

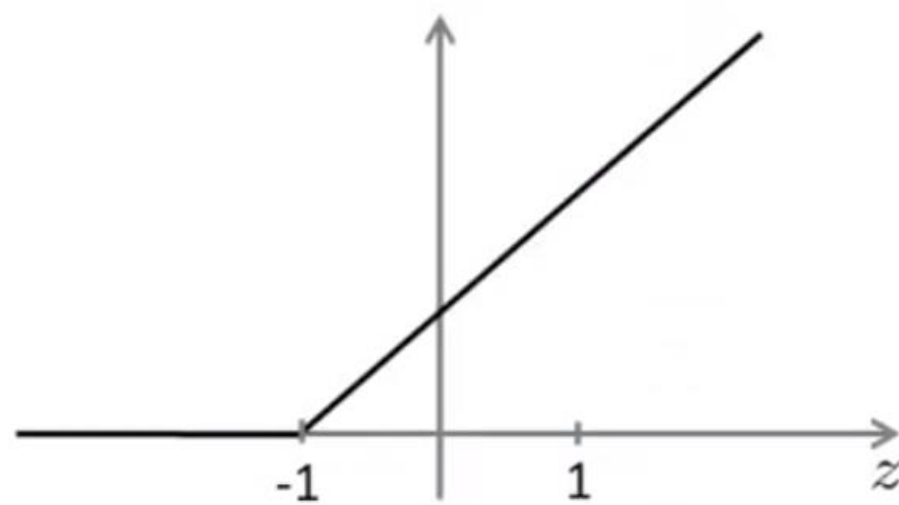
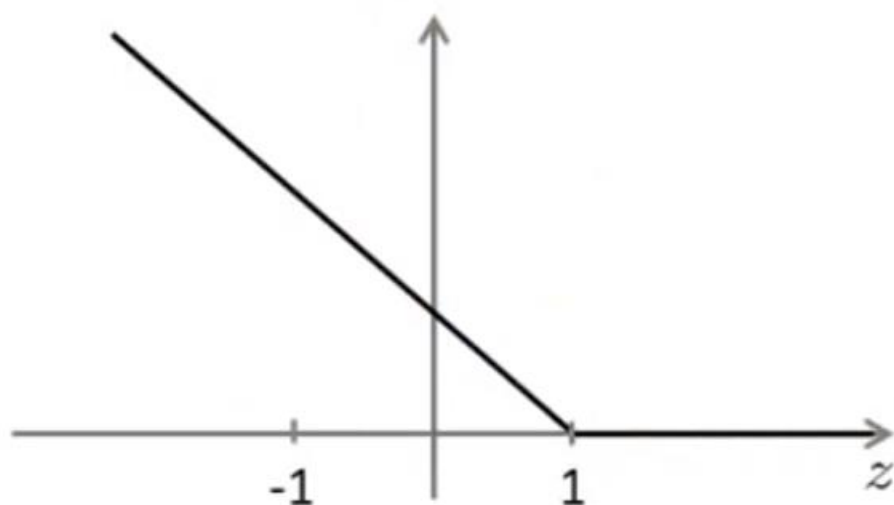
Large Margin Intuition

Large Margin Classification

Support Vector Machines

Support Vector Machine

$$\min_{\theta} C \sum_{i=1}^m \left[y^{(i)} \text{cost}_1(\theta^T x^{(i)}) + (1 - y^{(i)}) \text{cost}_0(\theta^T x^{(i)}) \right] + \frac{1}{2} \sum_{j=1}^n \theta_j^2$$

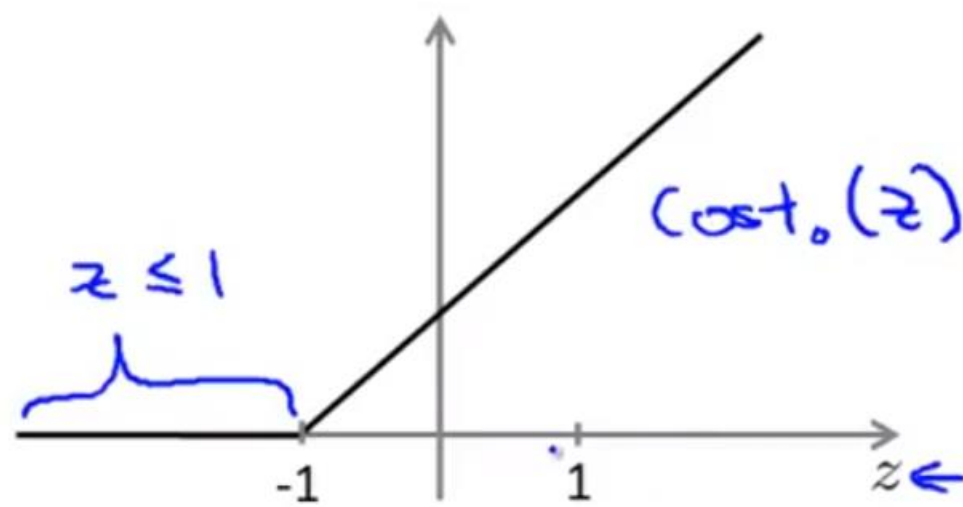
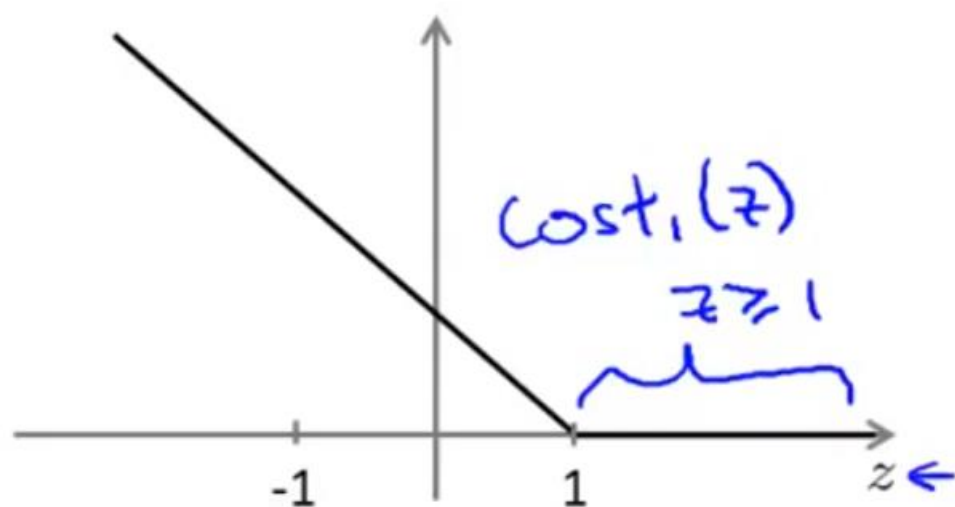


If $y = 1$, we want $\theta^T x \geq 1$ (not just ≥ 0)

If $y = 0$, we want $\theta^T x \leq -1$ (not just < 0)

Support Vector Machine

$$\rightarrow \min_{\theta} C \sum_{i=1}^m \left[y^{(i)} \underline{\text{cost}_1(\theta^T x^{(i)})} + (1 - y^{(i)}) \underline{\text{cost}_0(\theta^T x^{(i)})} \right] + \frac{1}{2} \sum_{j=1}^n \theta_j^2$$

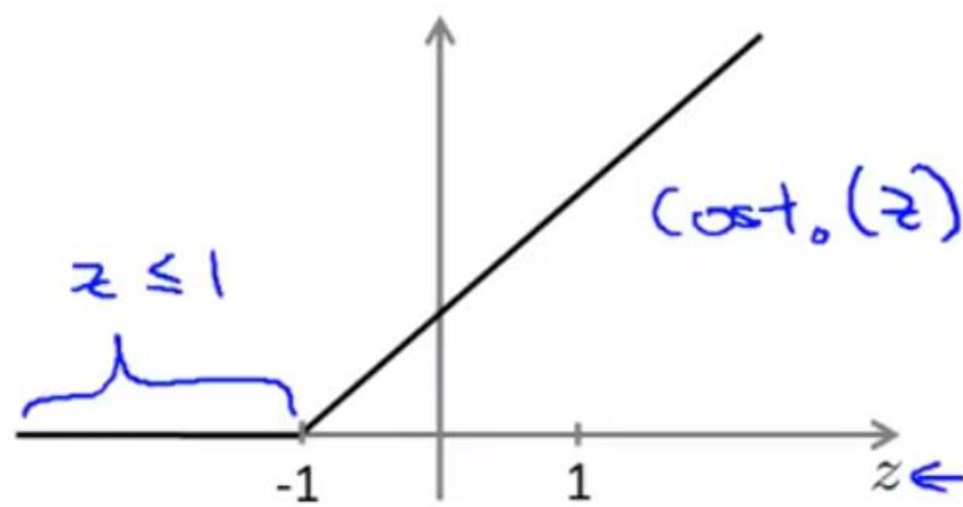
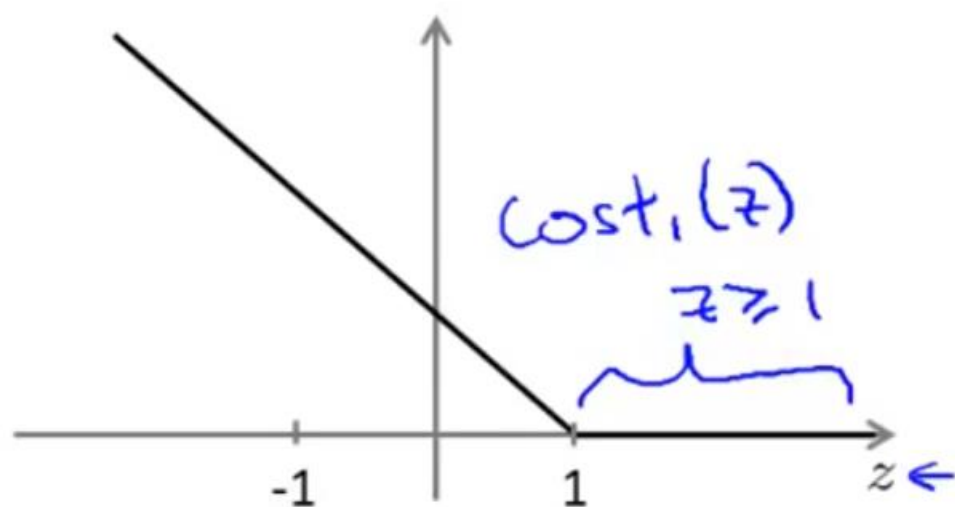


\rightarrow If $y = 1$, we want $\theta^T x \geq 1$ (not just ≥ 0)

\rightarrow If $y = 0$, we want $\theta^T x \leq -1$ (not just < 0)

Support Vector Machine

$$\rightarrow \min_{\theta} C \sum_{i=1}^m \left[y^{(i)} \underline{\text{cost}_1(\theta^T x^{(i)})} + (1 - y^{(i)}) \underline{\text{cost}_0(\theta^T x^{(i)})} \right] + \frac{1}{2} \sum_{i=1}^n \theta_j^2$$



\rightarrow If $y = 1$, we want $\theta^T x \geq 1$ (not just ≥ 0)

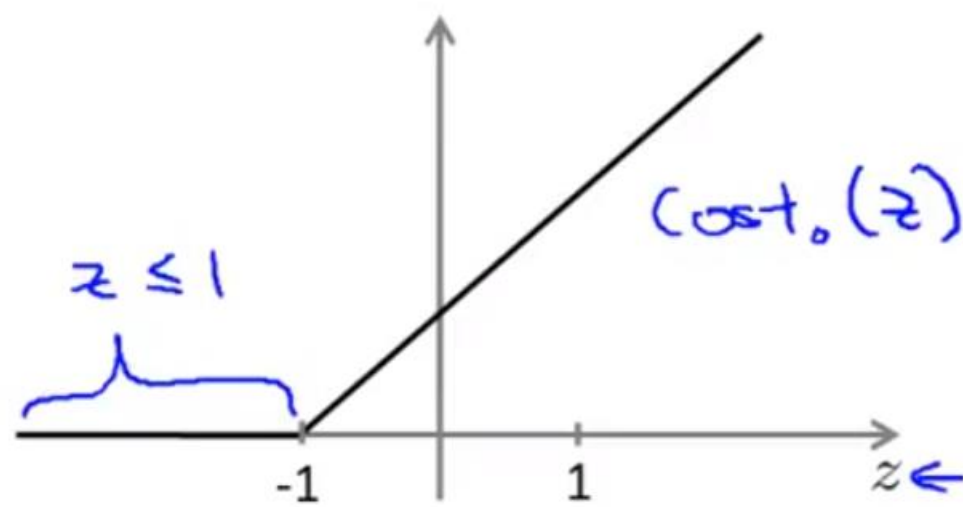
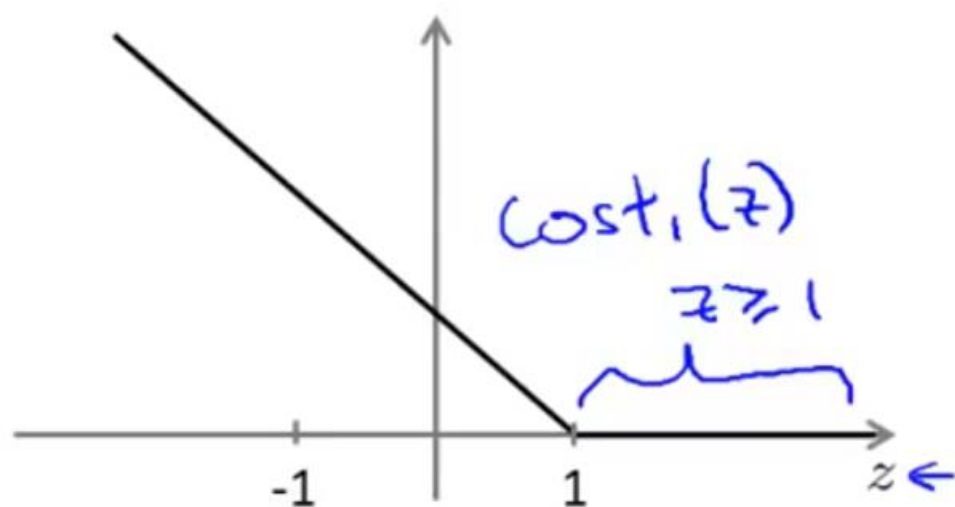
$$\theta^T x \geq \cancel{0} \quad 1$$

\rightarrow If $y = 0$, we want $\theta^T x \leq -1$ (not just < 0)

$$\theta^T x \leq \cancel{0} \quad -1$$

Support Vector Machine

$$\rightarrow \min_{\theta} C \sum_{i=1}^m \left[y^{(i)} \underline{\text{cost}_1(\theta^T x^{(i)})} + (1 - y^{(i)}) \underline{\text{cost}_0(\theta^T x^{(i)})} \right] + \frac{1}{2} \sum_{j=1}^n \theta_j^2$$



\rightarrow If $y = 1$, we want $\theta^T x \geq 1$ (not just ≥ 0)

$$\theta^T x \geq \cancel{0} \quad 1$$

\rightarrow If $y = 0$, we want $\theta^T x \leq -1$ (not just < 0)

$$\theta^T x \leq \cancel{0} \quad -1$$

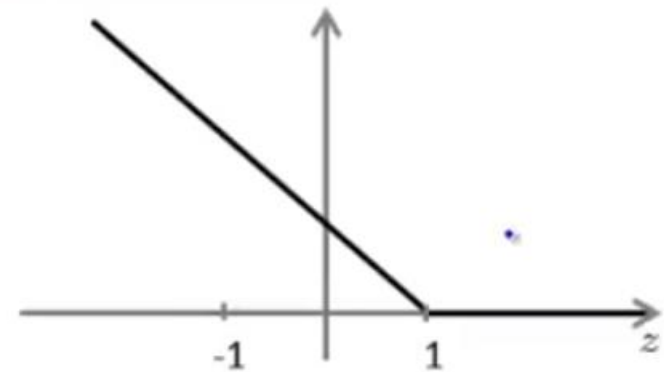
$$C = 100,000$$

SVM Decision Boundary

$$\min_{\theta} C \sum_{i=1}^m \left[y^{(i)} \text{cost}_1(\theta^T x^{(i)}) + (1 - y^{(i)}) \text{cost}_0(\theta^T x^{(i)}) \right] + \frac{1}{2} \sum_{j=1}^n \theta_j^2$$

Whenever $y^{(i)} = 1$:

$= 0$



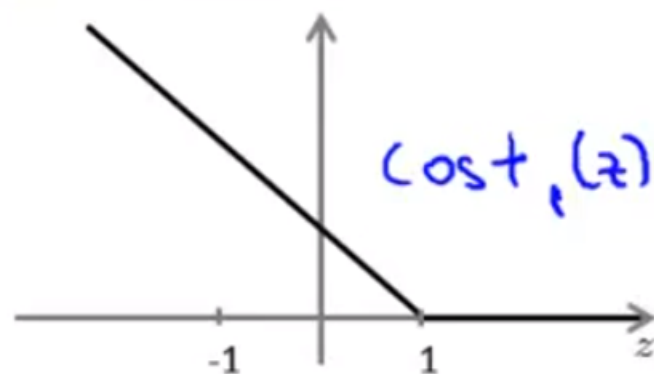
SVM Decision Boundary

$$\min_{\theta} C \sum_{i=1}^m \left[y^{(i)} \text{cost}_1(\theta^T x^{(i)}) + (1 - y^{(i)}) \text{cost}_0(\theta^T x^{(i)}) \right] + \frac{1}{2} \sum_{j=1}^n \theta_j^2$$

(Handwritten blue annotations: an arrow points from the \min_{θ} to the C term, and a bracket under the summation is labeled "= 0")

Whenever $y^{(i)} = 1$:

$$\theta^T x^{(i)} \geq 1$$



Cost is zero when $z > 1$

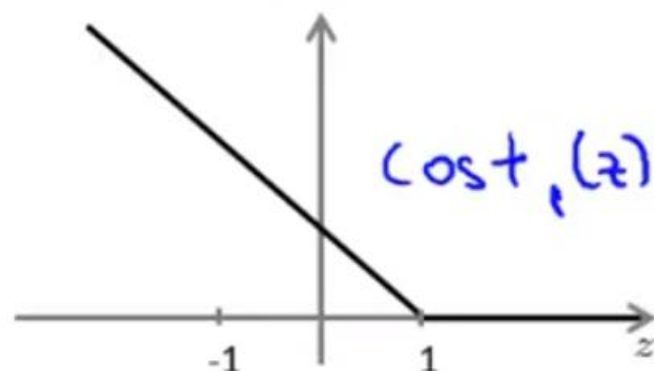
SVM Decision Boundary

$$\min_{\theta} C \sum_{i=1}^m \left[y^{(i)} \text{cost}_1(\theta^T x^{(i)}) + (1 - y^{(i)}) \text{cost}_0(\theta^T x^{(i)}) \right] + \frac{1}{2} \sum_{j=1}^n \theta_j^2$$

= 0

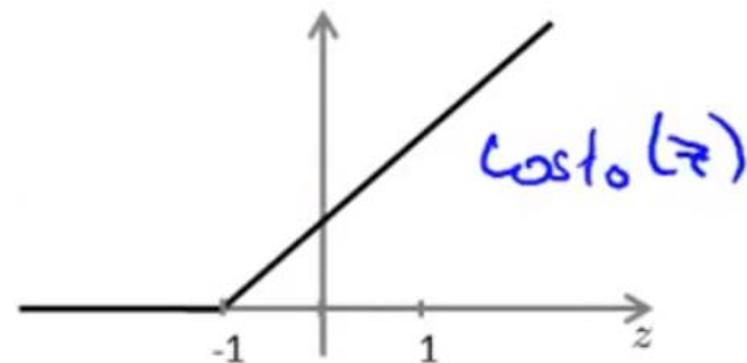
Whenever $y^{(i)} = 1$:

$$\theta^T x^{(i)} \geq 1$$



Whenever $y^{(i)} = 0$:

$$\theta^T x^{(i)} \leq -1$$



Cost is zero when $z < -1$

SVM Decision Boundary

$$\min_{\theta} C \sum_{i=1}^m \left[y^{(i)} \text{cost}_1(\theta^T x^{(i)}) + (1 - y^{(i)}) \text{cost}_0(\theta^T x^{(i)}) \right] + \frac{1}{2} \sum_{j=1}^n \theta_j^2$$

Whenever $y^{(i)} = 1$:

$$\theta^T x^{(i)} \geq 1$$

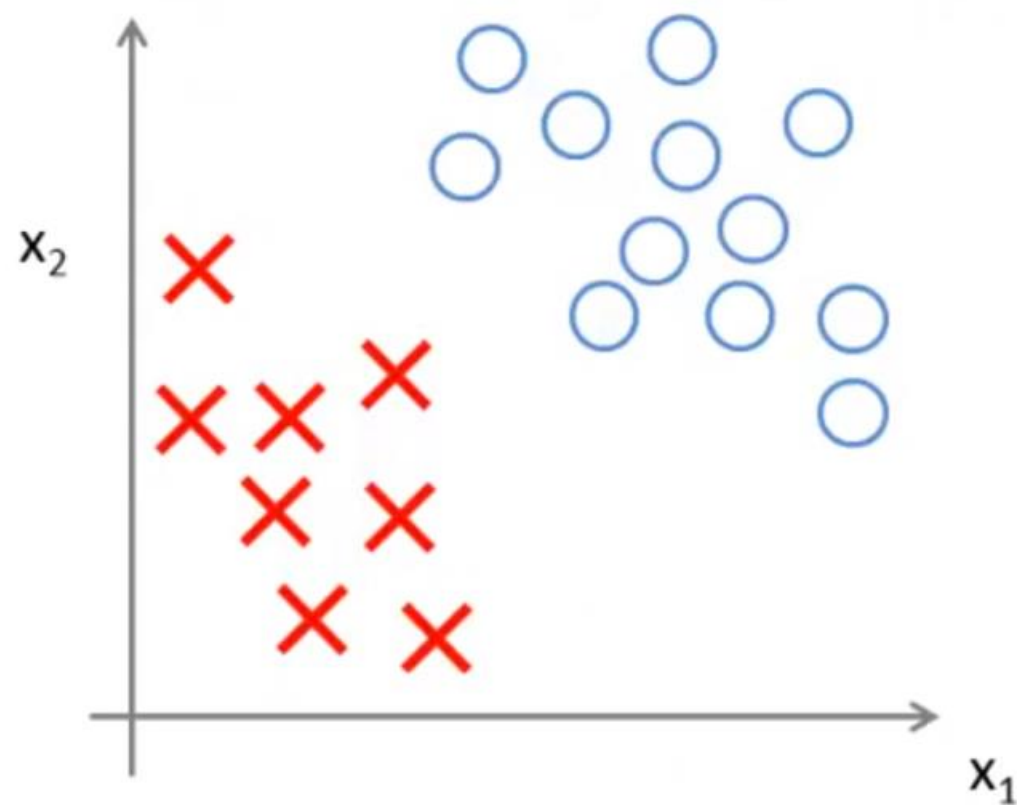
Whenever $y^{(i)} = 0$:

$$\theta^T x^{(i)} \leq -1$$

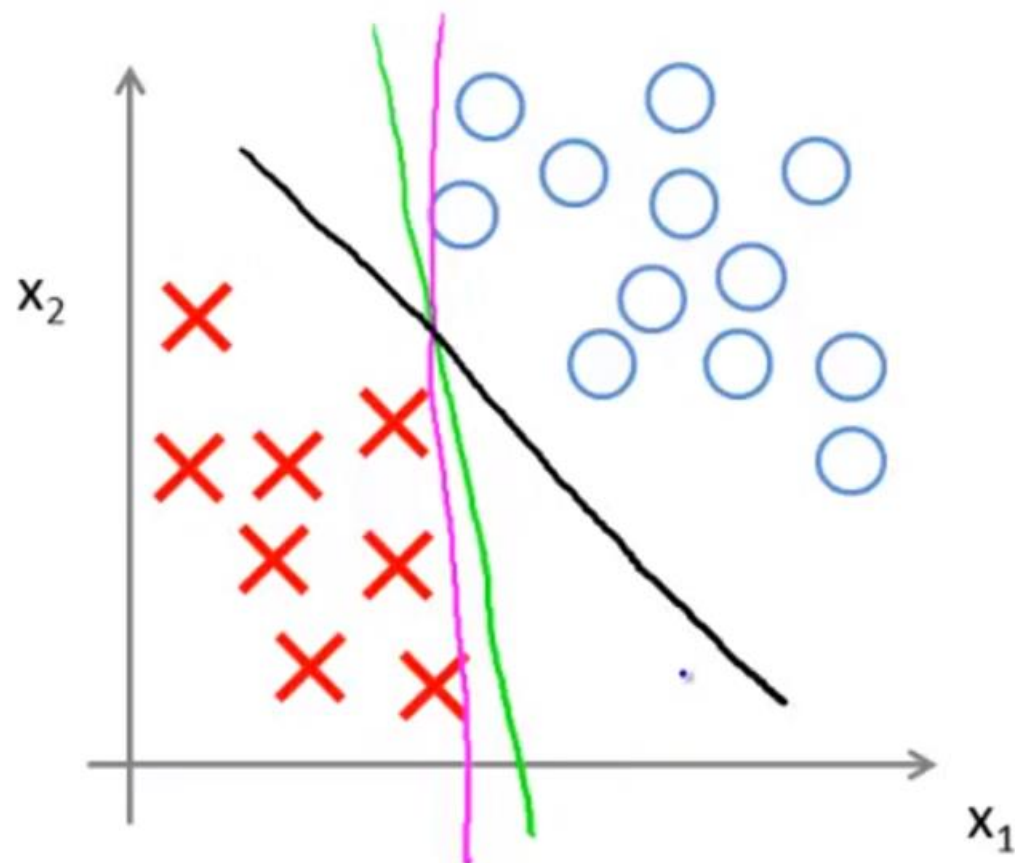
$$\min_{\theta} \cancel{C \times 0} + \frac{1}{2} \sum_{j=1}^n \theta_j^2$$

$$\text{s.t. } \begin{aligned} \theta^T x^{(i)} &\geq 1 & \text{if } y^{(i)} = 1 \\ \theta^T x^{(i)} &\leq -1 & \text{if } y^{(i)} = 0. \end{aligned}$$

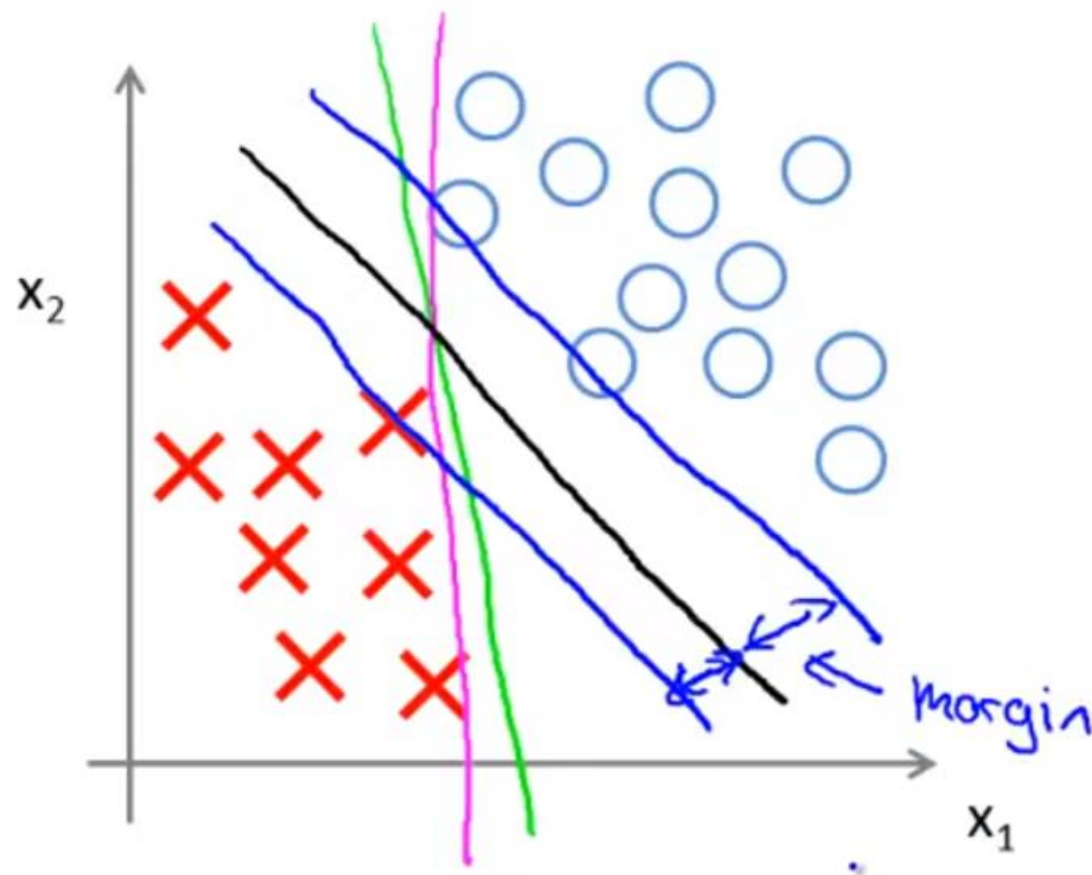
SVM Decision Boundary: Linearly separable case



SVM Decision Boundary: Linearly separable case

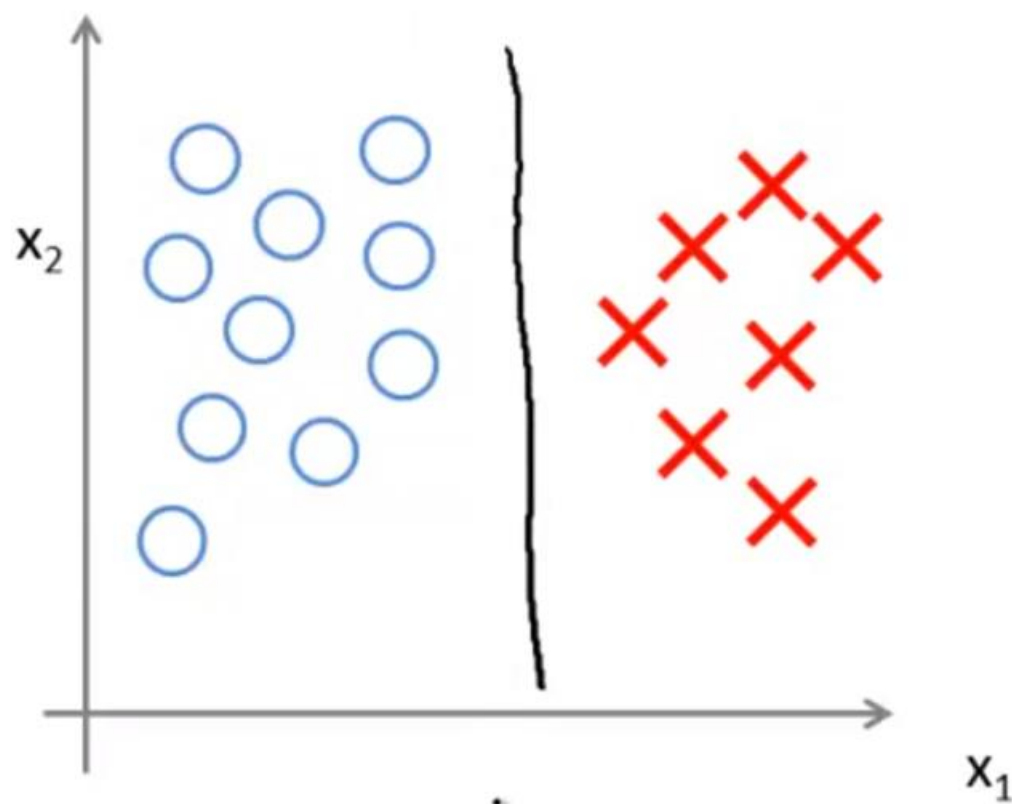


SVM Decision Boundary: Linearly separable case



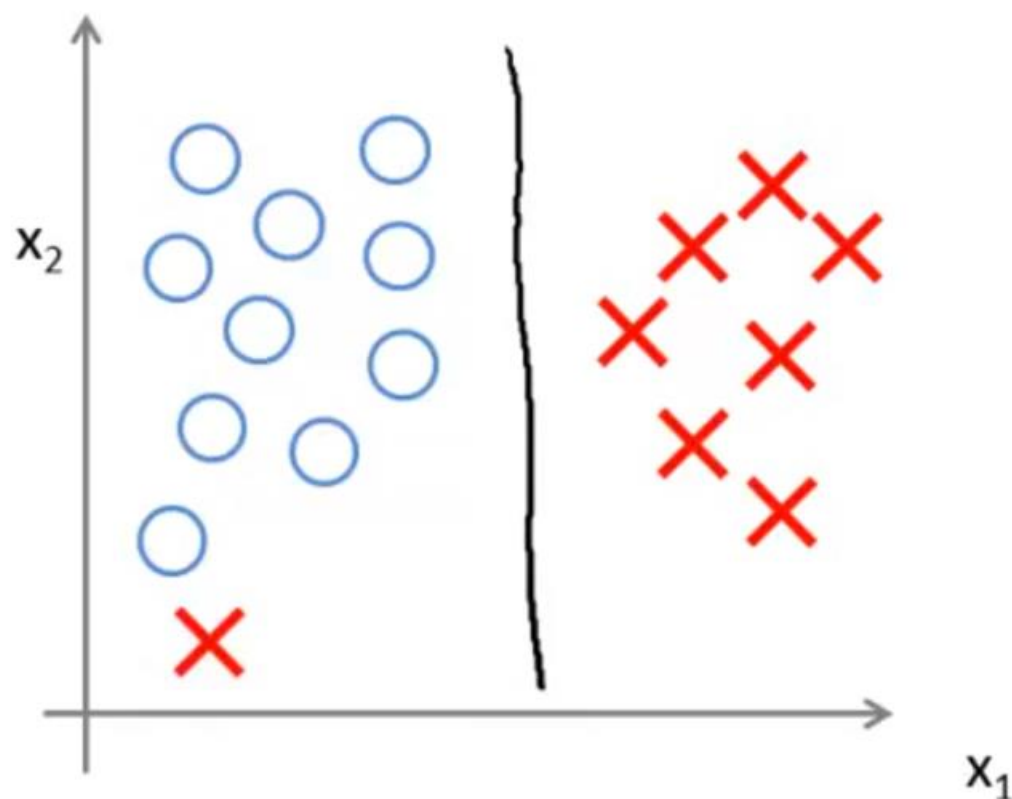
Large Margin Classifier

Large margin classifier in presence of outliers



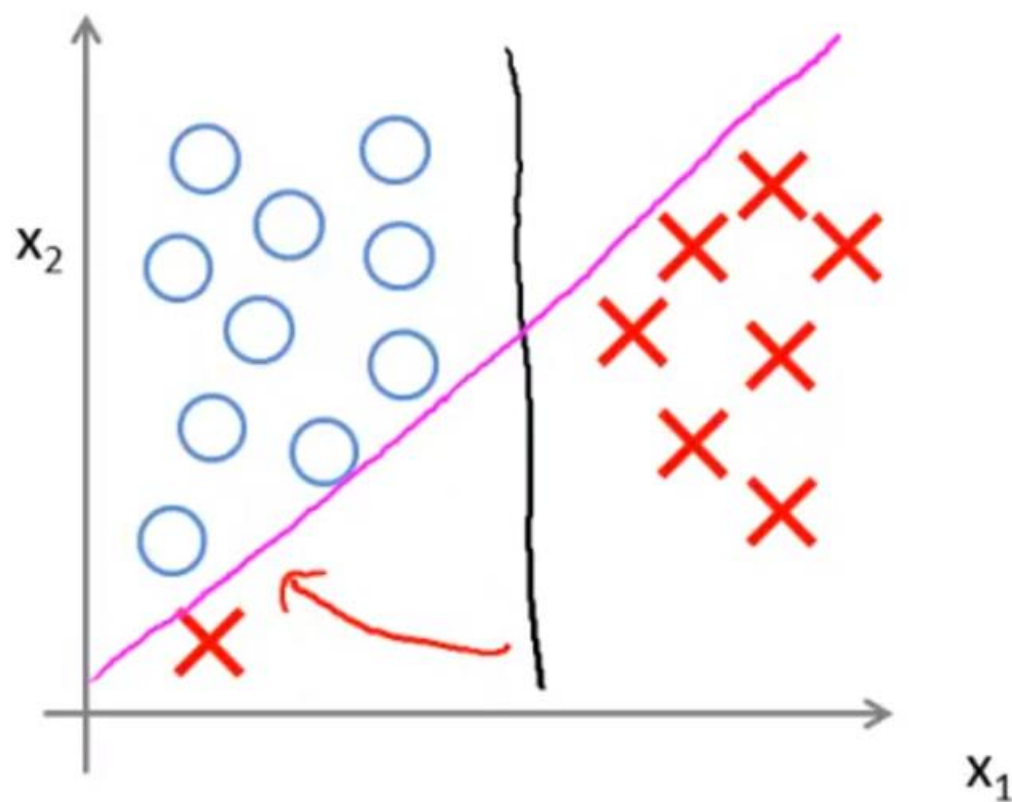
C very large

Large margin classifier in presence of outliers



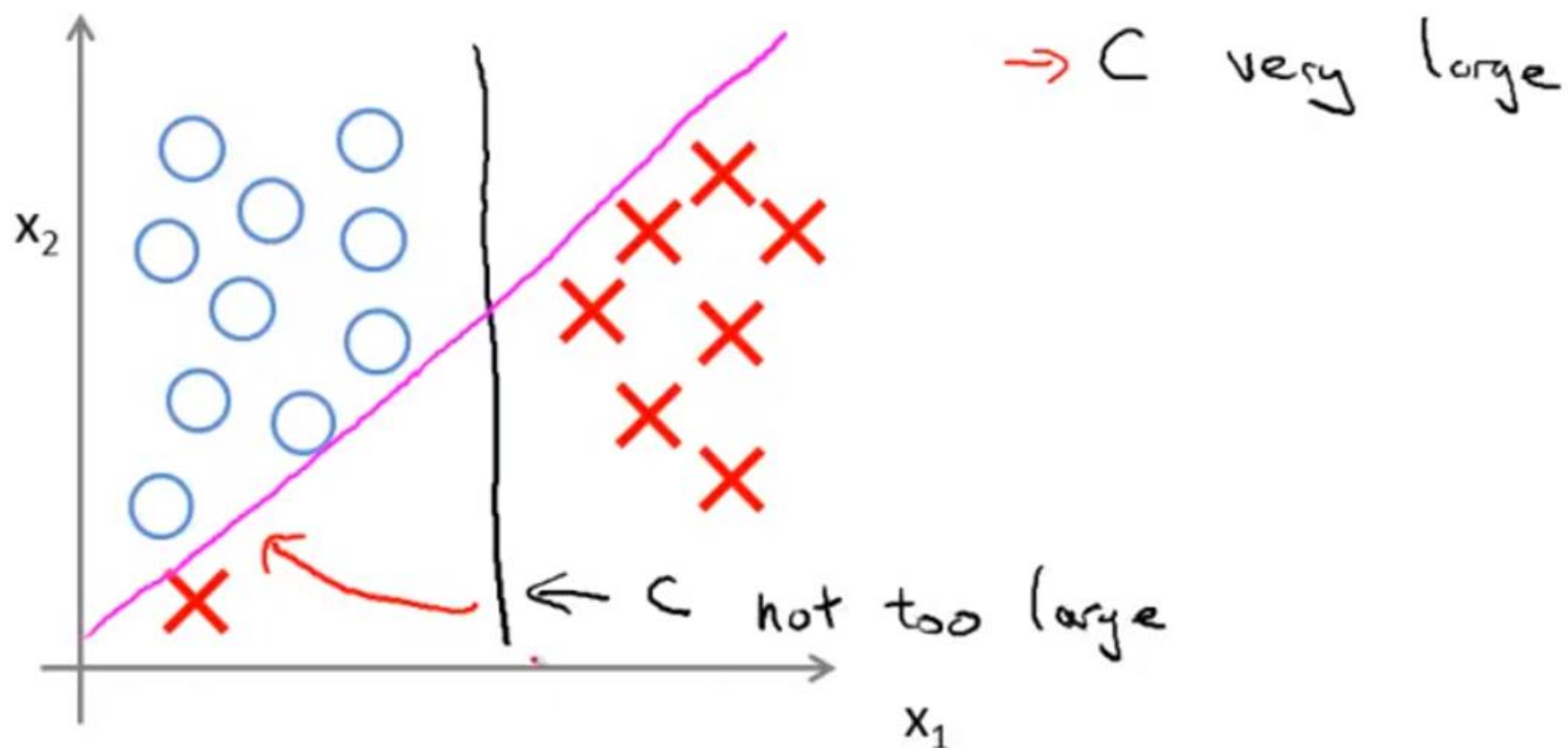
C very large

Large margin classifier in presence of outliers



C very large

Large margin classifier in presence of outliers



Large margin classifier in presence of outliers

