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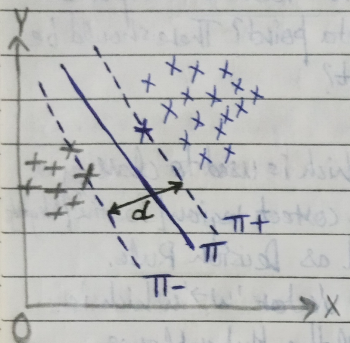
Hard Margin SVM.....



Equation of π ⇒ $\boxed{W^T X + B = 0}$

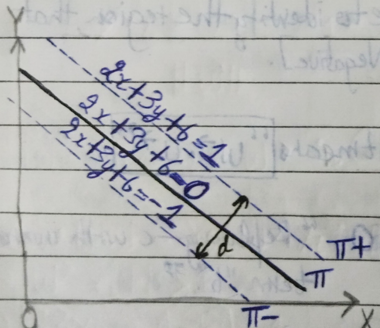
Assuming that the π+ and π- equations will be :-

π+ ⇒ $\boxed{W^T X + B = 1}$

π- ⇒ $\boxed{W^T X + B = -1}$

Q Why the magnitude between the π+ and π- are equal?

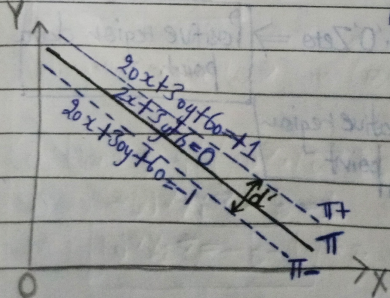
Ans The Decision Hyperplane is designed in such a way that the magnitude between the π- and the magnitude between the π+ are always same.



Let's say I will multiply the equation of π+ and π- will 10.

$\boxed{\pi+ \Rightarrow 20x+30y+60=1}$

$\boxed{\pi- \Rightarrow 20x+30y+60=-1}$



"We can observe that, $\boxed{d' < d}$. The margin is shrinked as we multiply the equation above 1."

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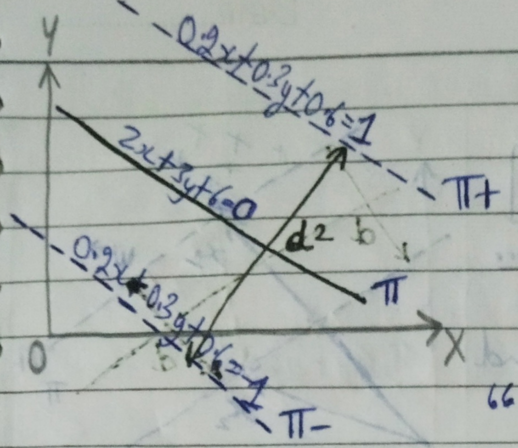
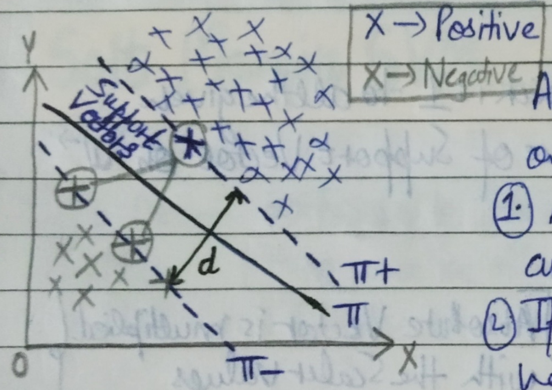


Let's say I will multiply the $\pi+$ and $\pi-$ which is less than '1', say '0.1'.

$$\boxed{\pi+ \Rightarrow 0.2x+0.3y+0.6=1}$$
$$\boxed{\pi- \Rightarrow 0.2x+0.3y+0.6=-1}$$

"We can observe that $\boxed{d2>d}$. It means when we multiply the equation of $\pi+$ and $\pi-$ with less than '1', the margin will expand."



As, per our SVM, we have some conditions only which this 'd' will be calculated:-

1. All the data should be properly classified and too much linear.
2. If any Positive data point lies inside the negative region or vica versa and if any data point is lies beyond the "$\pi+$" or "$\pi-$". then also our complete SVM will fail.

Constraints based on this

Constraints in Hard Margin SVM

1. π Equation $\Rightarrow \boxed{W^{\to T}\vec{X_i}+B=0}$, Similarly for $\pi+$

$\boxed{W^{\to T}\vec{X_i}+B=1}$, and for $\pi- = \boxed{W^{\to T}\vec{X_i}+B=-1}$

For Data points lies in the Positive region.

$$\boxed{Y_i(W^{\to T}X_i^{\to}+B)\geq 1}$$ (I) Constraint

Assuming that:-

$Y+=1$ [All Y+ outputs are labelled as 1]

$Y-=-1$ [All Y− outputs are labelled as -1]

For Data points lies in the Negative Region

$$\boxed{Y_i(W^{\to T}X_i^{\to}+B\leq 1}$$ (II) Constraint

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$\boxed{\text{For Data Points which lies at hyper Planes of Support Vectors}}$

$\boxed{Y_i(\vec{W}\cdot\vec{X_i}+b)=1}$

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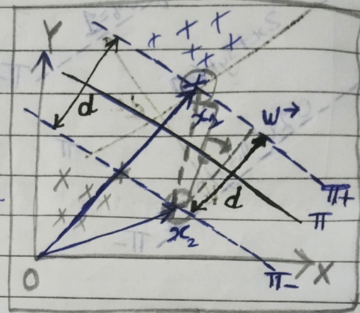
Combining (I) and (II) Constraints as:-

When $Y_i=1$

$Y_i(\vec{W}\cdot\vec{X_i}+B)\geq 1 \Rightarrow \boxed{1(\vec{W}\cdot\vec{X_i}+B)\geq 1}$

When $Y_i=-1 \Rightarrow \boxed{Y_i(\vec{W}\cdot\vec{X_i}+B)\geq 1}$ Both are same...

So, as according to the Graph, we have taken '2' Support Vectors and named them as 'x_1' and 'x_2'.



distance between the Support Vectors is:-

$\boxed{x_2-x_1}$

· We already have a vector named "$W^{\rightarrow}$" which is '⊥' to all the given hyper parameters. If we project the difference of Support Vectors on "$W^{\rightarrow}$" Vector, we will get the margin 'd'.

$$\therefore d=(x_2-x_1)*\left(\frac{W^{\rightarrow}}{\|W\|}\right)$$

[Absolute Vector is multiplied with the Scaler values]

$$\Rightarrow \frac{x_2 * W^{\rightarrow} - x_1 * W^{\rightarrow}}{\|W\|}$$

Putting the "$x_2 * W^{\rightarrow}$" in Constraint for Support Vectors:-

Constraint $= Y_i(\vec{W}\cdot\vec{X_i}+B)\geq 1 \Rightarrow 1(\vec{W}x_2+B)\geq 1$

$\Rightarrow \vec{W}x_2+B\geq 1$

$\Rightarrow \boxed{\vec{W}x_2 = 1-B} \Rightarrow 1.$

Putting the "$x_1 * W^{\rightarrow}$" in Constraint for Support Vectors:-

Constraint $= Y_i(\vec{W}\cdot\vec{X_i}+B)=1 \Rightarrow -1(\vec{W}\vec{X_i}+B)=1$

$\Rightarrow -\vec{W}\vec{X_i}-B=1$

$\boxed{\vec{W}\vec{X_i}=-B-1} \Rightarrow 2.$

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Putting the values in 1: and 2: in 'd' margin.

$$d = \frac{1-B-(-B-1)}{||W||} \Rightarrow \frac{1-\cancel{B}+\cancel{B}+1}{||W||} \qquad \boxed{d \rightarrow \frac{2}{||W||}}$$

It means $\text{argmax}\,(W^*, b^*) \boxed{\frac{2}{||W||}}$ [Should be maximum or Highest term]

given that $\boxed{Y_i(\vec{w}\,\vec{x_i}+B) \geq 0}$