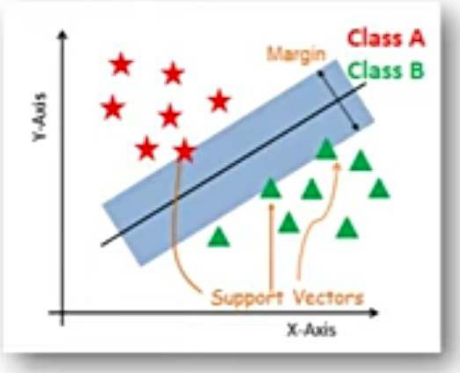
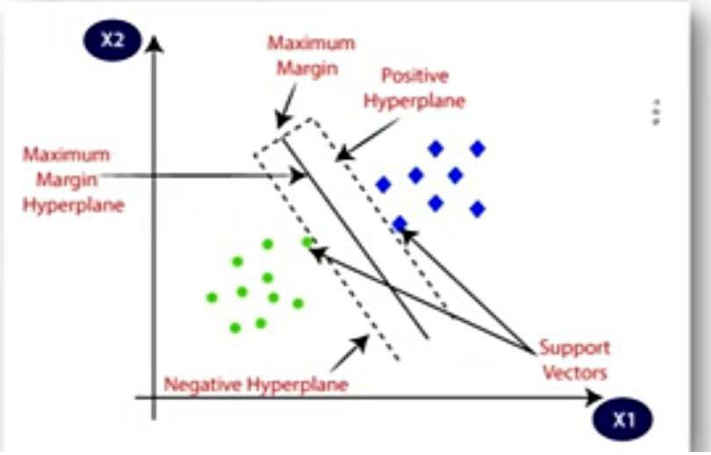
Support Vector Machine

- Support Vector Machine or SVM is one of the most popular Supervised Learning algorithms, which is used for Classification as well as Regression problems.
- However, primarily, it is used for Classification problems in Machine Learning.
- The goal of the SVM algorithm is to create the best line or decision boundary that can segregate n-dimensional space into classes so that we can easily put the new data point in the correct category in the future
- SVM algorithm can be used for Face detection, image classification, text categorization, etc.



Key Concepts of SVM

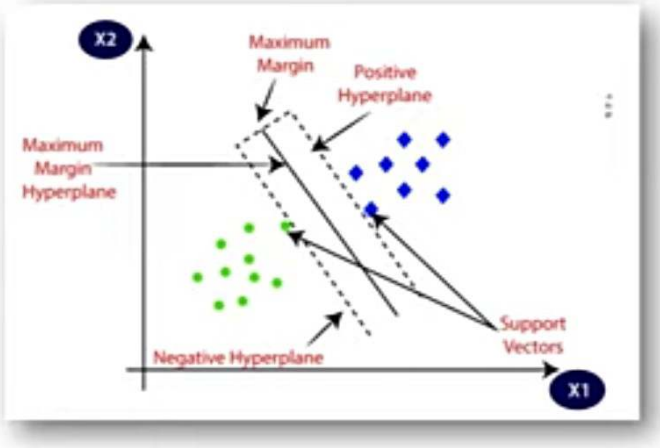
- **Support Vectors** − Data points that are closest to the hyperplane is called support vectors. Separating line will be defined with the help of these data points.
- **Hyperplane** − It is a decision plane or space which is divided between a set of objects having different classes.
- **Margin** − It may be defined as the gap between two lines on the closet data points of different classes. It can be calculated as the perpendicular distance from the line to the support vectors. Large margin is considered as a good margin and small margin is considered as a bad margin.

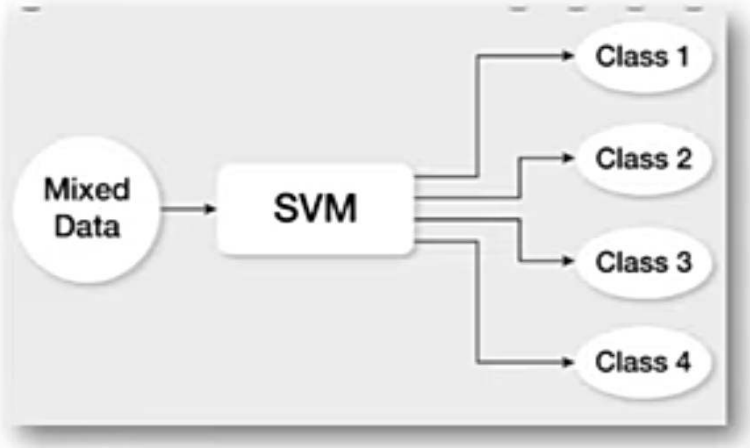


SVM Algorithms Steps

The basic steps of the SVM are:

1. Select **two hyperplanes** (in 2D) which separates the data **with no points between them** (red lines)
2. **Maximize their distance** (the margin)
3. The **average line** (here the line half way between the two red lines) will be the **decision boundary**

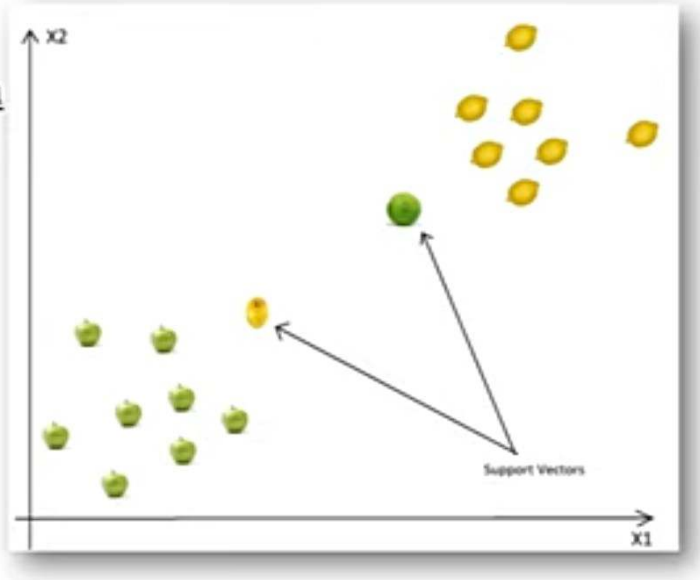




Working of SVM

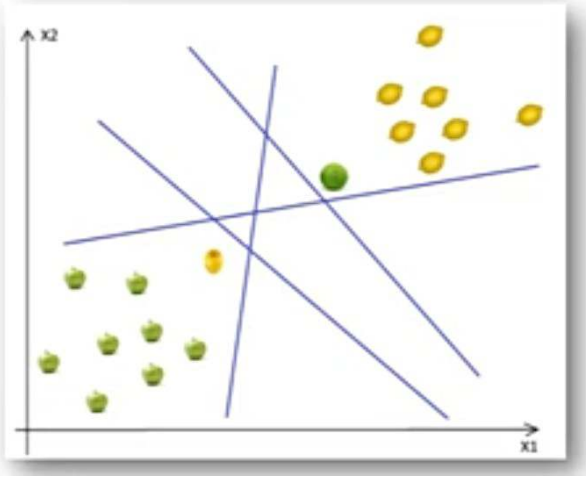
Scenario 1: Data is linearly separable:

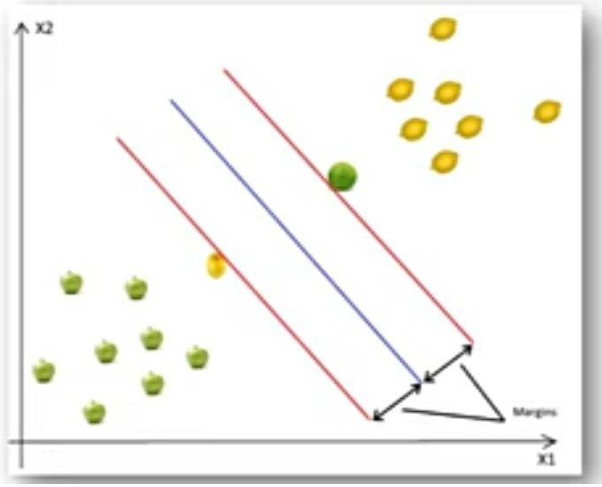
- Lets consider two classes, apples and lemons.
- In contrast, SVM will search for apples that are very similar to lemons, for example apples which are yellow and have elliptic form.
- This will be a support vector.
- The other support vector will be a lemon similar to an apple (green and rounded).
- So other algorithms learns the differences while SVM learns similarities.
- If we visualize the example above in 2D:



Working of SVM

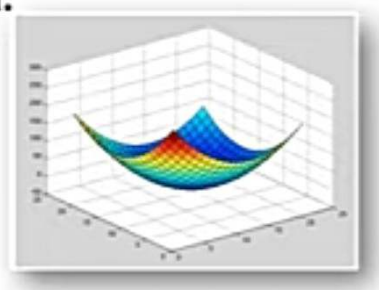
- Finding the Optimal Hyperplane
- Intuitively the **best line** is the line that is **far away from both apple and lemon examples** (has the largest margin).
- To have optimal solution, we have to **maximize the margin in both ways.**
- All in all, **support vectors are data points that defines the position and the margin of the hyperplane.**





About SVM Kernal

- "Kernel" is used **due to set of mathematical functions used in Support Vector Machine provides the window to manipulate the data.**
- It converts Low Dimensional Space into High Dimensional Space.
- To separate Non-Linear data Kernal is used.
- Let's assume that we add another dimension called X3.

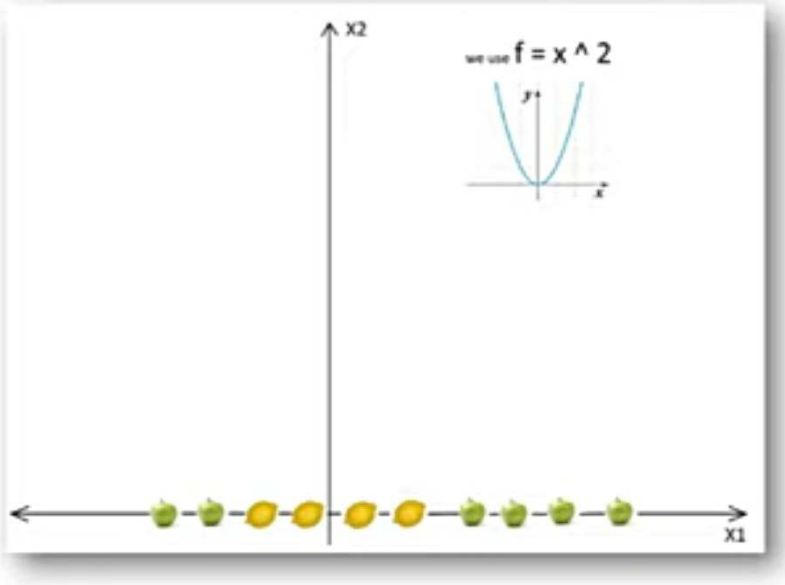


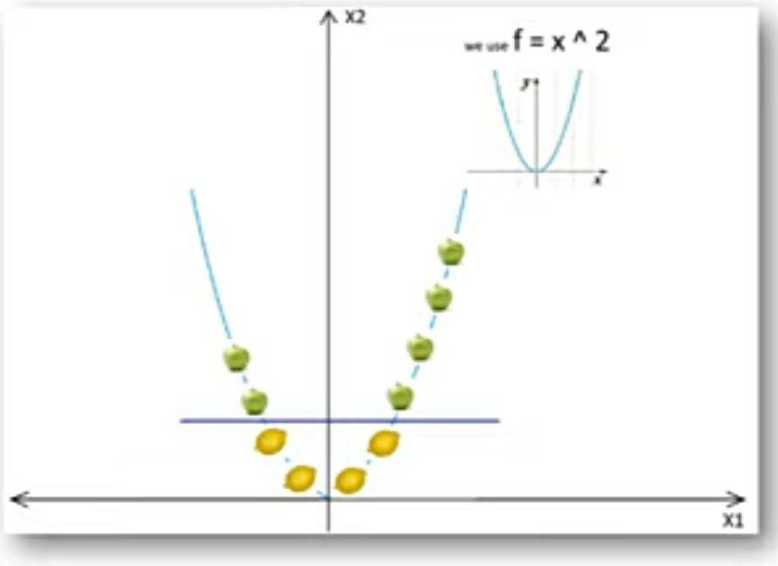
- Another important transformation is that in the new dimension the points are organized using this formula $x1^2 + x2^2$.
- These transformations are called **kernels**.
- **Popular kernels are:** Polynomial Kernel, Gaussian Kernel, Radial Basis Function (RBF), Laplace RBF Kernel, Sigmoid Kernel, Anove RBF Kernel

Working of SVM

Mapping from 1D to 2D

- After using the kernel transformations is happen.
- So after the transformation, we can easily delimit the two classes using just a single line.





Working of SVM

Mapping from 2D to 3D

- The basic idea is that when a data set is inseparable in the current dimensions, add another dimension, maybe that way the data will be separable.
- Given example above is in 2D and it is inseparable, but maybe in 3D there is a gap between the apples and the lemons, maybe there is a level difference, so lemons are on level one and lemons are on level two.
- In this case we can easily draw a separating hyperplane (in 3D a hyperplane is a plane) between level 1 and 2.