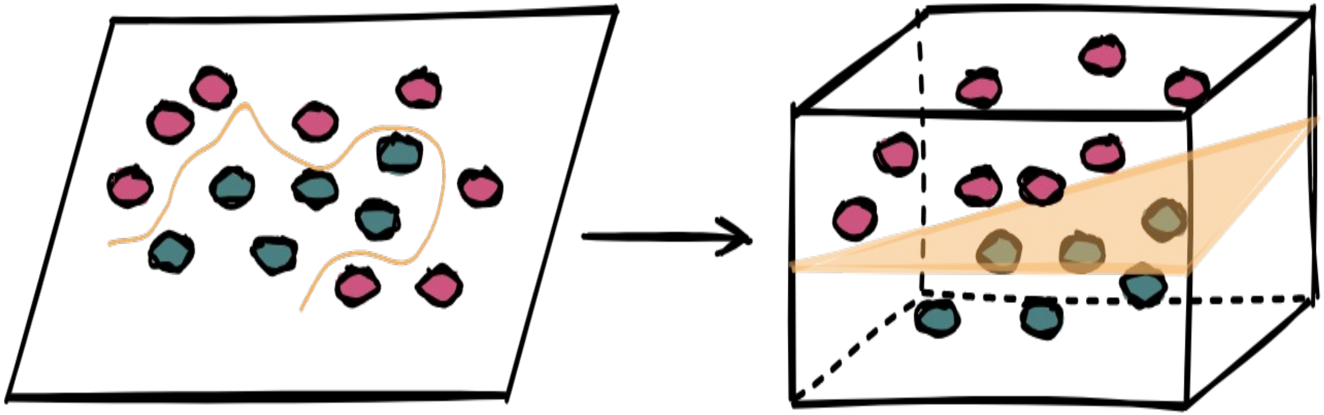
Support vector machines (SVM)



Week 12

Middlesex University Dubai;
CST4050; Instructor: Dr. Ivan Reznikov

Plan

- SVM Concept
- 1Dimensional Data
- Soft Margins and Support Vector Classifiers
- Ndimensional Data
- Kernels
- SVM for Multi-Class
- Pros and Cons

SVM concept

Support vector machine (SVM) is a simple algorithm that produces **significant accuracy with relatively low computation power.** SVM can be used for regression problems, but more often used to solve classification tasks.

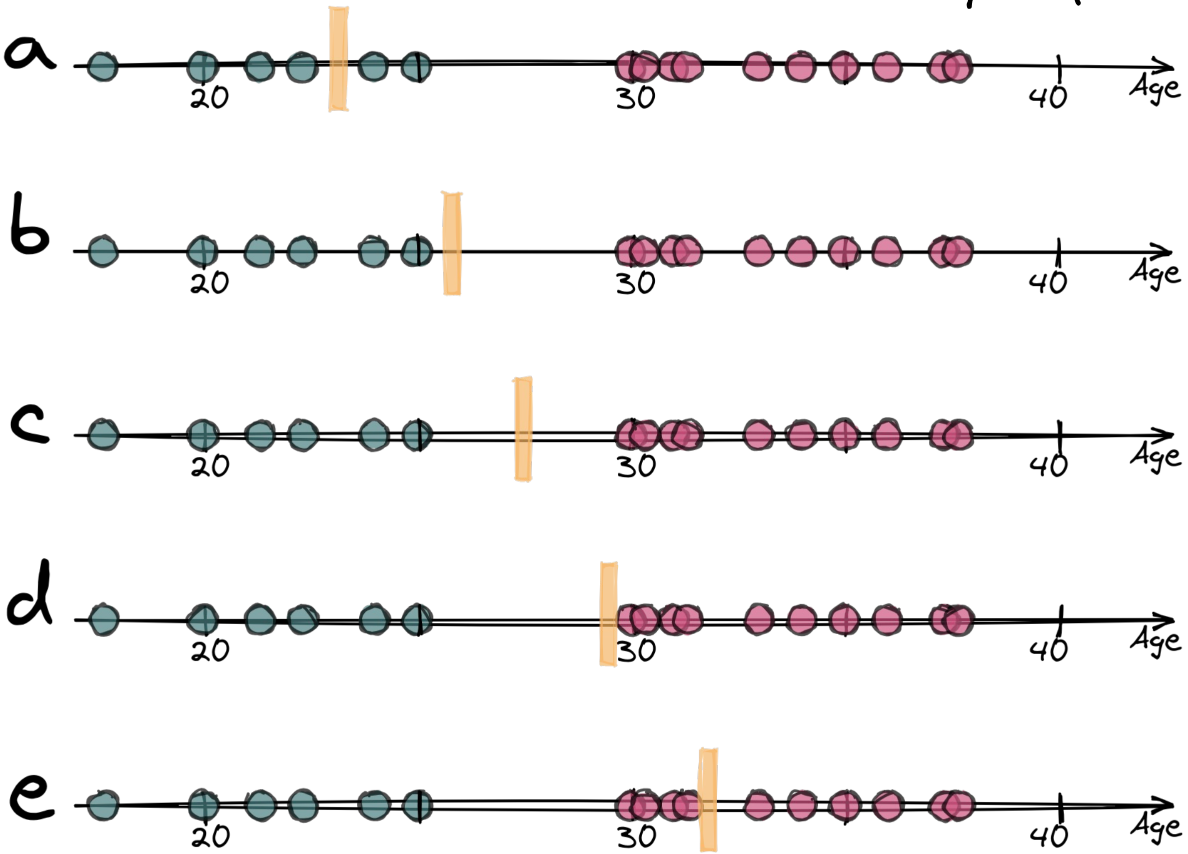
For the purpose of today's session, we'll slightly modify our usual dataset. Let's include a level column, that will be 1 for Overall Rating >= 70, else 0.

target	new target	
Overall Rating	Level	Age
40	0	37
50	0	30
55	0	36
55	0	31
60	0	35
60	0	31
60	0	38
60	0	34
65	0	33
65	0	30
65	0	27
65	0	23
70	1	34
70	1	29
70	1	22
75	1	25
75	1	21
80	1	24
85	1	20
90	1	18

(a) 1Dimensional Data

target	new target		
Overall Rating	Level	Age	
40	0	37	
50	0	30	
55	0	36	
55	0	31	
60	0	35	
60	0	31	
60	0	38	
60	0	34	
65	0	33	
65	0	30	
65	0	27	test
65	0	23	
70	1	34	
70	1	29	
70	1	22	
75	1	25	
75	1	21	
80	1	24	
85	1	20	
90	1	18	

What classifier would you pick?



(b) 1Dimensional Data

target	new target	
Overall Rating	Level	Age
40	0	37
50	0	30
55	0	36
55	0	31
60	0	35
60	0	31
60	0	38
60	0	34
65	0	33
65	0	30
65	0	27
65	0	23
70	1	34
70	1	29
70	1	22
75	1	25
75	1	21
80	1	24
85	1	20
90	1	18

test

What classifier would you pick now?

(c) 1Dimensional Data

target | new target

Overall Rating	Level	Age	
40	0	37	
50	0	30	
55	0	36	
55	0	31	
60	0	35	
60	0	31	
60	0	38	
60	0	34	
65	0	33	
65	0	30	
65	0	27	
65	0	23	test
70	1	34	test
70	1	29	
70	1	22	
75	1	25	
75	1	21	
80	1	24	
85	1	20	
90	1	18	

What classifier would you pick this time?

Soft margins

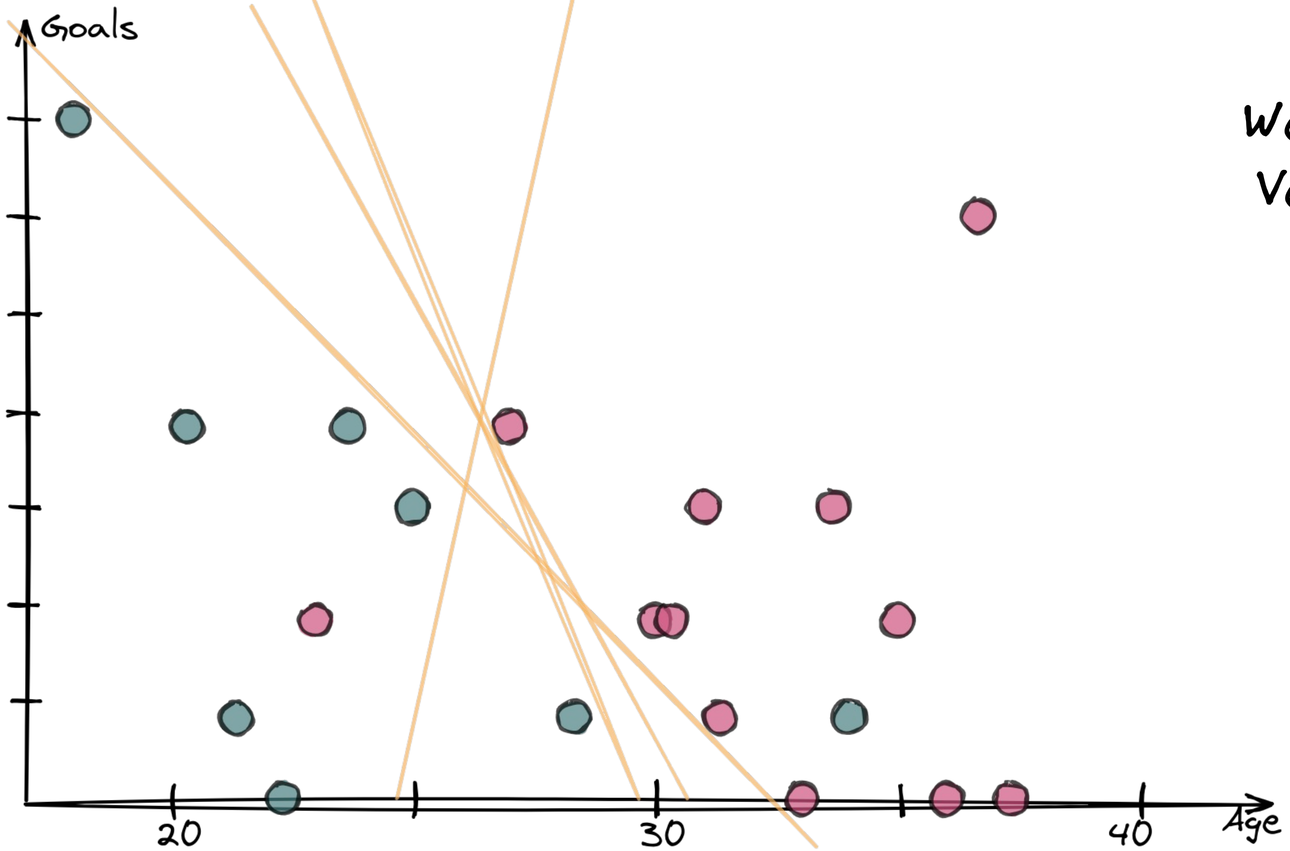
For 1D we only need a point to set threshold. It is considered as 0-dimensional hyperplane

Soft margins are more flexible and allow misclassification.

The thresh may be found empirically using cross-validation

2Dimensional Data

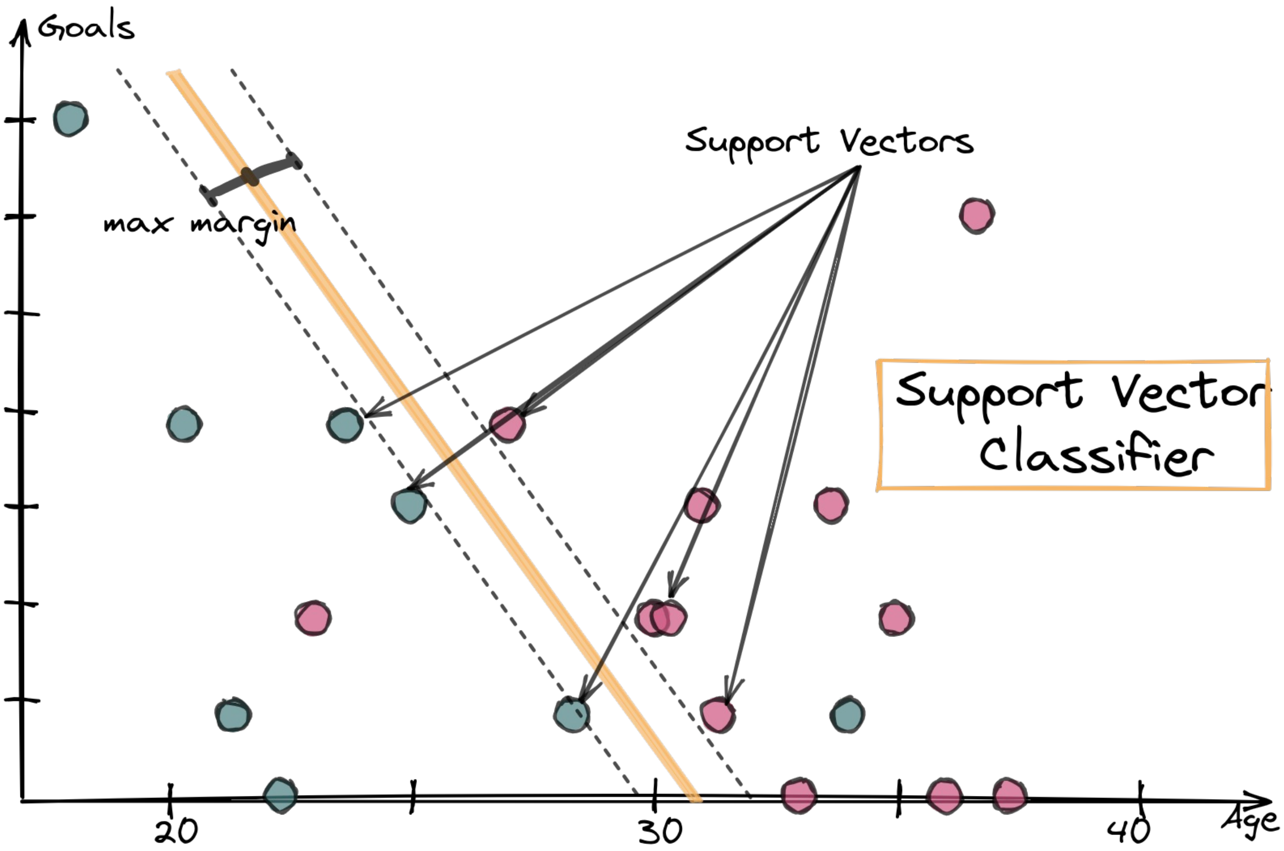
What classifier would you pick?



We can look for Support Vectors – border points of certain class.

After, we look for the maximum margin size

2Dimensional Data

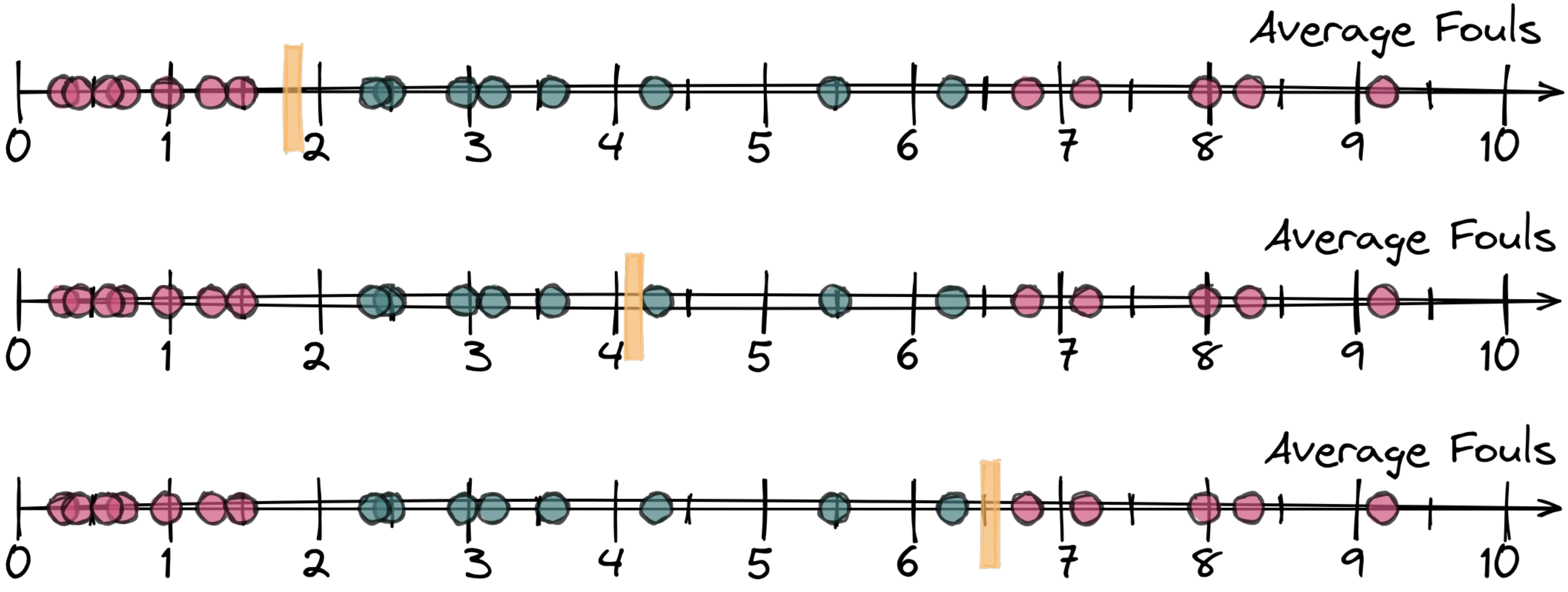


For 2Dimensional Data we need a line to set threshold. It is considered as 1-dimensional hyperplane.

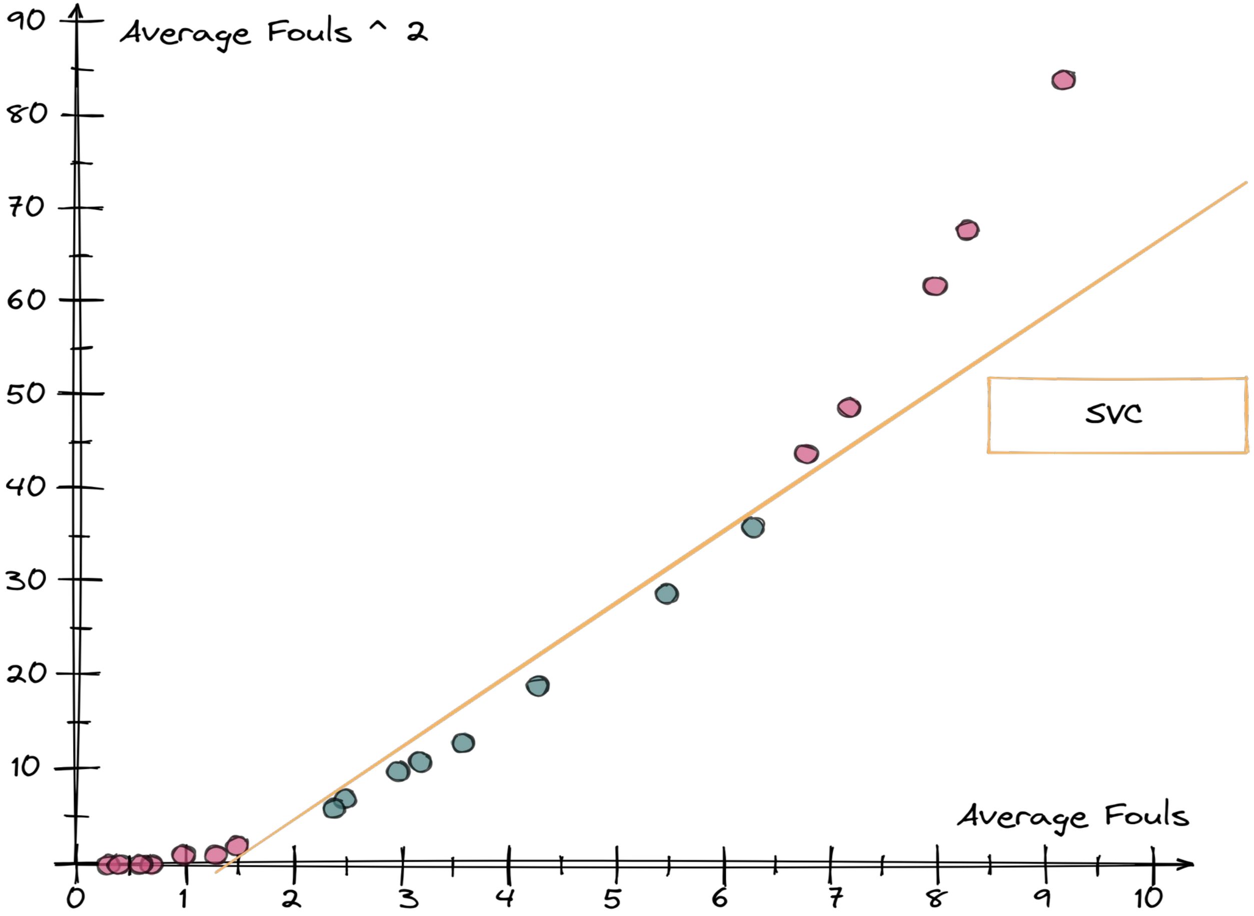
Similar situation we can imagine for higher dimensions.

SVM: Linear Kernel

What classifier would you pick?



SVM: Polynomial Kernel



We can plot our data in the following coordinates:

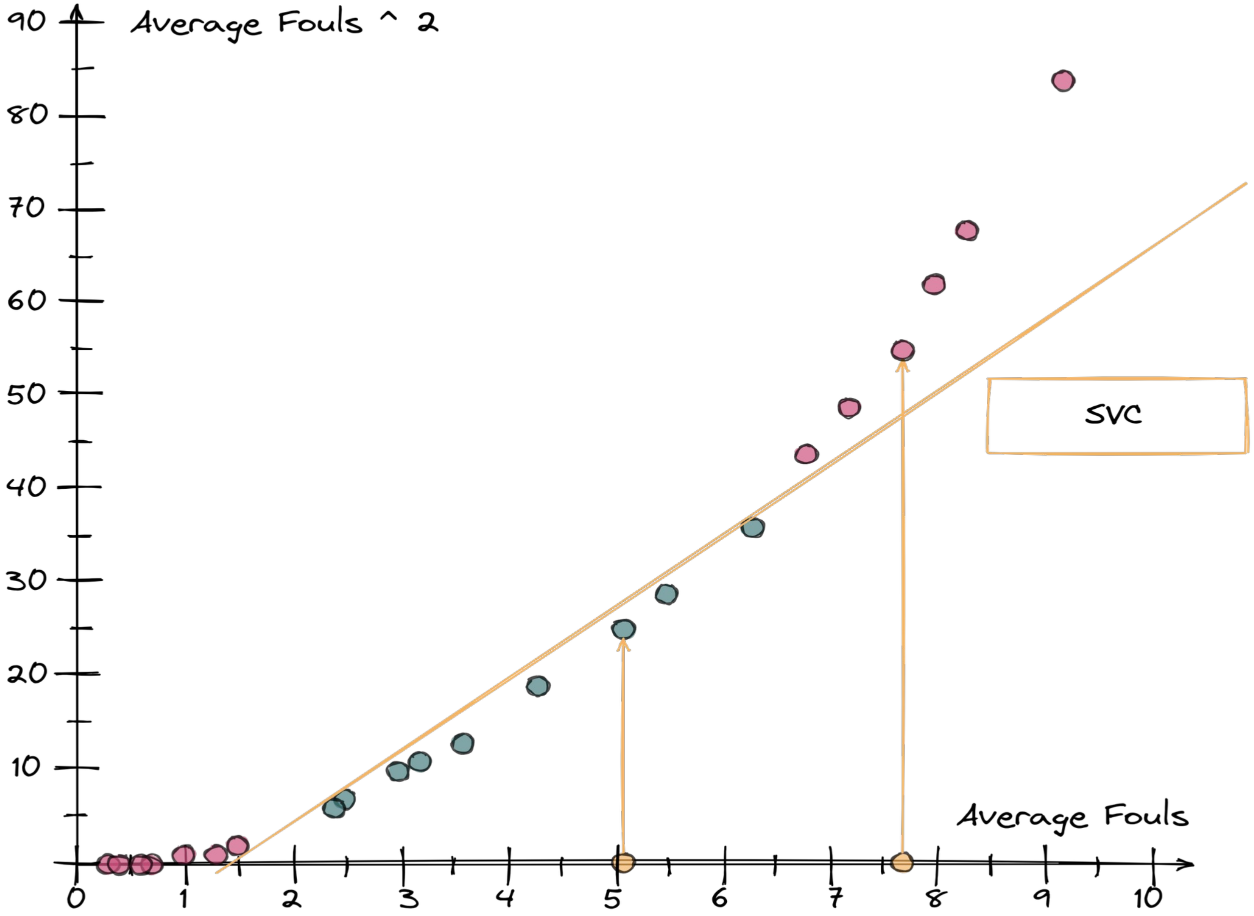
$X = x$

$Y = x^2$

Now we can look for a linear support vector classifier

The algorithm of transforming data and finding SVC is called **Support Vector Machines**

SVM: Polynomial Kernel

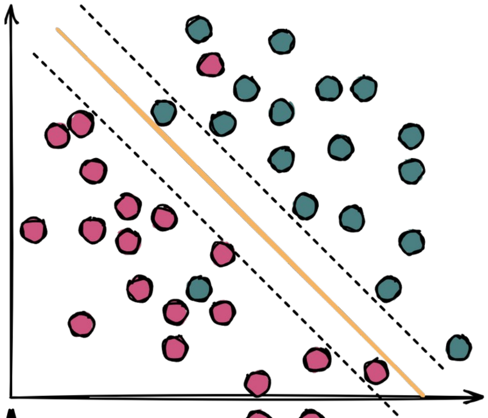


In order to classify a new data point, we'll need to classify it's x-x^2 position.

We could've used x^3, x^d or other formula. These are called **kernel functions**

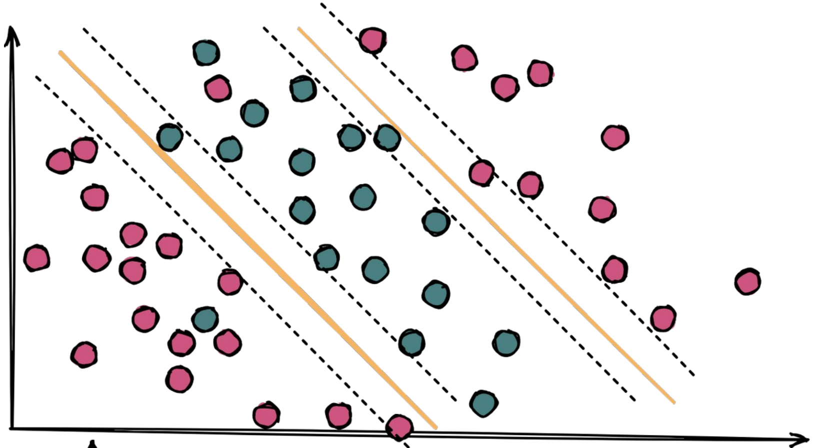
Also, rather than transforming data we can calculate pair relationships between data points. This is known as **kernel trick**

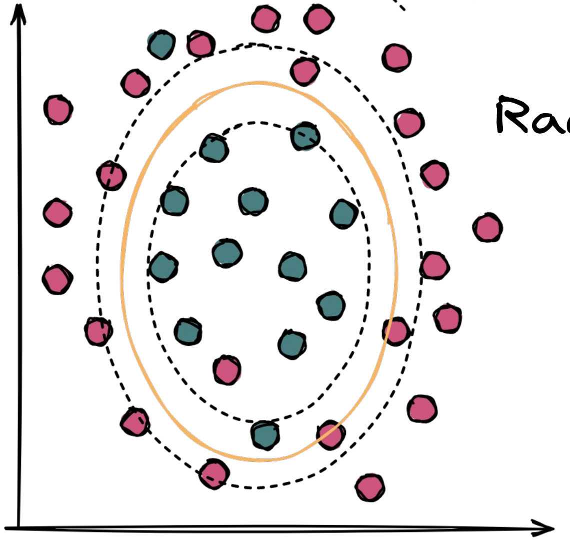
SVM: Types of Kernels



Linear kernel

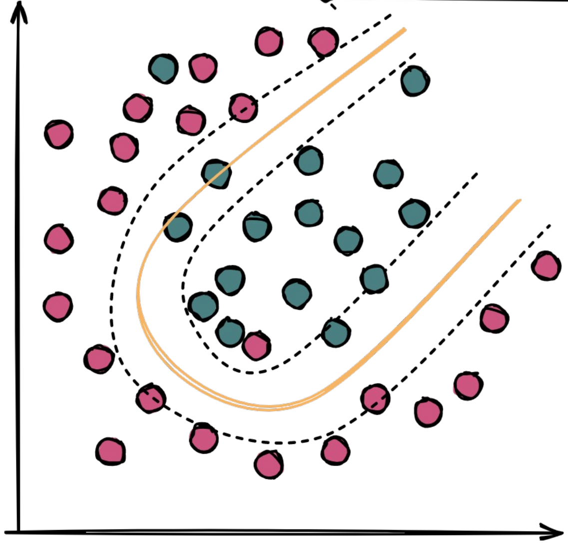
Sigmoid kernel



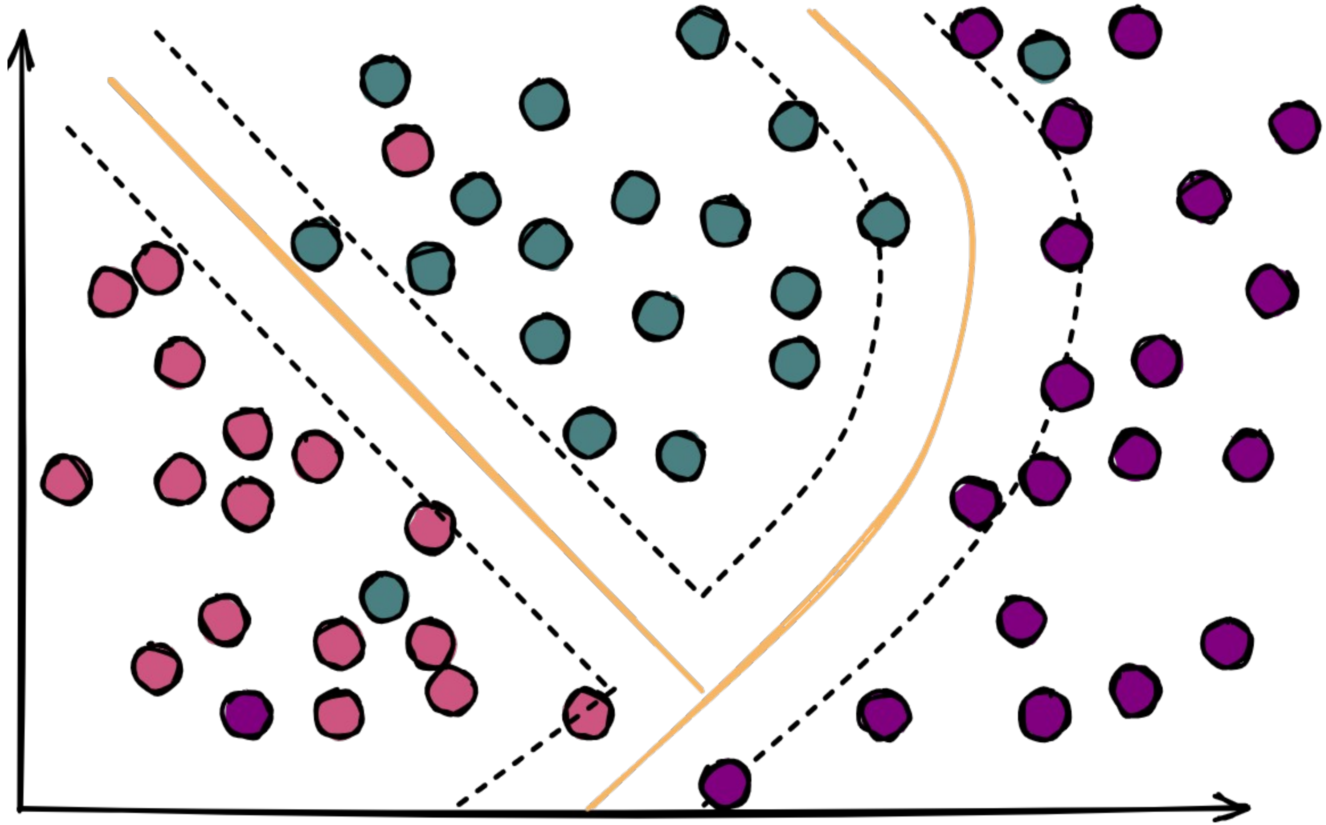


Radial kernel

Polynomial kernel



SVM: Multi-Class



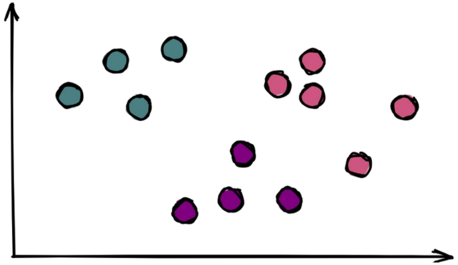
Besides binary classification (2 classes) SVM can handle tasks classifying more than 2 classes (multi-class).

Strategies involved:

- 1 vs all
- 1 vs 1

SVM: Multi-Class: 1 vs all

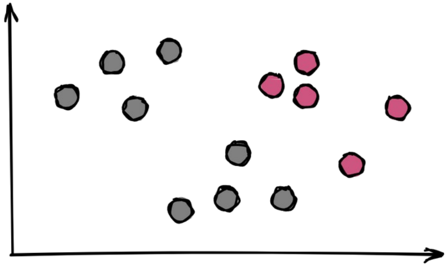
Feature1	Feature2	Target1
1	1	Red
2	10	Green
4	100	Purple
...	...	...



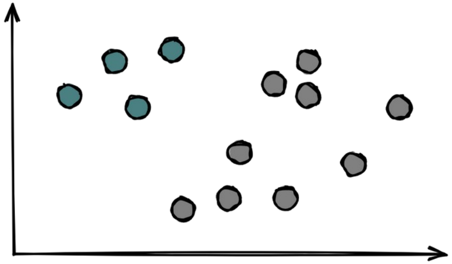
With the updated data we now calculate prob of each class. The class with highest score wins.

Creating training sets

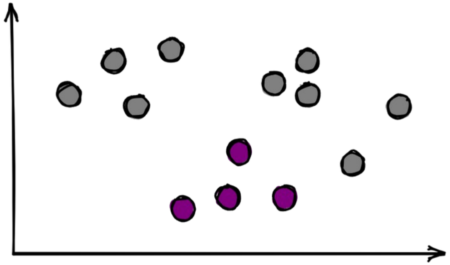
Feature1	Feature2	Target1
1	1	1
2	10	-1
4	100	-1
...	...	...



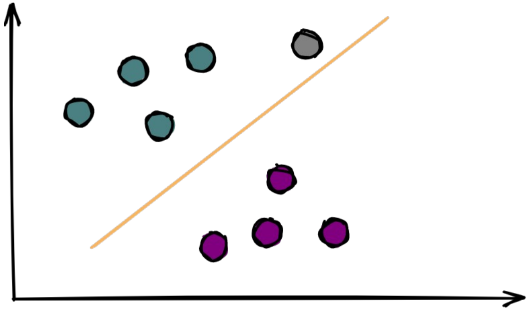
Feature1	Feature2	Target1
1	1	-1
2	10	1
4	100	-1
...	...	...



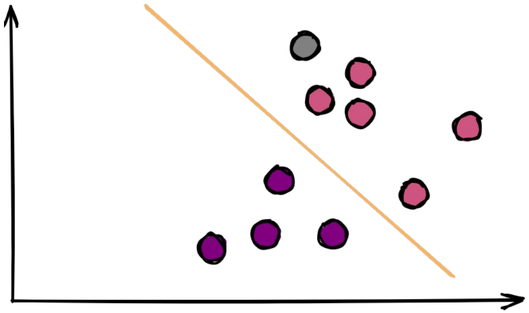
Feature1	Feature2	Target1
1	1	-1
2	10	-1
4	100	1
...	...	...



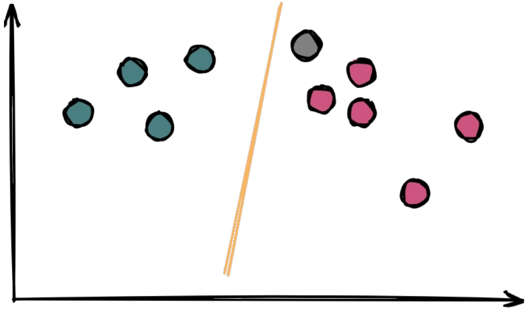
SVM: Multi-Class: 1 vs 1



Green vs Purple
Winner: Green

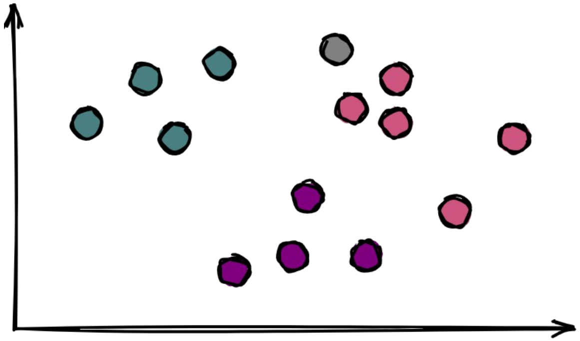


Red vs Purple:
Winner: **Red**



Green vs Red:
Winner: **Red**

Result: Red



Compared to 1 vs all, 1 vs 1 compares whether the data point should be classified as either class. The data point is assigned to class with most "wins".

Support Vector Machines

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- Works well on datasets with many features
- Provides a clear separation margin
- Effective for datasets where the number of features are greater than the number of data points
- Possible to specify different kernel functions to make a proper decision boundary

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- Require high training time, so not recommended for large datasets.
- Very sensitive to outliers.