

# CAB420 Machine Learning - Assignment 2 Report

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## Support Vector Machines

```
% Clear everything and turn off the warning
clc; clear all; close all;
warning('off','all');

% Load the datasets
svm_data = load('data_ps3_2.mat');
% Training Data
set1_train = svm_data.set1_train; % Set 1
set2_train = svm_data.set2_train; % Set 2
set3_train = svm_data.set3_train; % Set 3
set4_train = svm_data.set4_train; % Set 4

% Testing Data
set1_test = svm_data.set1_test; % Set 1
set2_test = svm_data.set2_test; % Set 2
set3_test = svm_data.set3_test; % Set 3
set4_test = svm_data.set4_test; % Set 4
```

### Part 1:

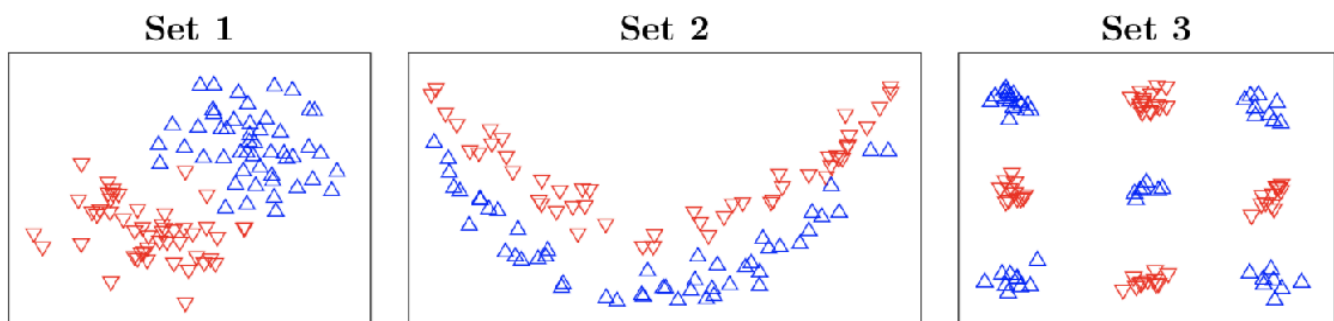


Figure 1: The 2-dimensional datasets of three sets

From the figure above, it is considered that the best kernels for training SVM classifiers on first, second and third datasets are linear, polynomial and Gaussian kernels respectively.

```
% For the first three datasets, consider the linear, second
% order polynomial, Gaussian of standard deviation 1 kernels
% Use C = 1000 for consistency
```

```
% Use linear kernels for dataset 1
svm_test(@Klinear,[],1000,set1_train,set1_test);
```

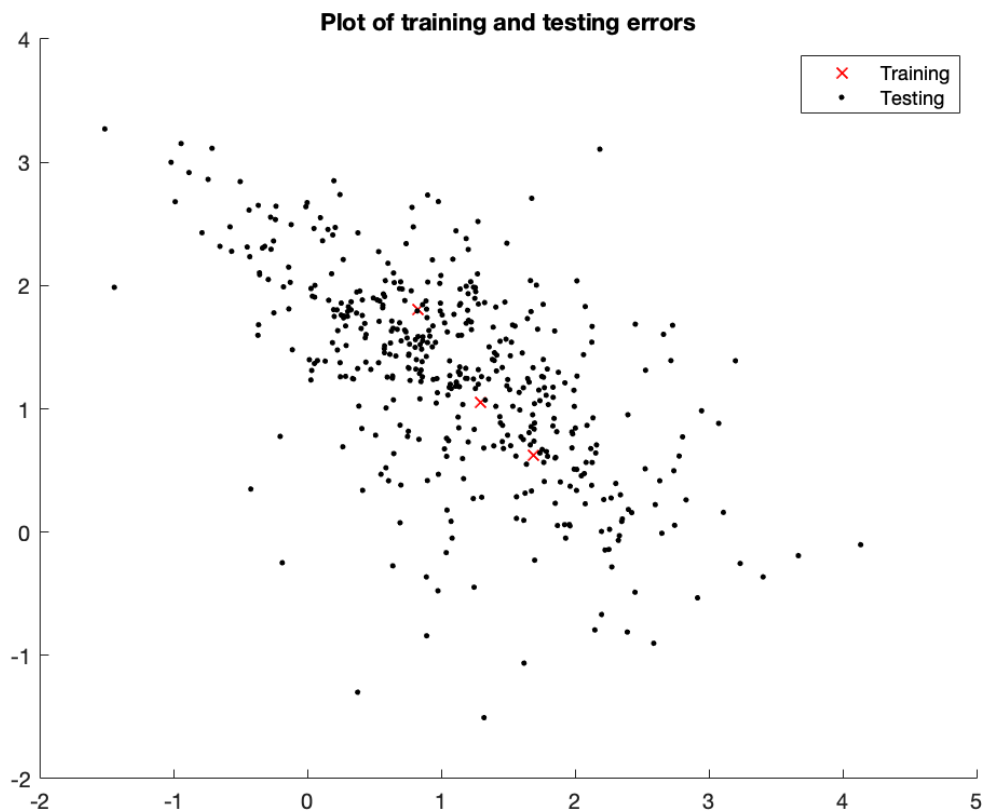
The interior-point-convex algorithm does not accept an initial point.  
Ignoring X0.

Minimum found that satisfies the constraints.

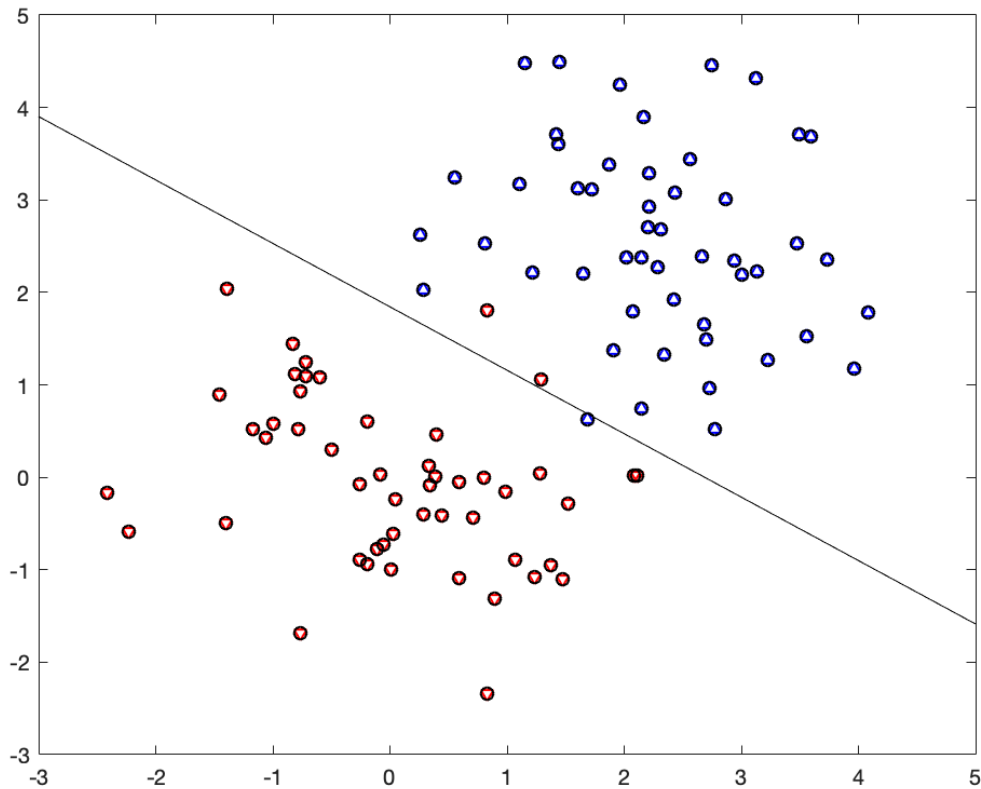
Optimization completed because the objective function is non-decreasing in  
feasible directions, to within the default value of the optimality tolerance,  
and constraints are satisfied to within the default value of the constraint tolerance.

<stopping criteria details>

WARNING: 3 training examples were misclassified!!!



TEST RESULTS: 0.0446 of test examples were misclassified.



```
% Use second order kernels for dataset 2
svm_test(@Kpoly,2,1000,set2_train,set2_test);
```

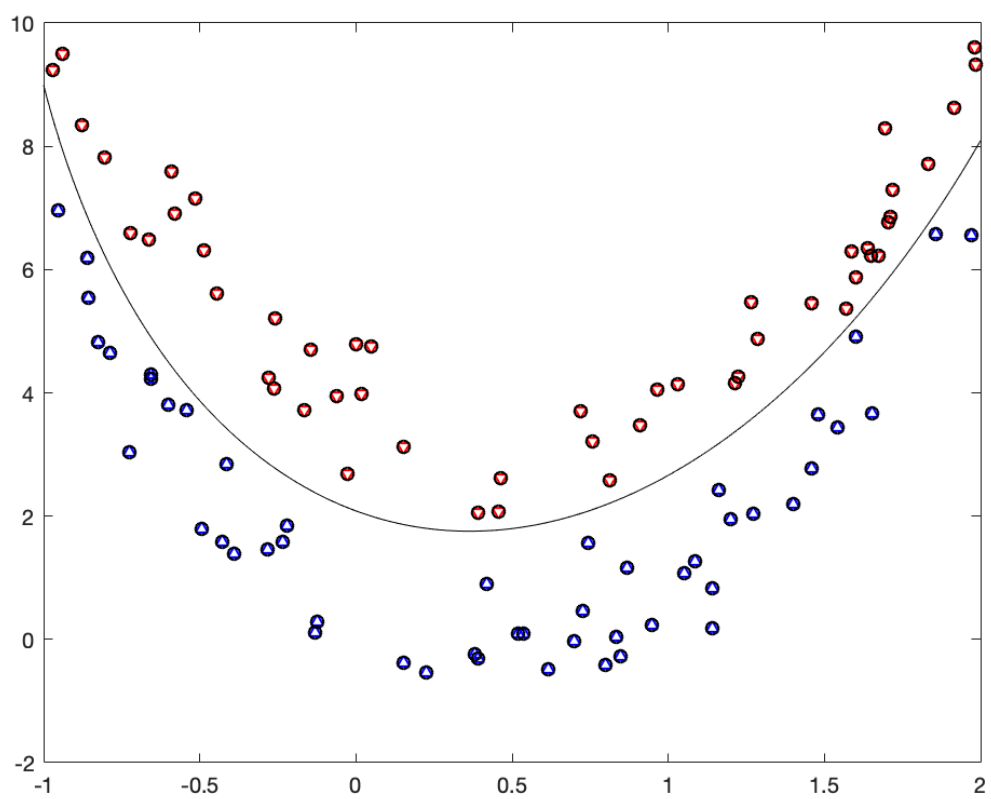
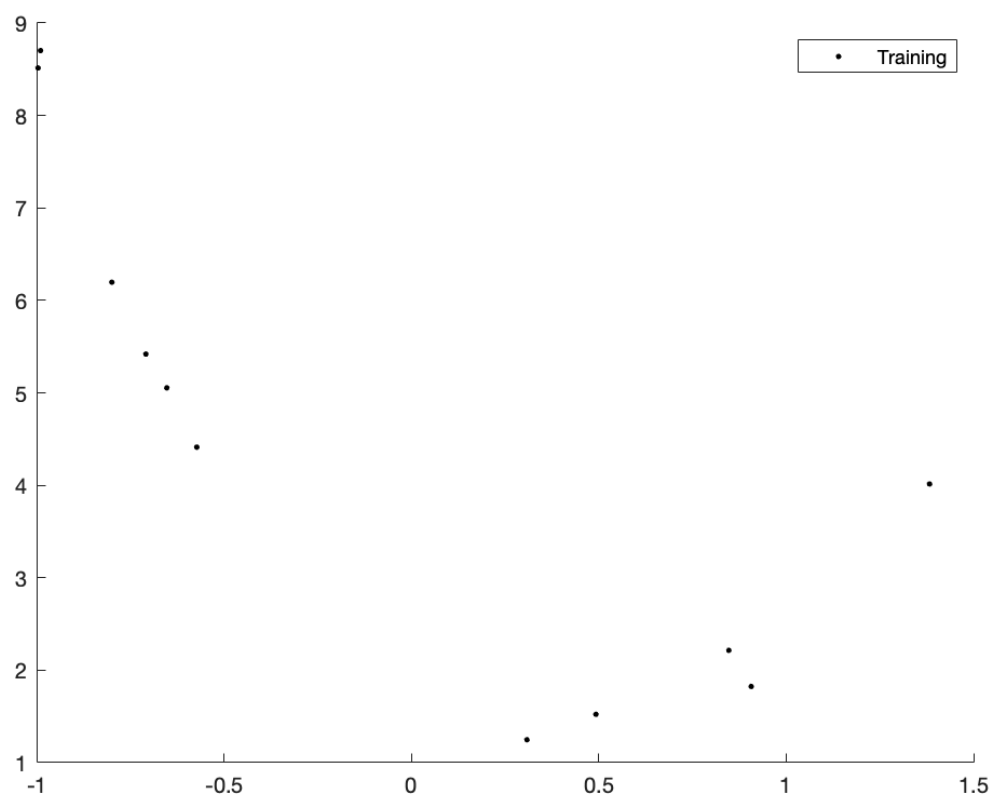
The interior-point-convex algorithm does not accept an initial point.  
Ignoring X0.

Minimum found that satisfies the constraints.

Optimization completed because the objective function is non-decreasing in  
feasible directions, to within the default value of the optimality tolerance,  
and constraints are satisfied to within the default value of the constraint tolerance.

<stopping criteria details>

TEST RESULTS: 0.011 of test examples were misclassified.



```
% Use Gaussian of standard deviation 1 kernels for dataset 3
svm_test(@Kgaussian,1,1000,set3_train,set3_test);
```

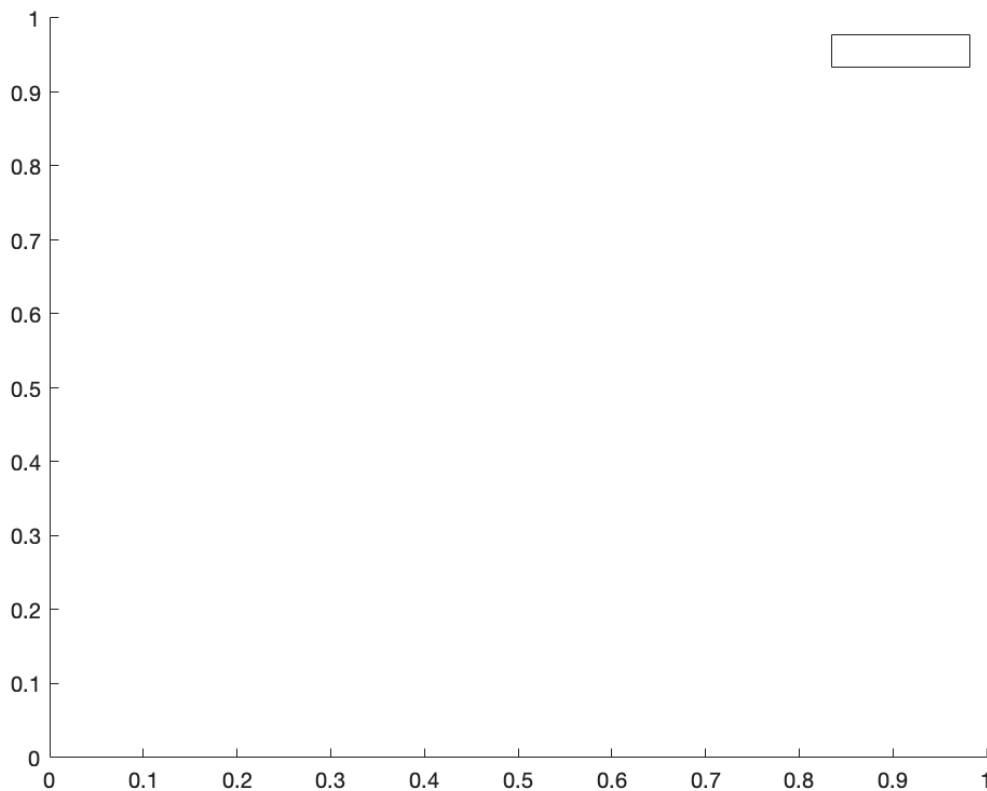
The interior-point-convex algorithm does not accept an initial point.  
Ignoring X0.

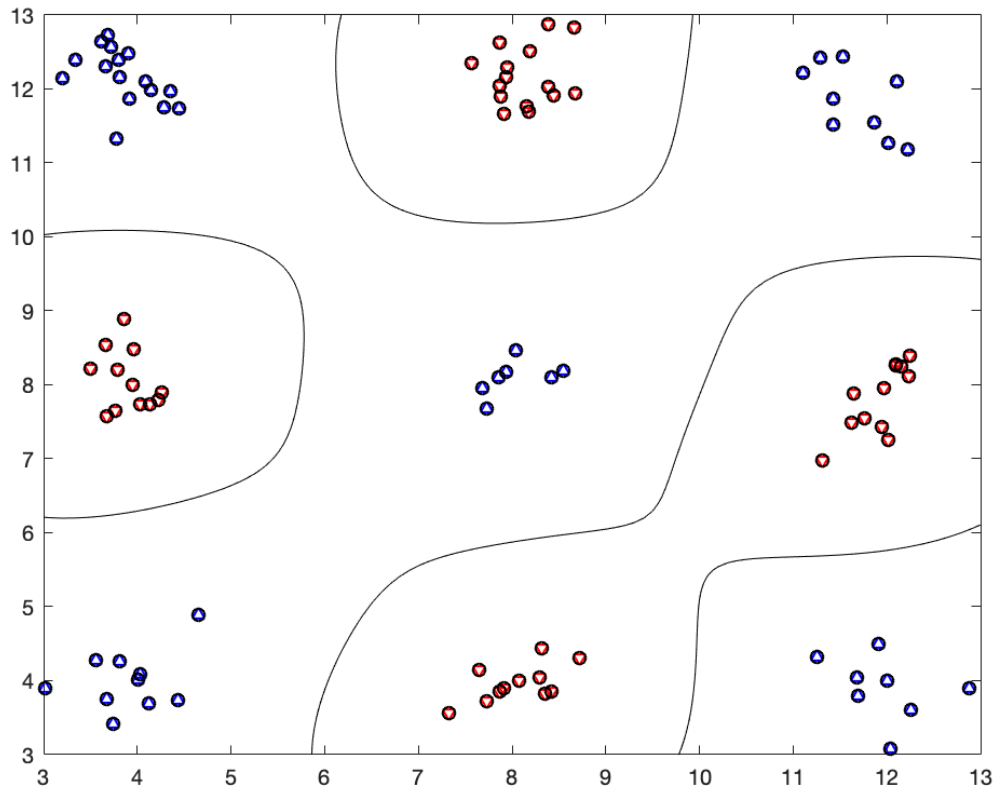
Minimum found that satisfies the constraints.

Optimization completed because the objective function is non-decreasing in  
feasible directions, to within the default value of the optimality tolerance,  
and constraints are satisfied to within the default value of the constraint tolerance.

<stopping criteria details>

TEST RESULTS: 0 of test examples were misclassified.





## Part 2:

```
TestError = zeros(3,1); % Initialize TestError variable

% Train and test 4th dataset with a linear kernel
svm_linear4 = svm_train(set4_train,@Klinear,[],1000); % Training
```

The interior-point-convex algorithm does not accept an initial point.  
Ignoring X0.

Minimum found that satisfies the constraints.

Optimization completed because the objective function is non-decreasing in  
feasible directions, to within the default value of the optimality tolerance,  
and constraints are satisfied to within the default value of the constraint tolerance.

<stopping criteria details>

```
y_linear4 = sign(svm_discrim_func(set4_test.X,svm_linear4)); % Prediction
errors_linear = find(y_linear4 ~= set4_test.y); % Testing Error
TestError(1) = length(errors_linear)/length(set4_test.y); % Output the result
fprintf('Linear SVM: %g of 4th test examples were misclassified.\n',...
    length(errors_linear)/length(set4_test.y));
```

Linear SVM: 0.1375 of 4th test examples were misclassified.

```
% Train and test 4th dataset with a polynomial of degree 2 kernel
svm_poly4 = svm_train(set4_train,@Klinear,2,1000); % Training
```

The interior-point-convex algorithm does not accept an initial point.  
Ignoring X0.

Minimum found that satisfies the constraints.

Optimization completed because the objective function is non-decreasing in  
feasible directions, to within the default value of the optimality tolerance,  
and constraints are satisfied to within the default value of the constraint tolerance.

<stopping criteria details>

```
y_poly4 = sign(svm_discrim_func(set4_test.X,svm_poly4)); % Prediction
errors_poly = find(y_poly4 ~= set4_test.y); % Testing Error
TestError(2) = length(errors_poly)/length(set4_test.y);% Output the result
fprintf('Polynomial SVM: %g of 4th test examples were misclassified.\n',...
    length(errors_poly)/length(set4_test.y));
```

Polynomial SVM: 0.1375 of 4th test examples were misclassified.

```
% Train and test 4th dataset with a Gaussian of standard deviation 1.5 kernels
svm_gaussian4 = svm_train(set4_train,@Kgaussian,1.5,1000); % Training
```

The interior-point-convex algorithm does not accept an initial point.  
Ignoring X0.

Minimum found that satisfies the constraints.

Optimization completed because the objective function is non-decreasing in  
feasible directions, to within the default value of the optimality tolerance,  
and constraints are satisfied to within the default value of the constraint tolerance.

<stopping criteria details>

```
y_gaussian4 = sign(svm_discrim_func(set4_test.X,svm_gaussian4)); % Prediction
errors_gaussian = find(y_gaussian4 ~= set4_test.y); % Testing Error
TestError(3) = length(errors_gaussian)/length(set4_test.y); % Output the result
fprintf('Gaussian SVM: %g of 4th test examples were misclassified.\n',...
    length(errors_gaussian)/length(set4_test.y));
```

Gaussian SVM: 0.085 of 4th test examples were misclassified.

```
Kernel = {'Linear';'Polynomial of degree 2';'Gaussian of std 1.5'};
```

```
% The test errors of 4th dataset trained on different kernels is as below:
t = table(TestError,Kernel);
display(t);
```

t = 3×2 table

	TestError	Kernel
1	0.1375	'Linear'
2	0.1375	'Polynomial...

	TestError	Kernel
3	0.0850	'Gaussian o...