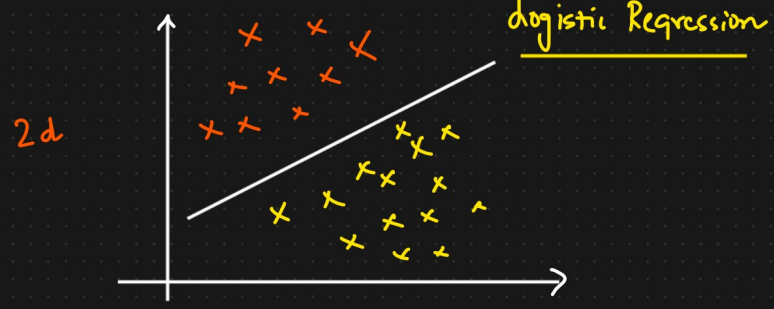
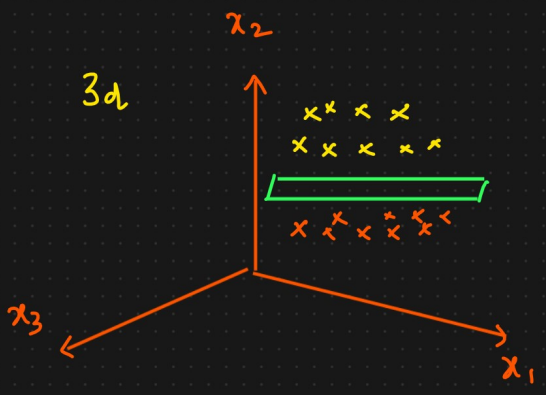
Support Vector Machines ML Algorithm

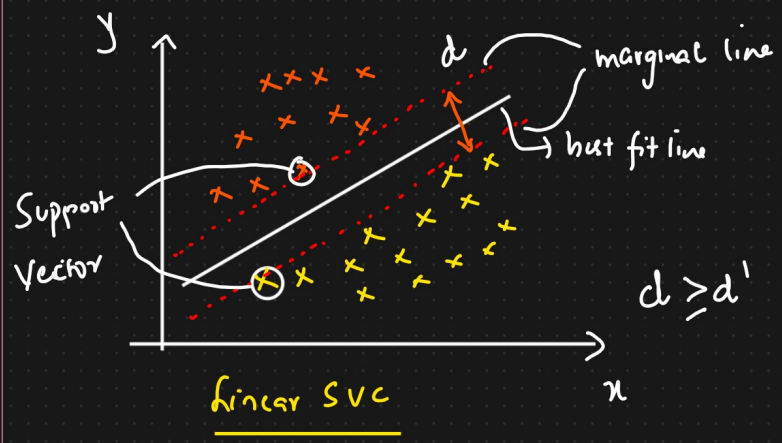
① SVC (Support Vector Classifier) ⟶ classification

② SVR (Support Vector Regressor) ⟶ Regression





① Support Vector Classifier (SVC)

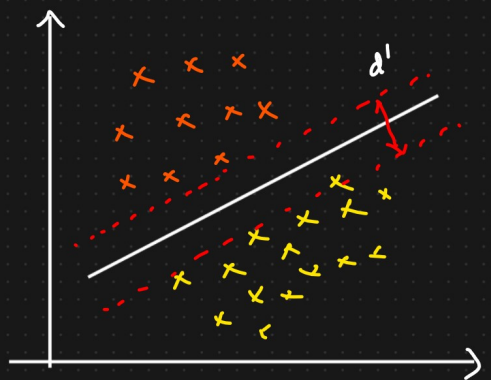


$d \geq d'$

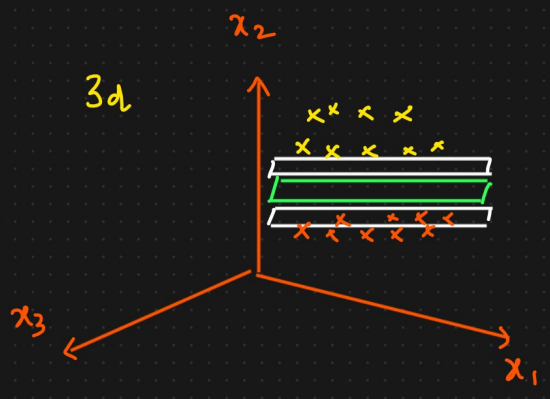
linear SVC

distance is maximum

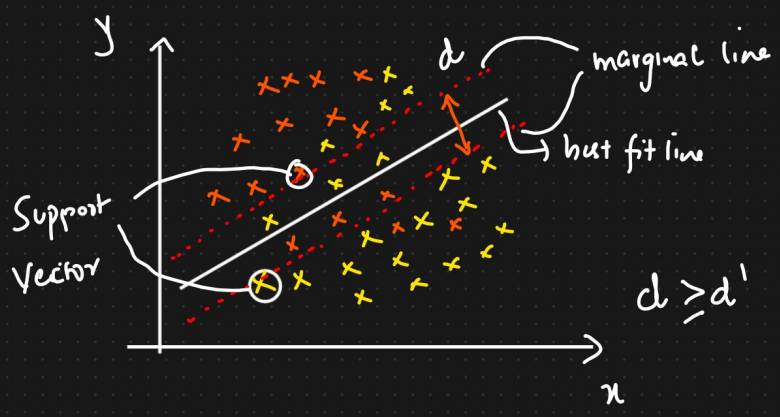
d = marginal plane distance



if $d' \geq d$



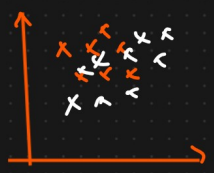
Soft Margin And Hard Margin In SVC



Hard Margin = None of the datapoints are misclassified

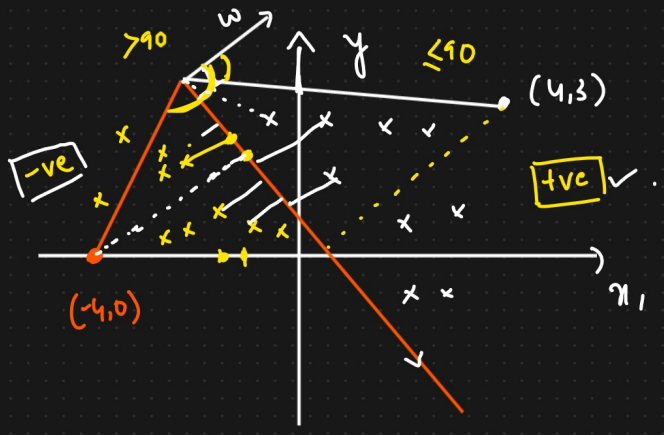
⇓

Impossible



② Soft Margin : Some data point are misclassified [Error]

③ Support Vector Machines (SVC) Maths Intuition



$w^T x + b = 0$

Equation of a straight line

$y = mx + c \iff ax + by + c = 0$

$h_\theta(x) = \theta_0 + \theta_1 x_1$

$by = -ax - c$

$y = \frac{-a}{b} x - \frac{c}{b}$

$y = \theta_0 + \theta_1 x_1 + \theta_2 x_2 + \theta_3 x_3$

$y = m x + c$

$y = b + [w_1 x_1 + w_2 x_2 + w_3 x_3]$

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

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

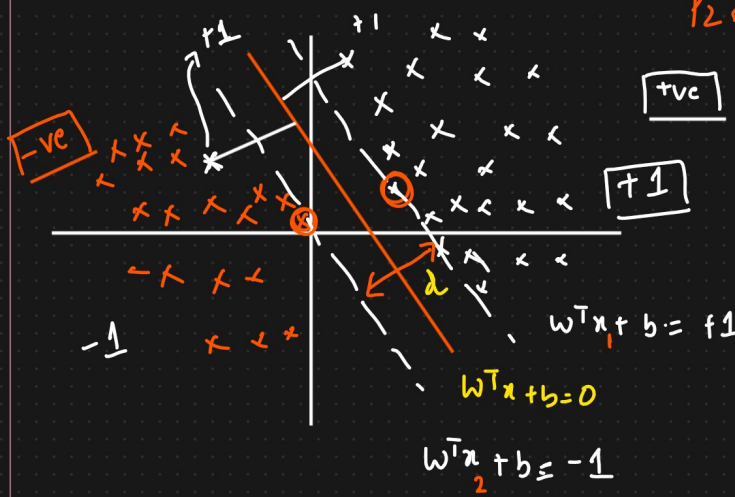
$$w^T x = [w_1 x_1 + w_2 x_2 + w_3 x_3]$$

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

$ax + by + c = 0$

$$w^T x + b = 0$$

Marginal plane in SVC



$P_1 \Leftarrow x_1 \Rightarrow (x_1, x_2)$

$P_2 \Leftarrow x_2 \Rightarrow (x_1, x_2)$

$w^T x_1 + b = +1$

$w^T x_2 + b = -1$

(-) (-) (+)

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

$\Downarrow$

Maximize

Cost function

Maximize w, b $\quad \dfrac{2}{\|w\|}$ $\Rightarrow$ Distance between Marginal plane

Constraint such that

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

$\Downarrow$

For all correctly classified data points

$$y_i * (w^T x + b) \geq 1.$$

Modified Cost function of SVC

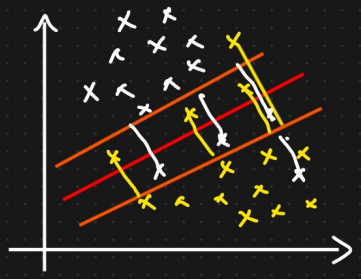
$$\underset{w,b}{\text{Maximize}} \quad \frac{2}{\|w\|} \Rightarrow \boxed{\underset{w,b}{\text{Minimize}} \quad \frac{\|w\|}{2}}$$

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

$C_i = 5$



$$\text{Cost fn} = \underset{w,b}{\text{Min}} \frac{\|w\|}{2} + \boxed{C_i \sum_{i=1}^{n} \xi_i} \Rightarrow \text{Hinge loss}$$

C_i → hyperparameter

ξ_i → 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}