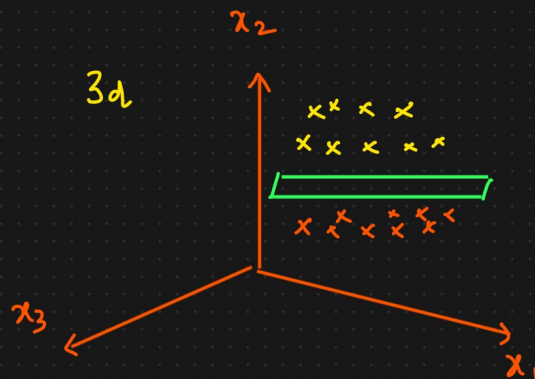
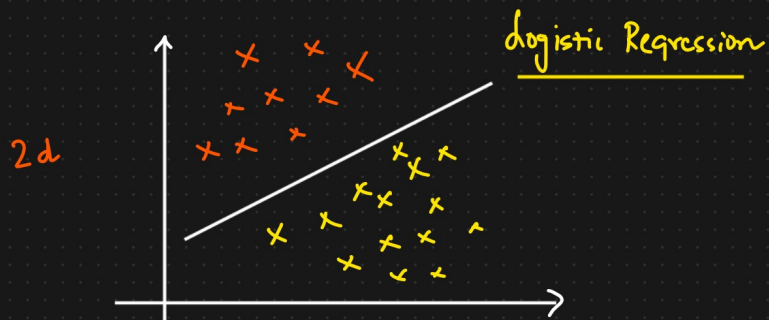


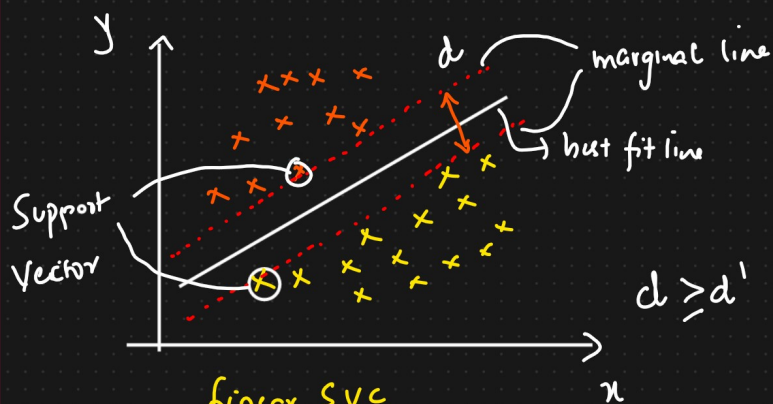
Support Vector Machines ML Algorithm

① SVC (Support Vector Classifier) \rightarrow Classification

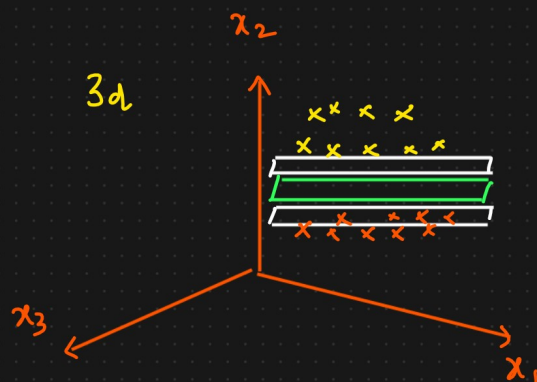
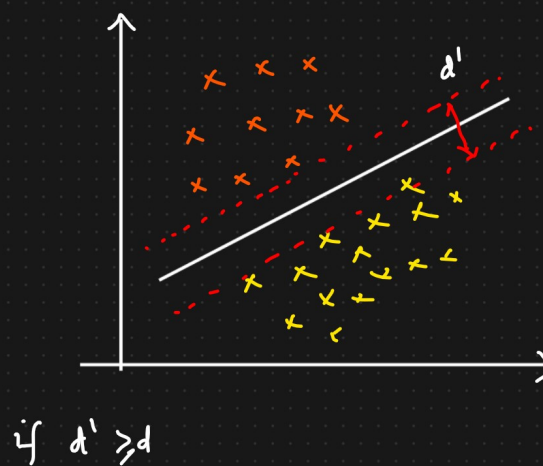
② SVR (Support Vector Regressor) \rightarrow Regression



① Support Vector Classifier (SVC)

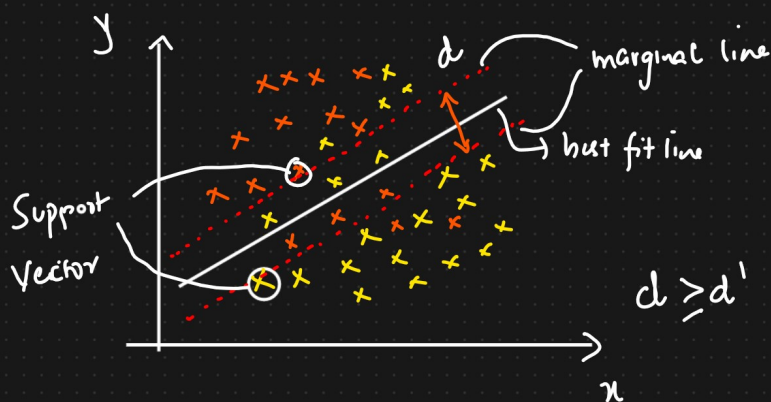


$d =$ marginal plane distance

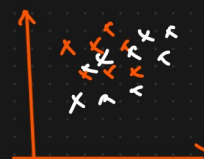


Soft Margin And Hard Margin In SVC

Hard Margin = None of the datapoints are misclassified

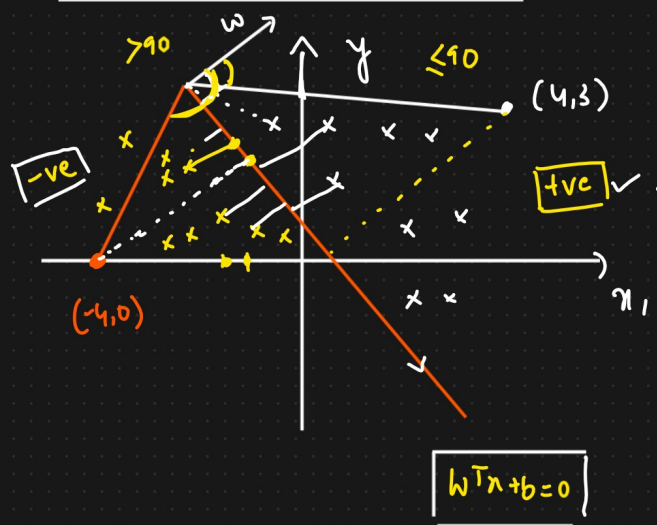


↓
Impossible



② Soft Margin ÷ Some data point are misclassified [error]

③ Support Vector Machines (SVC) Maths Intuition



Equation of a straight line

$$\hat{y} = mx + c \Leftrightarrow ax + by + c = 0$$

$$h(x) = \theta_0 + \theta_1 x, \quad by = -ax - c$$

$$y = \theta_0 + \theta_1 x_1 + \theta_2 x_2 + \theta_3 x_3, \quad y = \frac{-a}{b}x - \frac{c}{b}$$

$$y = b + [w_1 x_1 + w_2 x_2 + w_3 x_3], \quad y = mx + c$$

$$w = \begin{bmatrix} w_1 \\ w_2 \\ w_3 \end{bmatrix}, \quad x = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

$$w^T = [w_1 \ w_2 \ w_3] \cdot x = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

$$w^T x = [w_1 x_1 + w_2 x_2 + w_3 x_3]$$

$$y = w^T x + b \Rightarrow y = mx + c$$

$$ax + by + c = 0$$

$$\boxed{w^T x + b = 0}$$

Marginal plane in SVC

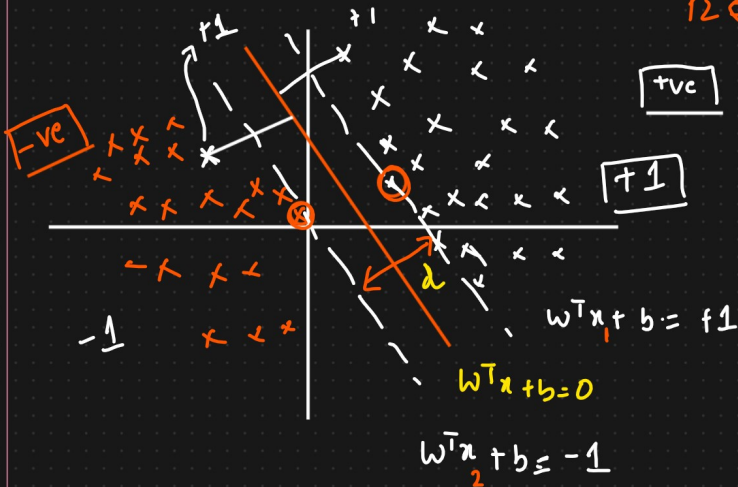
$$P_1 \in \pi_1 \Rightarrow (x_1, x_2)$$

$$P_2 \in \pi_2 \Rightarrow (x_1, x_2)$$

$$w^T x_1 + b = +1$$

$$w^T x_2 + b = -1$$

$$\begin{matrix} (-) & (-) & (+) \end{matrix}$$



$$\vec{w} \Leftarrow \frac{w^T(x_1 - x_2)}{\|w\|} = \boxed{\frac{2}{\|w\|}} \Rightarrow \text{distance between Marginal planes.}$$

↓
Maximize

Cost function

Maximize
 w, b

$$\boxed{\frac{2}{\|w\|}}$$

\Rightarrow Distance between Marginal plane

Constraint such that

$$y_i \begin{cases} +1 & \text{if } w^T x + b \geq 1 \\ -1 & \text{if } w^T x + b \leq -1 \end{cases}$$

↓

For all correctly classified data points

$$\boxed{y_i * w^T x + b} \geq 1.$$

Modified Cost function of SVC

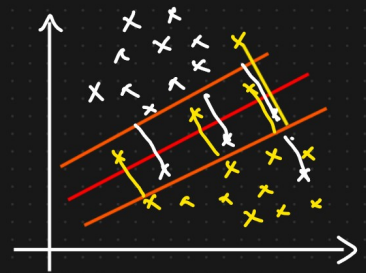
$$\text{Maximize } \frac{2}{\|w\|} \Rightarrow \boxed{\text{Minimize } \frac{\|w\|}{2}}_{w, b}$$

Constraint such that

$$y_i \begin{cases} +1 & \text{if } w^T x + b \geq 1 \\ -1 & \text{if } w^T x + b \leq -1 \end{cases}$$

Cost function of Soft Margin SVC

$$\boxed{C_i = 5}$$



$$\text{Cost fn} = \min_{w, b} \frac{\|w\|}{2} + \underbrace{\left[C_i \sum_{i=1}^n \xi_i \right]}_{\text{hyperparameter}} \Rightarrow \text{hinge loss}$$

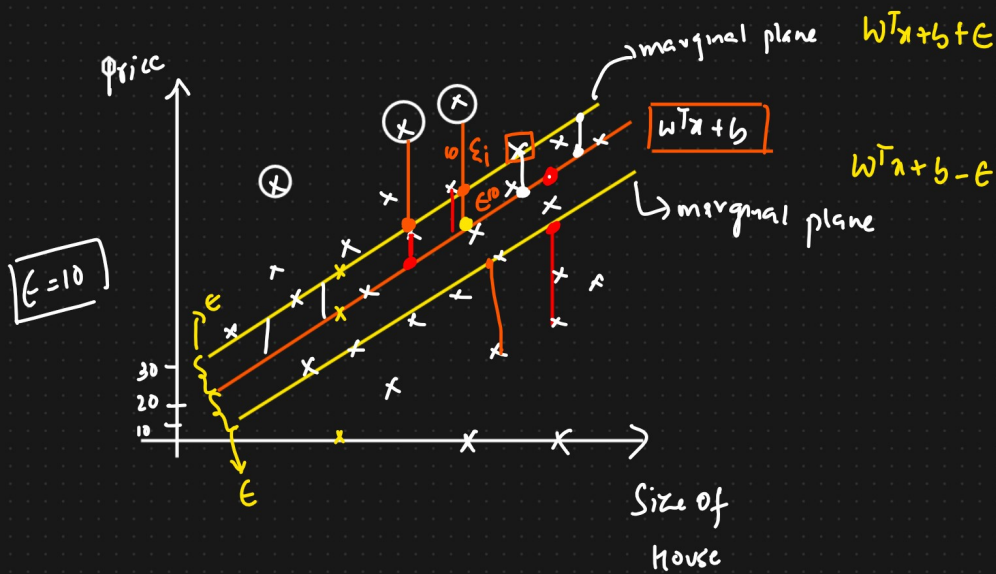
Summation of the distance of incorrect data points to the marginal plane

$$\boxed{C = \frac{1}{\lambda}}$$

{How many points we can consider for misclassification}

Support Vector Regressor (SVR)

ϵ = Marginal Error



$$\xi_i = 10, \epsilon = 10$$

$$\leq 20$$

Cost fn

$$\text{Min}_{w, b} \frac{\|w\|}{2} + \left[C \sum_{i=1}^n \xi_i \right] \Rightarrow \text{Hinge loss}$$

Constraint

$$|y_i - w^T x_i| \leq \epsilon + \xi_i$$

ϵ Marginal Error

ξ_i = Error above the Margin