Contents

Tai Duc Nguyen - ECEC 487 - 10/26/2019

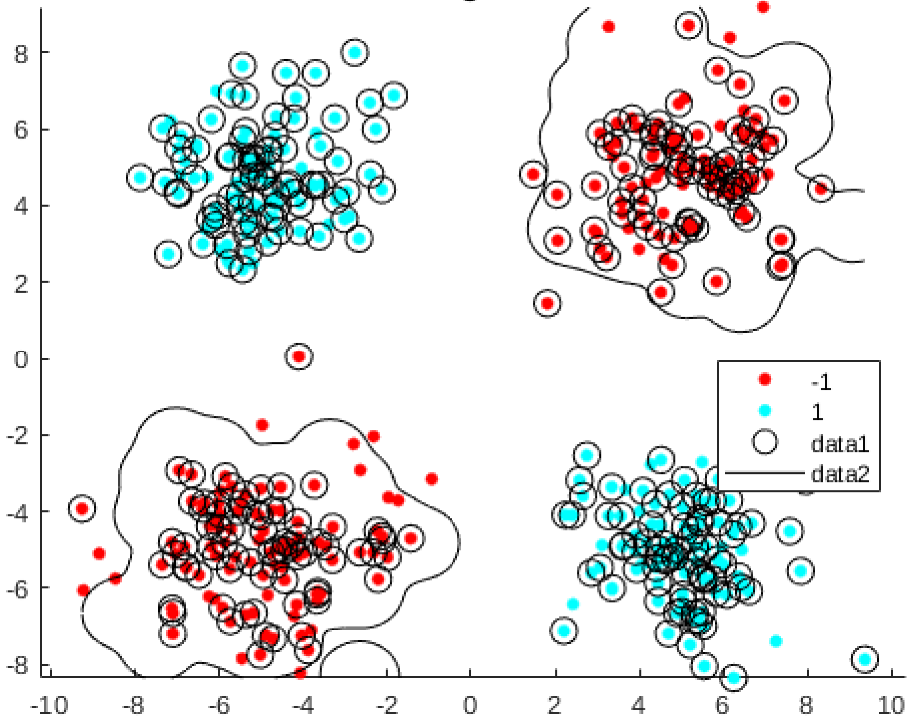
```
close all; clear all;
```

Problem 4.6 Page 248

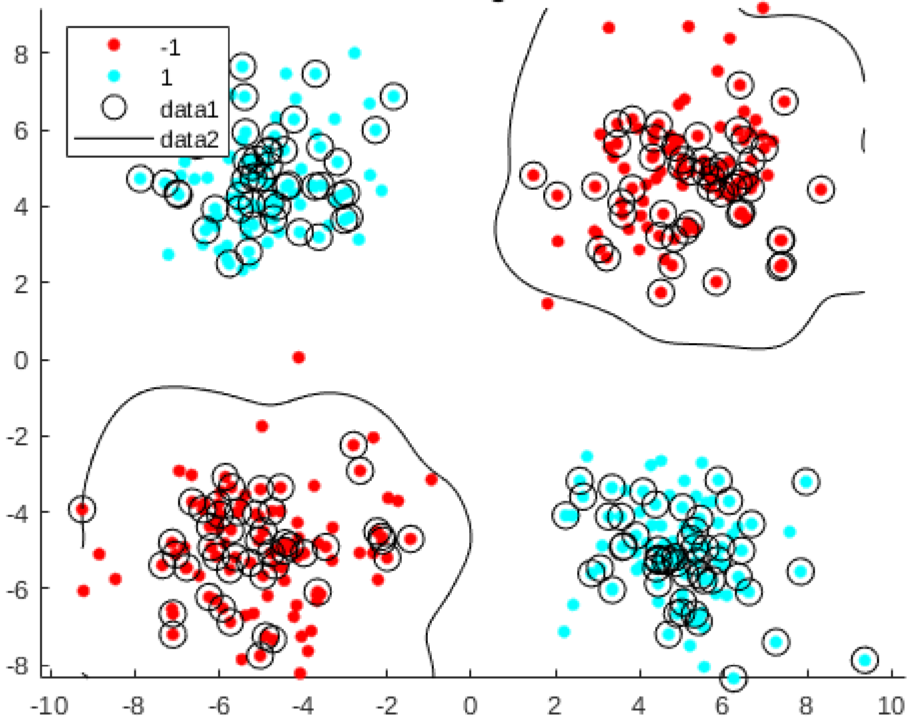
```
m = [-5 5 5 -5; 5 -5 5 -5];
s = 2;
N = 100;

randn('seed',0);
[x1, y1] = data_generator(m,s,N);

randn('seed',10);
[x2, y2] = data_generator(m,s,N);

tol = 0.001;

C = [1 100 1000 1000];
sigma = [0.5 1 2 4];
```

Use example code for plotting the support vectors from https://www.mathworks.com/help/stats/fitcsvm.html#bvdn8ei-1

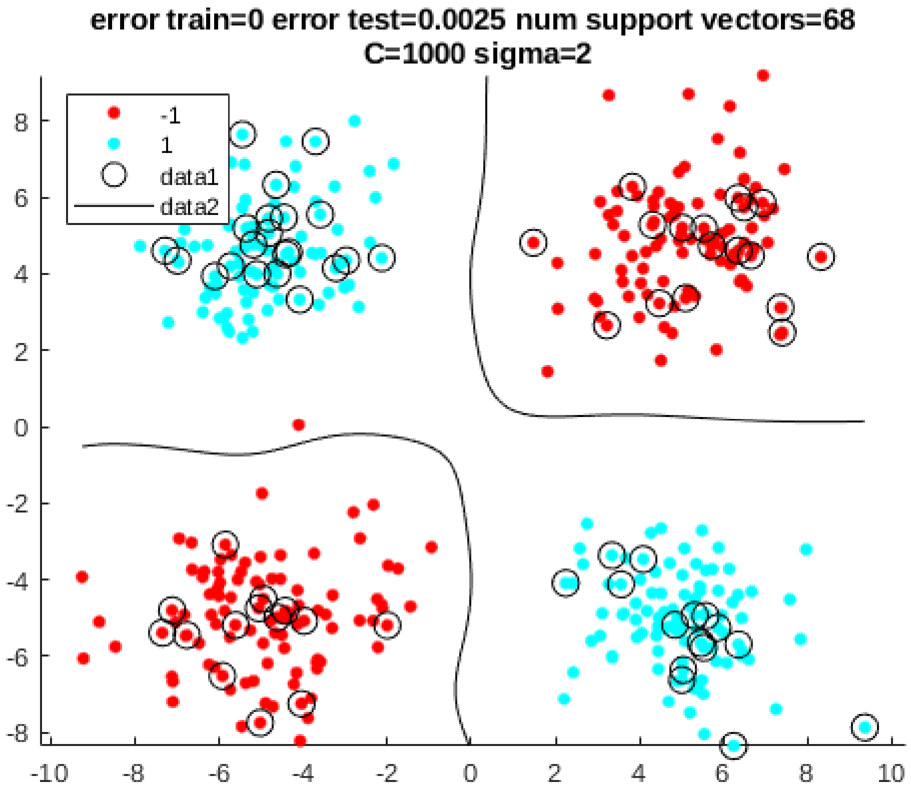
```
d = 0.02;
[x1Grid,x2Grid] = meshgrid(min(x2(1,:)):d:max(x2(1,:)),...
    min(x2(2,:)):d:max(x2(2,:)));
xGrid = [x1Grid(:),x2Grid(:)];

for i=1:length(C)
    [svm,pe_tr,pe_te] = SVM_class(x1,y1,x2,y2,tol,C(i),sigma(i));

    [~,scores1] = predict(svm,xGrid);
    figure
    hold on
    h(1:2) = gscatter(x2(1,:),x2(2,:),y2);
    h(3) = plot(x2(1,svm.IsSupportVector),x2(2,svm.IsSupportVector),'ko','MarkerSize',10);
    % Support vectors
    contour(x1Grid,x2Grid,reshape(scores1(:,2),size(x1Grid)),[0 0],'k');
    title({['error train=',num2str(pe_tr),' error test=',num2str(pe_te),...
        ' num support vectors=',num2str(length(svm.SupportVectors))],...
        [' C=',num2str(C(i)),' sigma=',num2str(sigma(i))]});
    hold off
end
```

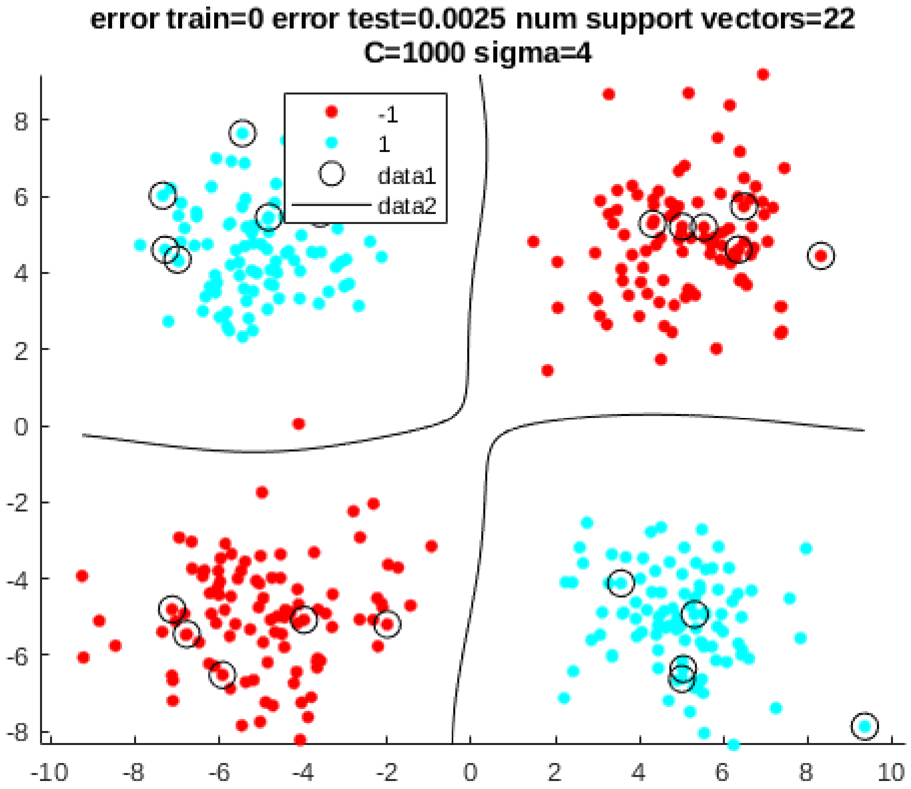


error train=0 error test=0.03 num support vectors=320
C=1 sigma=0.5



error train=0 error test=0.0075 num support vectors=201
C=100 sigma=1


error train=0 error test=0.0025 num support vectors=68
C=1000 sigma=2


error train=0 error test=0.0025 num support vectors=22
C=1000 sigma=4

Decision Tree Exercise

```
% This excercise will be completed with a larger dataset because the
% prunning effect is not easy to be seen when the dataset is small.
```

```
randn('seed',0);
[x1, y1] = data_generator(m,s,N*1000);

randn('seed',10);
[x2, y2] = data_generator(m,s,N*1000);


maxSplit = 100;

dectree = fitctree(x1',y1','MaxNumSplits',maxSplit);
train_res = predict(dectree,x1');
pe_tr = sum(y1'~=train_res)/length(y1);

L = max(dectree.PruneList);

er = zeros(max(dectree.PruneList),1);

test_res = predict(dectree,x2');
pe_te = sum(y2'~=test_res)/length(y2);

er(1) = pe_te;

for j=2:max(dectree.PruneList)
    dectree = prune(dectree,'level',1);
    test_res = predict(dectree,x2');
    pe_te = sum(y2'~=test_res)/length(y2);
    er(j) = pe_te;
end
figure
hold on
er_t = 0:1:L-1;
plot(er_t,er)
title({['training error is: ', num2str(pe_tr)],...
    ['Plot of test set error vs. pruning level']})
xlabel('Pruning Level');
ylabel('Test Set Error')
[v,i] = min(er);
plot(er_t(i),er(i),'ko','MarkerSize',10);
text(er_t(i),er(i),['(' num2str(er_t(i)) ',  ' num2str(er(i)) ')'])
```

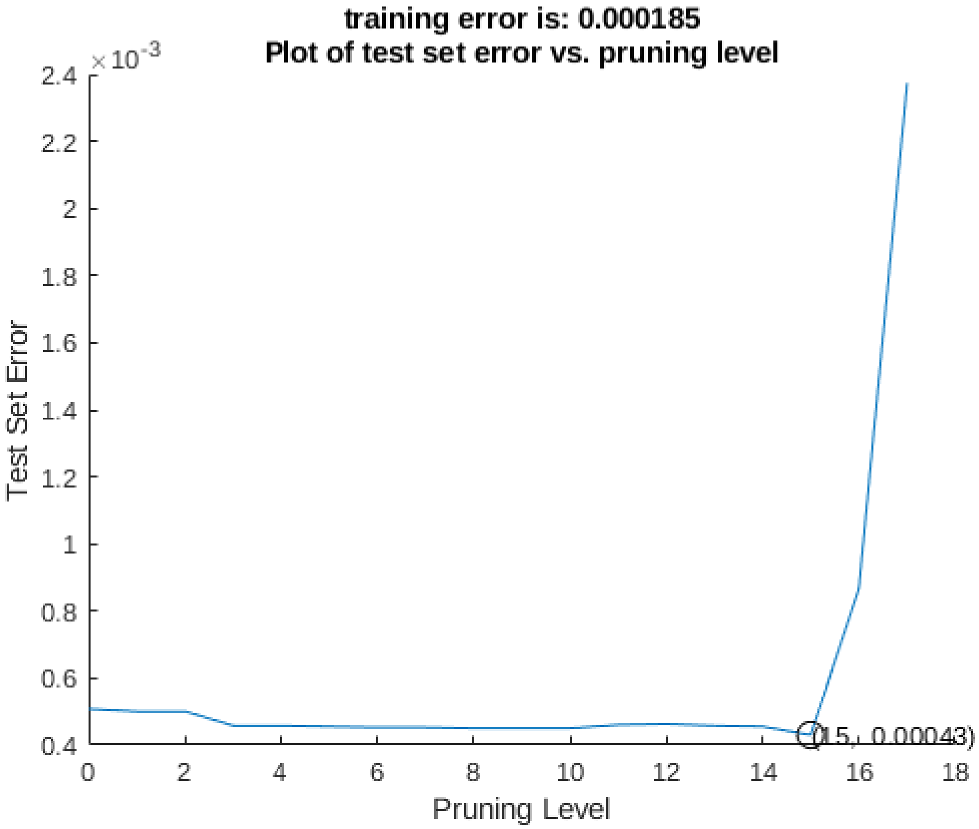
Conclusions from previous Exercises

The Support Vector Machine algorithm is evaluated with different number of C (box constraint) and sigma (kernel scale). It is apparent that increasing C will result in a lesser number of support vectors. The same relationship also applies for sigma.

```
% From the experiment above, the lowest error test of the SVM is 0.0025
% with a dataset of 400 points.
% However, the Decision Tree algorithm results in a much lower error rate
% 0.00043 for a larger dataset of 400*1000=400,000 points.
% With regards to the Decision Tree algorithm, the pruning level does have
% an impact to the accuracy, however, dependent on the split-level and the
% minimum leaf size after training because if the depth of the tree is
% shallow, then removing leaves will remove necessary decisions. Hence, the
% code above chose a large dataset and the maximum number of split is high
% (100).
```

[Function] Using the data generation procedures from textbook CX 4.2 Page 244-245

```
function [x,y] = data_generator(m,s,N)
    S = s*eye(2);
    [l,c] = size(m);
    x = []; % Creating the training set
    for i = 1:c
        x = [x mvnrnd(m(:,i)',S,N)'];
    end
    y=[ones(1,N) ones(1,N) -ones(1,N) -ones(1,N)];
end
```



[Function] Using the SVM Classifier from textbook CX 4.5 Page 247 with modifications

```
function [svm,pe_tr,pe_te] = SVM_class(X1,y1,X2,y2,tol,C,sigma)
    svm = fitcsvm(X1', y1','KernelFunction','rbf',...
    'KernelScale',sigma,'BoxConstraint',C,...
    'Solver','SMO','KKTTolerance',tol,...
    'IterationLimit',20000,'CacheSize',10000);

    %Computation of the error probability
    train_res = predict(svm,X1');
    pe_tr = sum(y1'~=train_res)/length(y1);
    test_res = predict(svm,X2');
    pe_te = sum(y2'~=test_res)/length(y2);
end
```

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