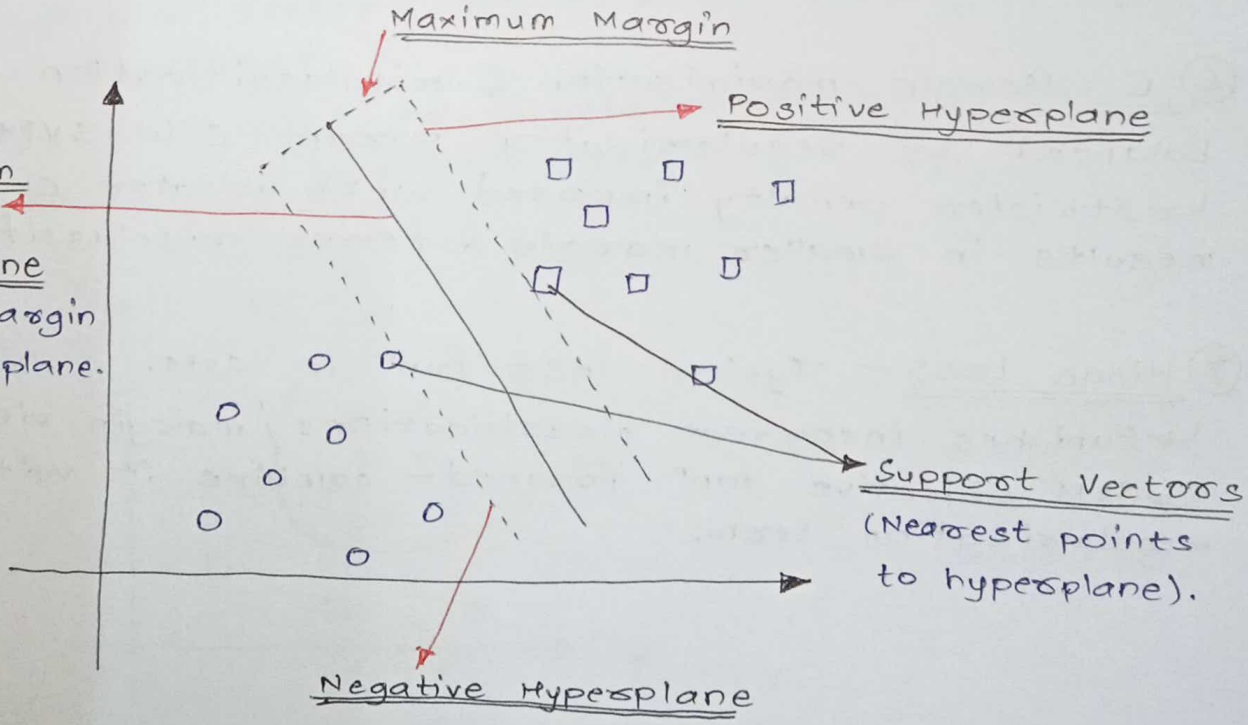
* Support Vector Machine (SVM)

SVM :-

- Supervised Learning algo.
- Classification & Regression problems.
- Mostly for classification.
- Works ~~wth~~ best when dataset small & complex.
- Logistic Regression & SVM similar, find best hyperplane, LR work on probabilistic approach & SVM - statistical approach.

- Goal - Find best line / decision boundary that segregate n-dimensional space into classes, so classify new data easily. c/a Hyperplane.

- SVM choose extreme points / vectors help in creating hyperplane. c/a Support Vectors. so, algo termed Support Vector Machine.



Terminologies in SVM :-

1. **Hyperplane** – Decision boundary used separate different class data points in feature space.
   - For linear classifica^n – linear eq^n : $wx + b = 0$.

2. **Support Vectors** – Closest data points to the hyperplane, critical role in hyperplane & margin.

3. **Margin** – Dist. bet^n hyperplane & support vector.
   - Main objective : Maximize margin.
   - Max margin $\Rightarrow$ better performance.

4. **Hard margin** – Max-margin hyperplane / hard margin hyperplane – properly separate data points of different categories without classifications.

5. **Soft Margin** – Data point not perfectly separable / contains outliers.
   - Each data point contain slack variable introduced by SVM soft-margin formula^n, soften strict margin requirement & permit misclassification / violations.

6. **C** – Margin maximisation & misclassification fines balanced by regularisation param C in SVM.
   - stricter penalty imposed with greater C value, results in smaller margin & fewer misclassification.

7. **Hinge Loss** – Typical loss fun^n in SVM.
   - Punishes incorrect classifications / margin violations.
   - SVM objective fun^n formed – combine it with the regularization term.

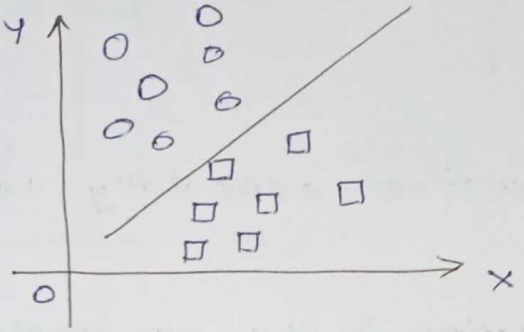
Types of SVM:

① **Linear SVM** – use linear decision boundary to separate data points in different classes.

↳ Suitable - data points linearly separable.

↳ Hyperplane entirely divide data points in classes.

↳ Hyperplane that maximizes margen betⁿ classes is the decision boundary.

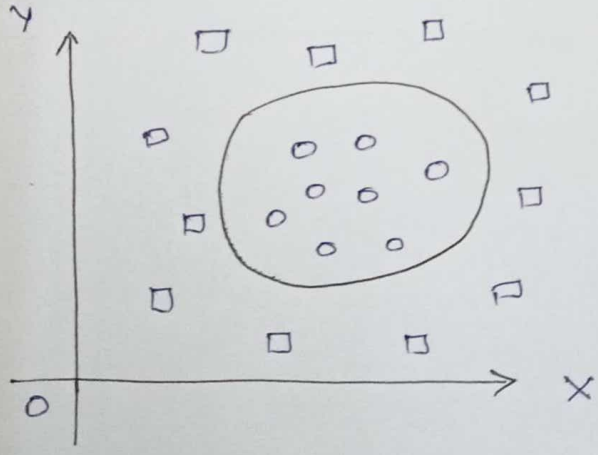


② **Non-Linear SVM** – cannot separated by straight line.

↳ Using kernel funⁿ, non-linear SVM handle non-linearly separable data.

↳ original i/p data transformed by kernel funⁿ into high-dim feature space, where data points can linearly separated.

↳ Linear SVM used to locate non-linear decision boundary in this modified space.



Advantages of SVM –

1. Effective in high-dim spaces & work well with small amount of data as well.
2. Can handle both linear & non-linear decision boundaries.
3. Help prevent overfitting & generalizes well to unseen data.

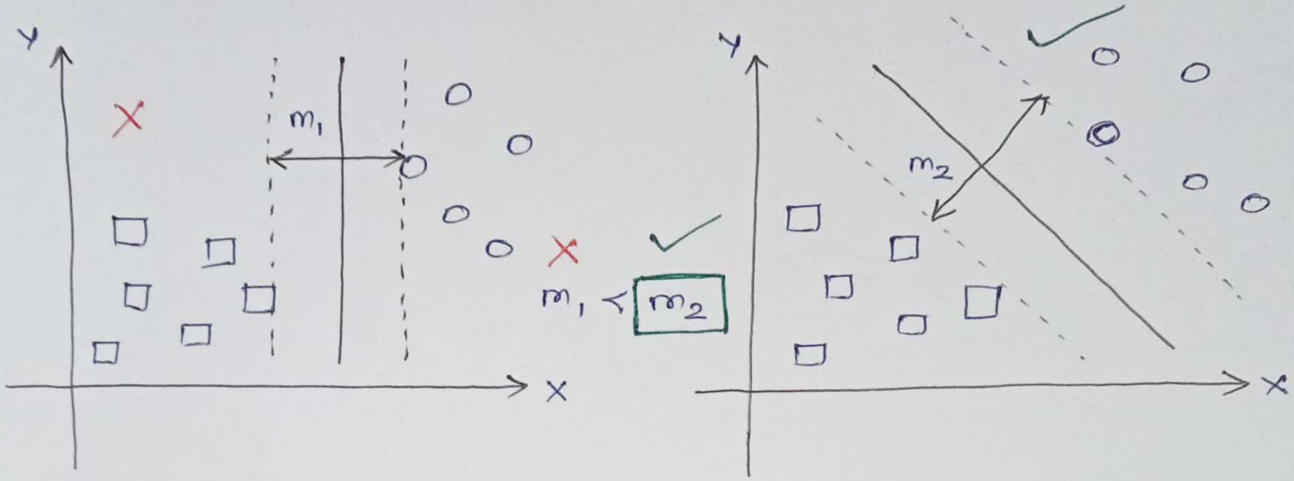
Limitations of SVM :

1. computationally expensive, especially large datasets or complex kernels.
2. Proper kernel selection & its parameter crucial for achieving good results.
2. Interpreting results of complex kernel might be challenging.

1) Linear SVM :-

↳ Linearly separable data - when 1 line divide complete data into 2 classes.

↳ Can apply Linear SVM on that data.



↳ Margine value less.
↳ More missclassification.
↳ More errors.
↳ Less accuracy.

↳ Greater margin.
↳ No/less missclassification
↳ Better prediction.
↳ Better accuracy
↳ No/less Error.

• Note :- Select hyperplane with max. margin.
Maximal Margin Hyperplane (MMH).