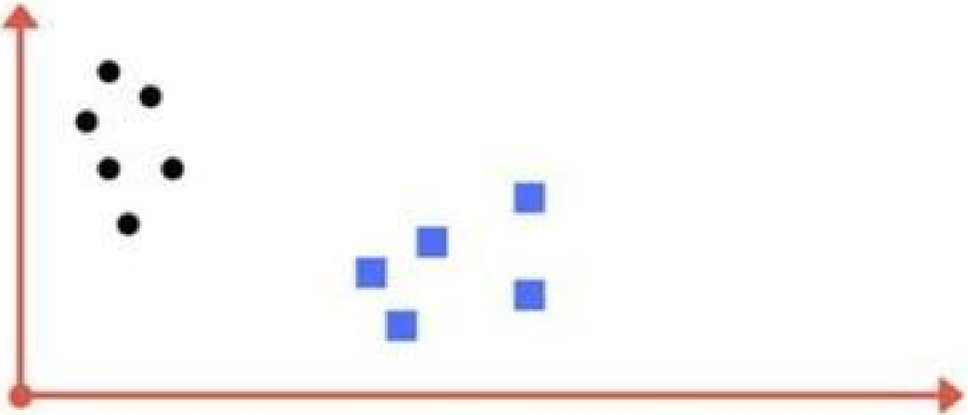
Introduction

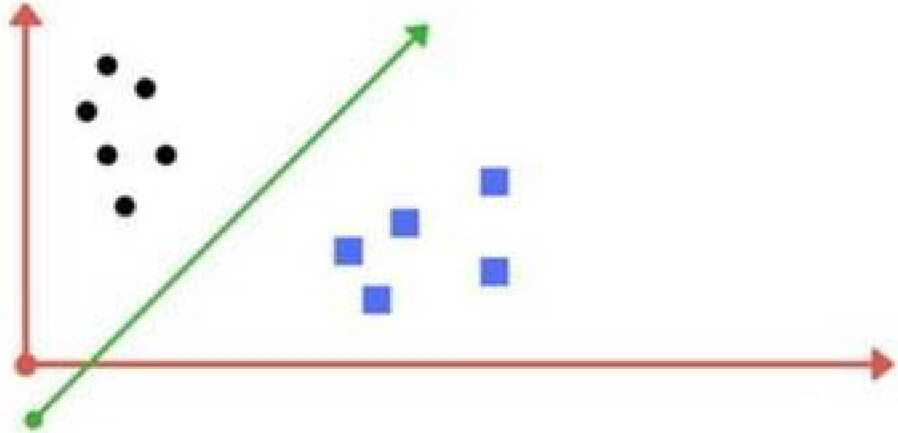
SVM

A Support Vector Machine (SVM) is a discriminative classifier which intakes training data (supervised learning), the algorithm outputs an optimal hyperplane which categorizes new examples.



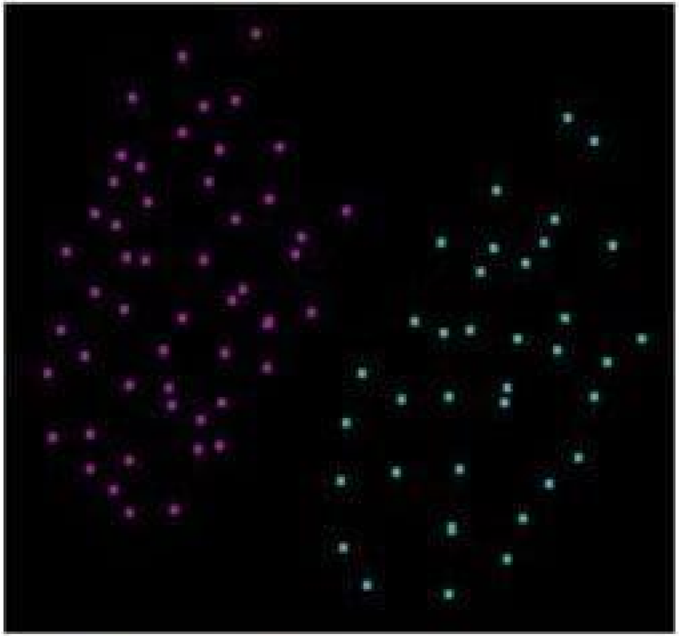
What could be drawn to classify the black dots from blue squares?

Linearly separable data

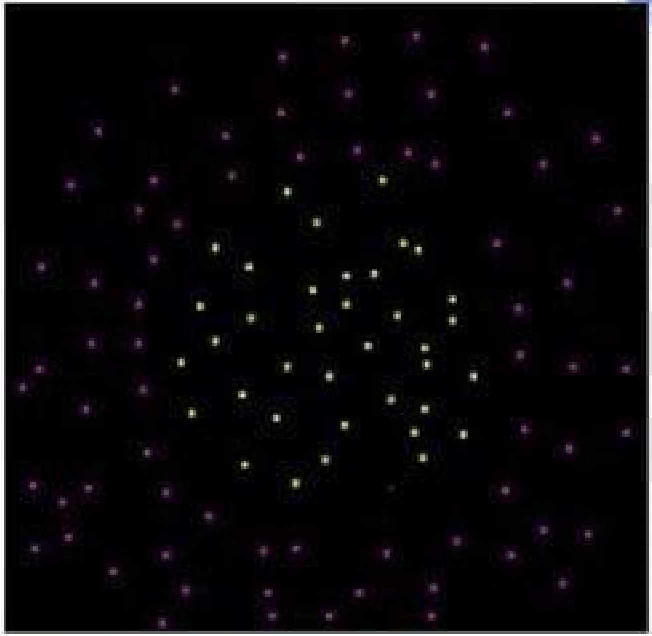


A line drawn between these data points classify the black dots and blue squares.

Linear vs Nonlinear separable data

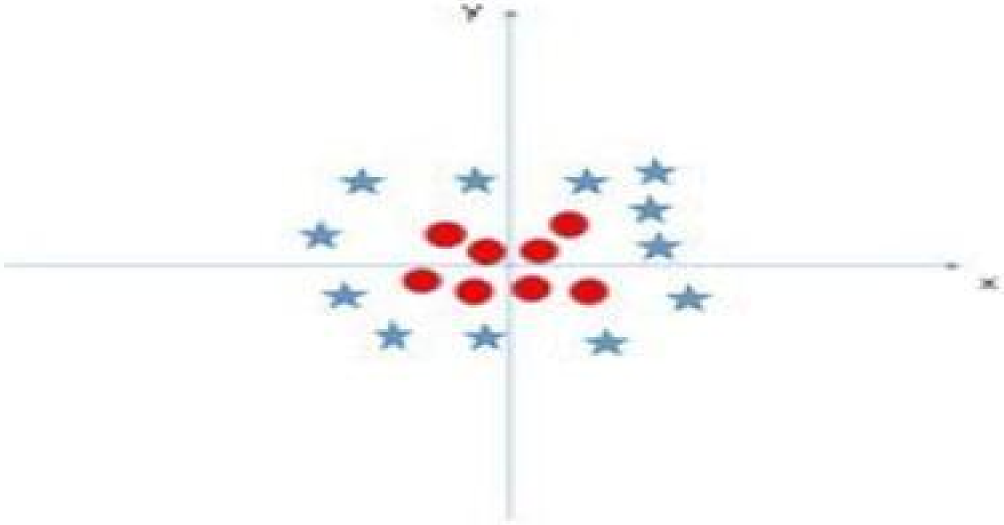


Linearly separable data



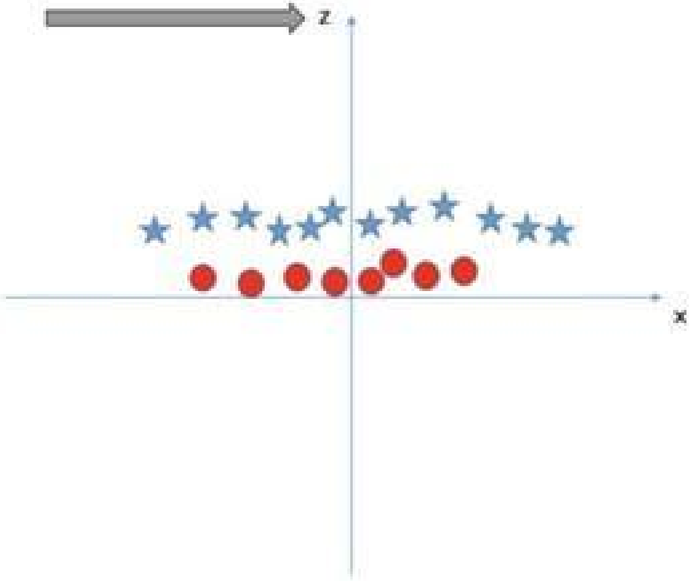
Non linearly separable data

NonLinearly separable data



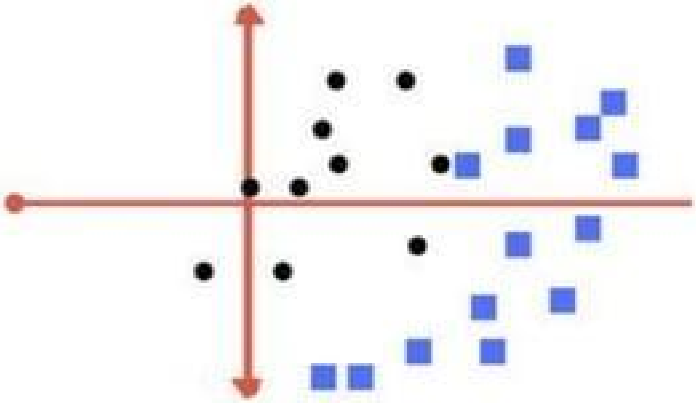
What could be drawn to classify these data points (red dots from blue stars)?

NonLinearly separable data

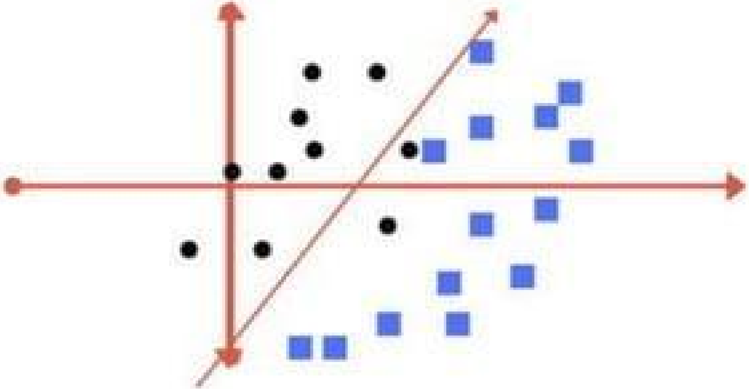


Here the hyperplane is a 2d plane drawn parallel to x-axis that is the separator.

Non Linear data (type 2)



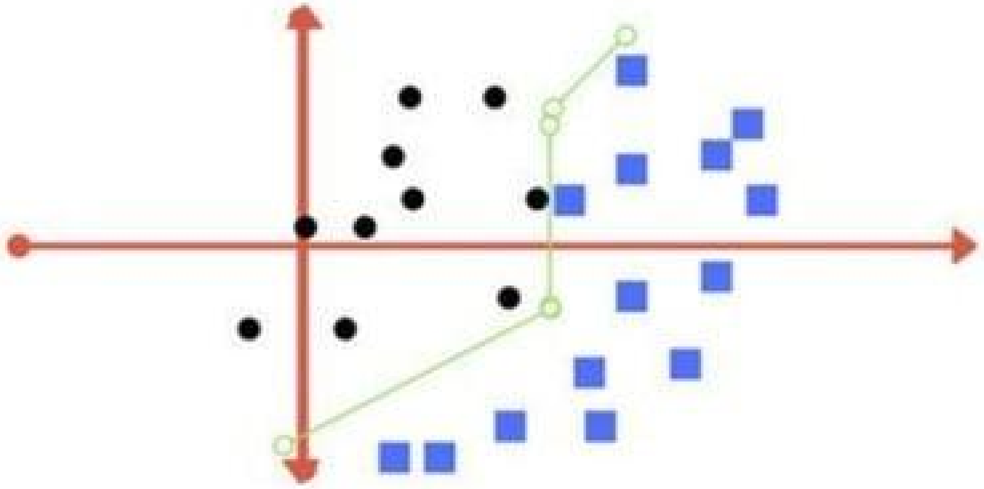
Raw Data



Line as Hyperplane

For the previous data the **line** , if used as a **Hyperplane**

- Two black dots also fall in category of blue squares
- Data separation is not perfect
- It tolerates some **outliers** in the classification



This type of separator best provides the classification.

But

- It is quite difficult to train a model like this .
- This is termed as **Regularisation parameter.**

Tuning Parameters

SVM

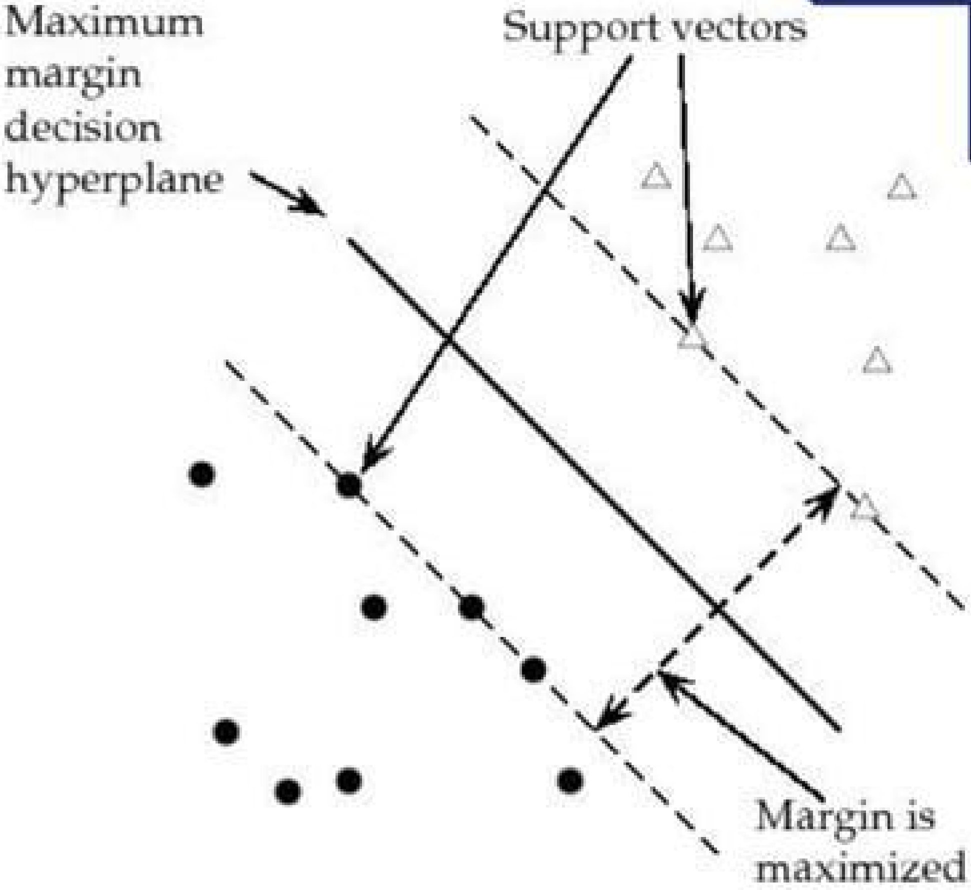
1. Kernel
2. Regularization
3. Gamma
4. Margin

Margin

Margin is the perpendicular distance between the closest data points and the Hyperplane (on both sides)

The best optimised line (hyperplane) with maximum margin is termed as Margin Maximal Hyperplane.

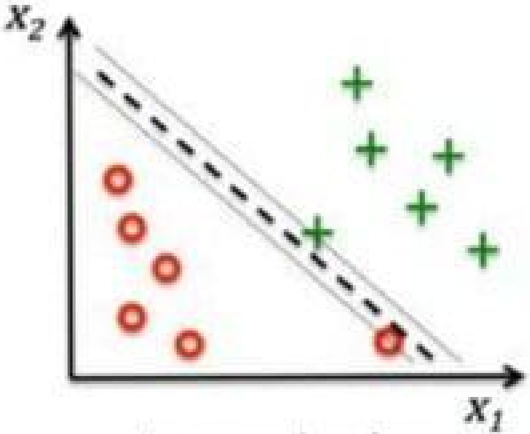
The closest points where the margin distance is calculated are considered as the support vectors.


Maximum margin decision hyperplane
Support vectors
Margin is maximized

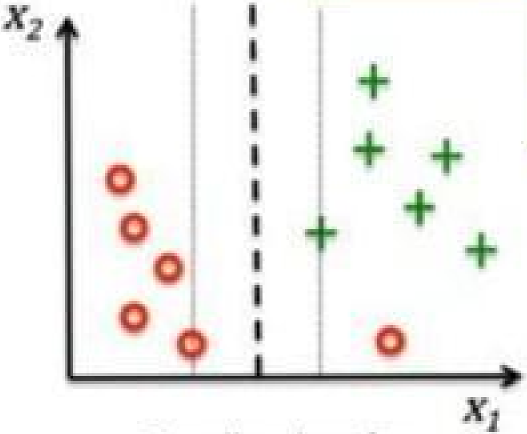
Regularization

- Also the ‘ C ‘ parameter in Python’s SkLearn Library
- Optimises SVM classifier to avoid misclassifying the data.
- C → large Margin of hyperplane → small
- C → small Margin of hyperplane → large
    - misclassification(possible)

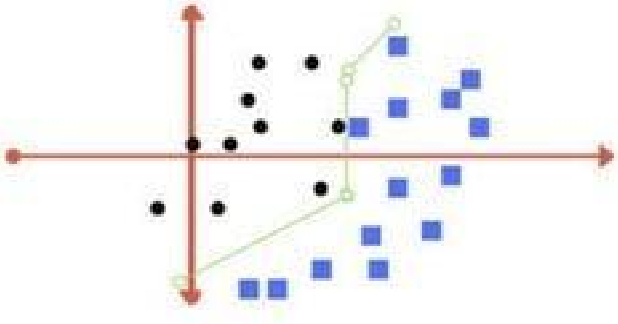
1. C ---> large , chance of overfit
2. C ---> small , chance of underfitting

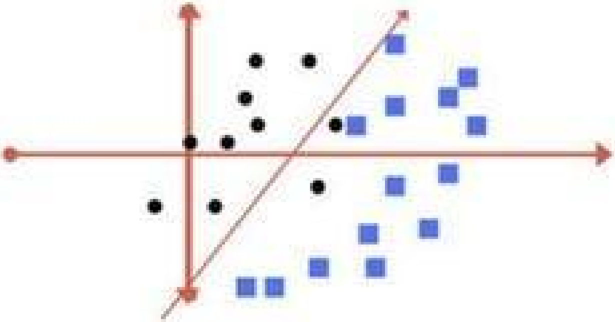


Large value for parameter *C*



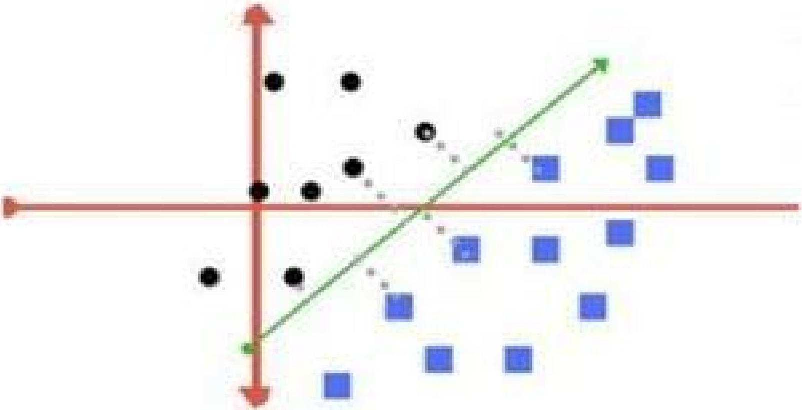
Small value for parameter *C*



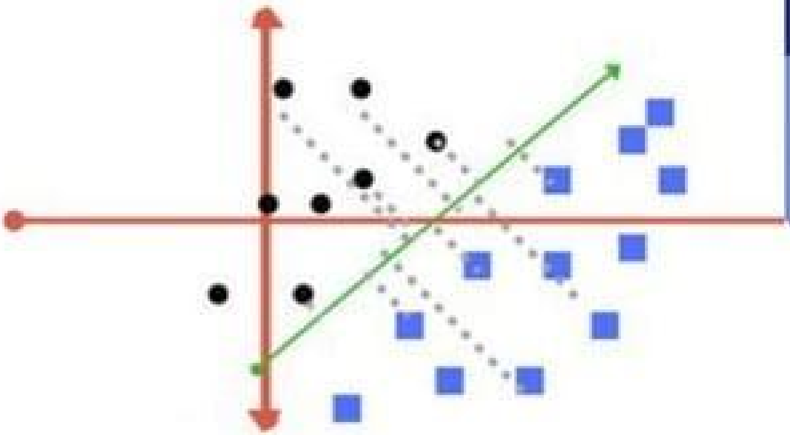


Gamma

- Defines how far influences the calculation of of plausible line of separation.
- Low gamma -----> points far from plausible line are considered for calculation
- High gamma -----> points close to plausible line are considered for calculation



High Gamma Value



Low Gamma Value

Kernels

- Mathematical functions for transforming data
- using some linear algebra
- Different SVM algorithms use different types of kernel functions

Various kernels available

1. Linear kernel
2. Non - linear kernel
3. Radial basis function (RBF)
4. Sigmoid
5. Polynomial
6. Exponential

Example :

$K(x, y) \quad = \quad \langle f(x), f(y) \rangle$

Kernel function   dot product of n- dimensional inputs

Mathematical representation

$x = (x1, x2, x3); y = (y1, y2, y3)$

$f(x) = (x1x1, x1x2, x1x3, x2x1, x2x2, x2x3, x3x1, x3x2, x3x3)$

$f(y) = (y1y1, y1y2, y1y3, y2y1, y2y2, y2y3, y3y1, y3y2, y3y3)$

$K(x, y) = (\langle x, y \rangle)^2$

$x = (1, 2, 3)$

$y = (4, 5, 6)$

$f(x) = (1, 2, 3, 2, 4, 6, 3, 6, 9)$

$f(y) = (16, 20, 24, 20, 25, 30, 24, 30, 36)$

$\langle f(x), f(y) \rangle = 16 + 40 + 72 + 40 + 100 + 180 + 72 + 180 + 324 = 1024$

$K(x, y) = (4 + 10 + 18)^2 = 1024$ ----> Kernel function

Pros :

- It works really well with clear margin of separation
- It is effective in high dimensional spaces.
- It is effective in cases where number of dimensions is greater than the number of samples.
- It uses a subset of training points in the decision function (called support vectors), so it is also memory efficient.

Cons :

- It doesn't perform well, when we have large data set because the required training time is higher
- It also doesn't perform very well, when the data set has more noise i.e. target classes are overlapping
- SVM doesn't directly provide probability estimates, these are calculated using an expensive five-fold cross-validation. It is related SVC method of Python scikit-learn library.

Applications :

1. Face detection
2. Text and hypertext categorization
3. Classification of images
4. Bioinformatics
5. Handwriting recognition
6. Protein fold and remote homology detection
7. Generalized predictive control(GPC)