1 vs i

i vs. i+1  i vs i+2  i vs i+3  ….  i vs C-1

Ex1: i=0

0 vs. 1, 0 vs. 2, 0 vs. 3, …., 0 vs. C-1

Ex2: i=4

0 vs 4, 1 vs 4, 2 vs. 4, 3 vs. 4, 4 vs. 5, 4 vs. 6, …, 4 vs. C-1

# Classifying an instance x

win[m]=0 for every class m

For each classifier for (m,n)

$$f(x) = \sum_i \alpha_i y_i K(x_i, x) - \rho$$

$$= \sum_i weight_i \; K(x_i, x) - \rho$$

where $x_i$ is a training instance with label $c_m$ or $c_n$.

if $f(x) > 0$

then $win[m]{+}{+}$

else $win[n]{+}{+}$

$\text{sysLabel} = \arg\, max_m \; win[m]$

To classify x with a m-vs-n classifier (m < n):

$\rho$ is stored at what position?

For each $x_i$ belonging to $c_m$

## 0 vs. m, 1 vs. m, ..., m-1 vs. m,

## m vs. m+1, m vs. m+2, ..., m vs. n, ...

the weight for m-vs-n is stored at position n-1

For each $x_i$ belonging to $c_n$

## 0 vs. n, 1 vs. n, 2 vs. n, ..., m vs. n, ...

the weight for m-vs-n is stored at position m