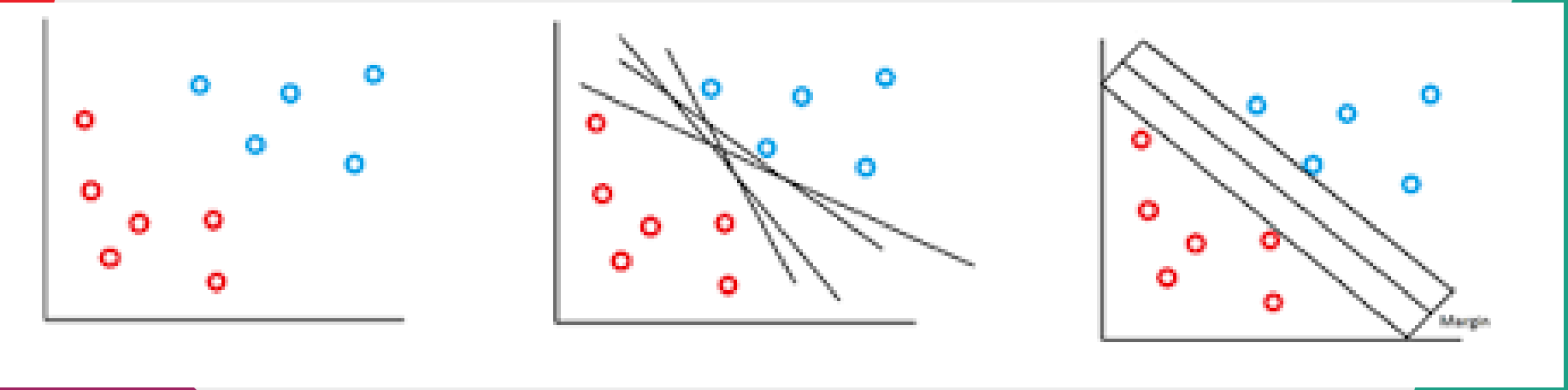
Support Vector Machines

- Week 7

Motivation

- Large range of possible decision boundaries
- Construct boundary with maximum margin



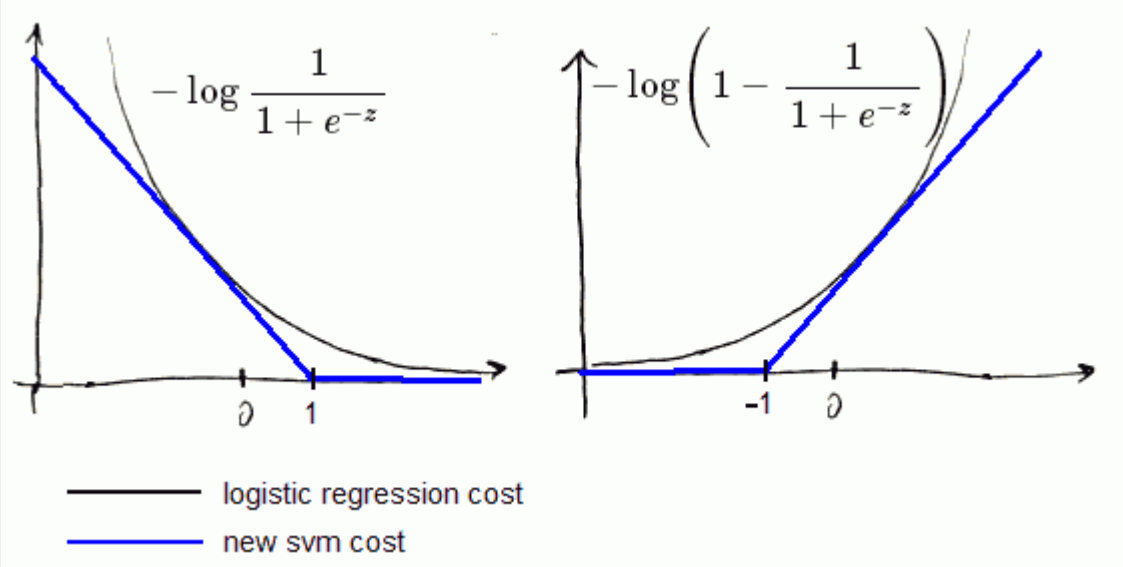
https://quantdare.com/svm-versus-a-monkey/

Rethink Cost

- Recall Cost:

$$\min_{\theta} \frac{1}{m} \sum_{i} \left(y^{(i)} log(h_\theta(x^{(i)})) - (1 - y^{(i)}) log(1 - h_\theta(x^{(i)})) \right) - \frac{\lambda}{2m} \sum_{i} ||\theta^i||^2$$

- For y=0, demand $z = \theta^T x < -1$
- For y=1, demand $z = \theta^T x > 1$



http://mlwiki.org/index.php/Support_Vector_Machines

Rethink (Con't)

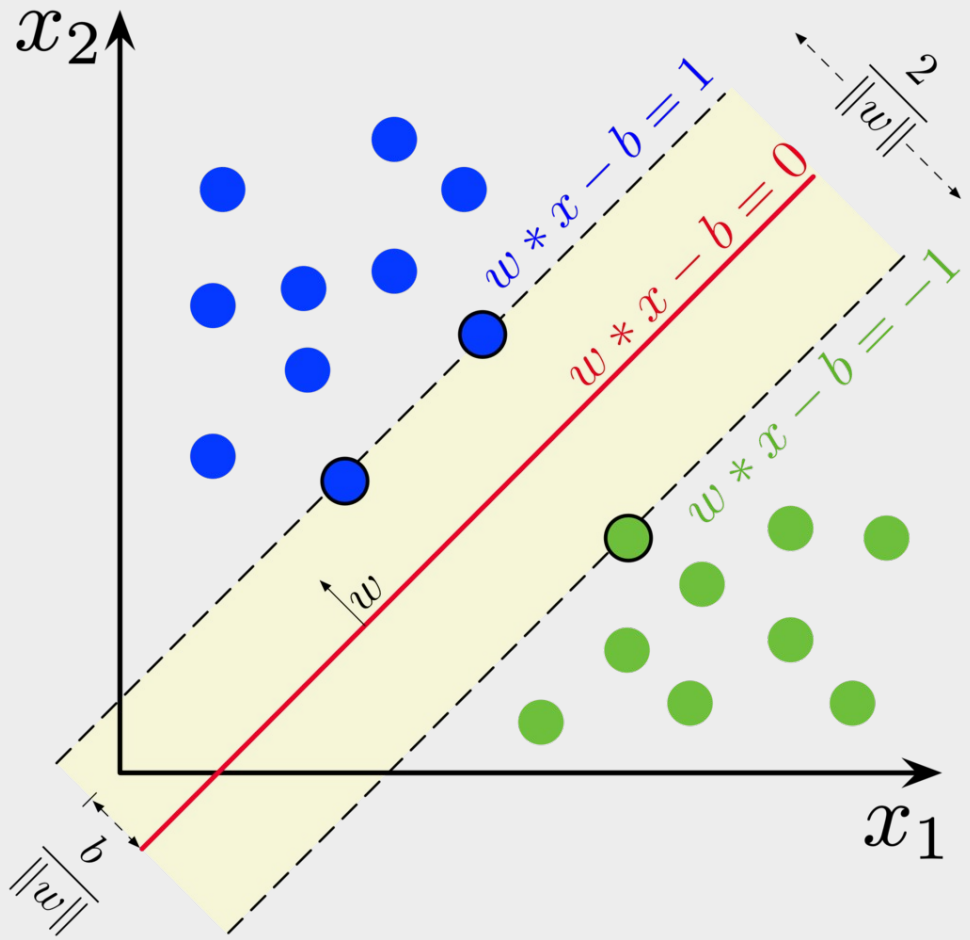
- Original Cost:

$$\min_{\theta} \frac{1}{m} \sum_{i} \left(y^{(i)} log(h_\theta(x^{(i)})) - (1 - y^{(i)}) log(1 - h_\theta(x^{(i)})) \right) - \frac{\lambda}{2m} \sum_{i} ||\theta^i||^2$$

- New Cost:

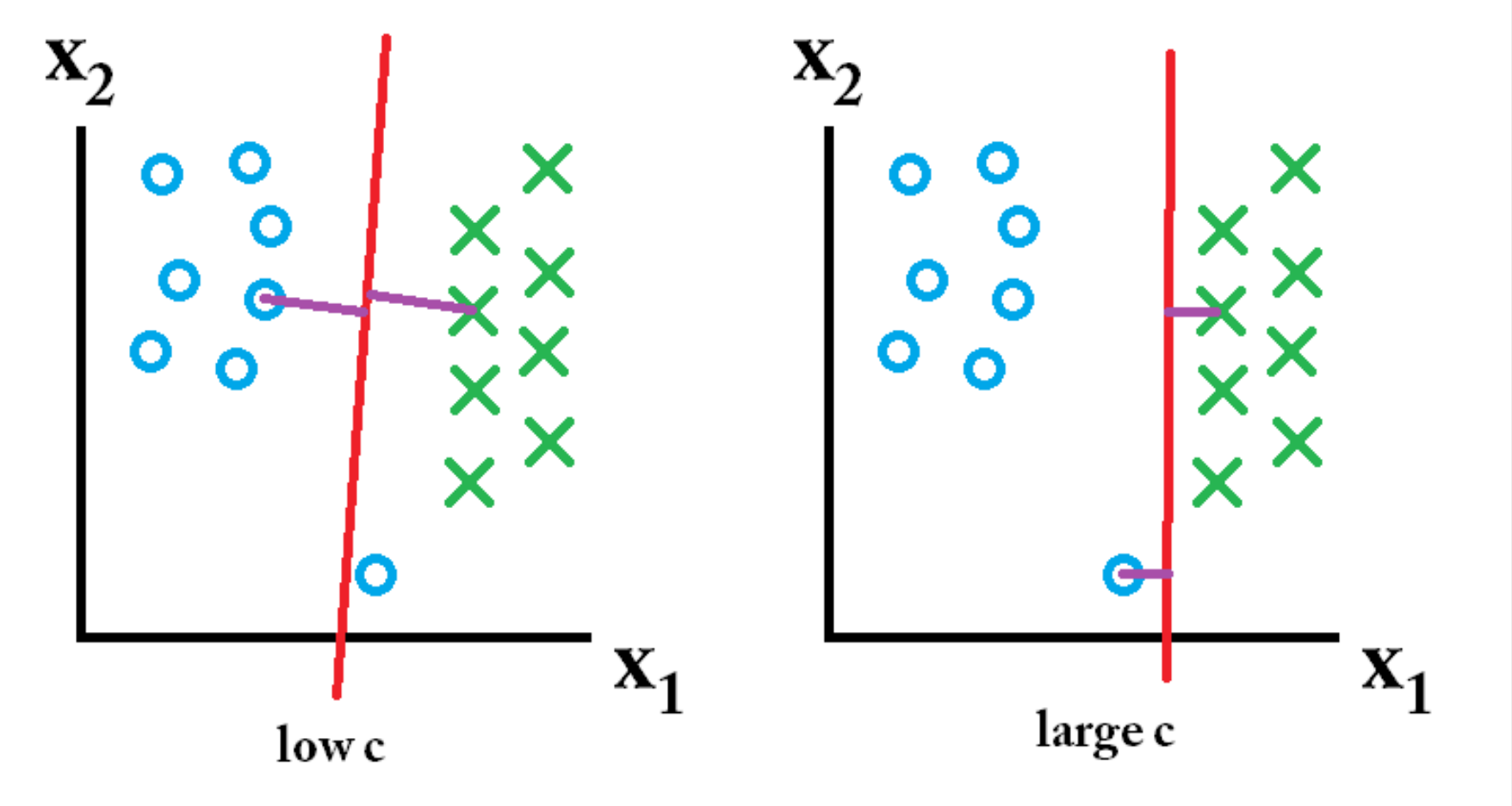
$$\min_{\theta} C \left(\sum_{i} \left(y^{(i)} cost_1(\theta^T x^{(i)}) - (1 - y^{(i)}) cost_0(\theta^T x^{(i)}) \right) \right) - \frac{1}{2} \sum_{i} ||\theta^i||^2$$

- Note C: can be *similar* to regularization



Note: $w*x-b=z=\theta^T x$

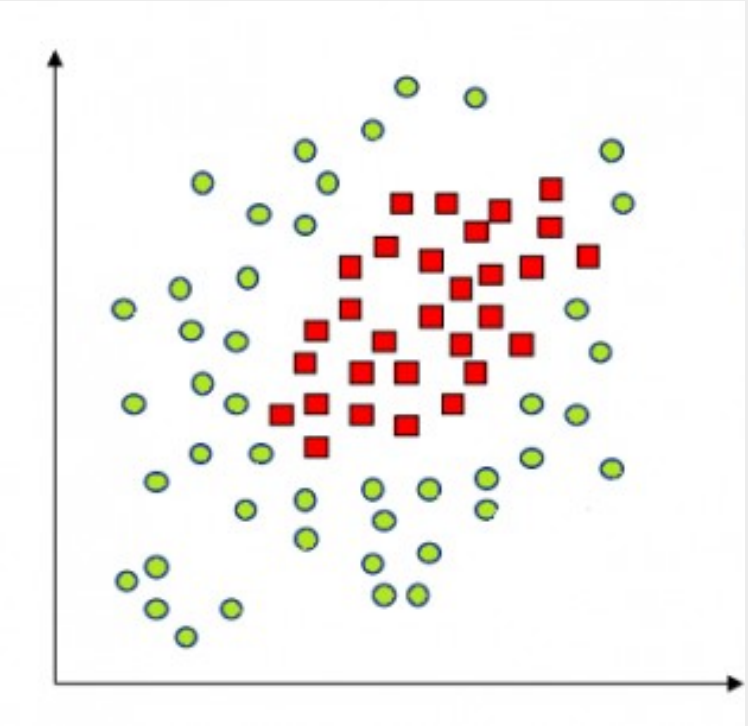
Role of ‘C’



https://stats.stackexchange.com/questions/31066/what-is-the-influence-of-c-in-svms-with-linear-kernel

Non-Linear cases

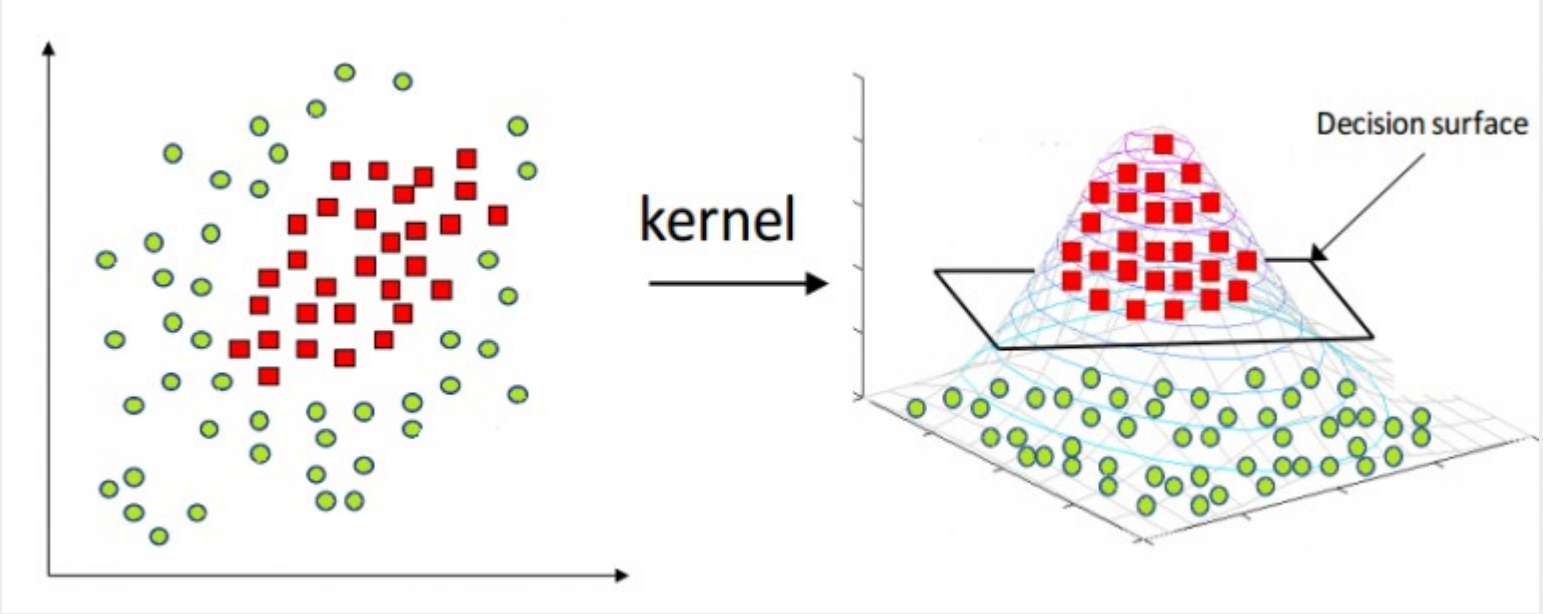
- What about cases with no linear boundary?



https://www.hackerearth.com/blog/machine-learning/simple-tutorial-svm-parameter-tuning-python-r/

Kernel Trick

- “Add” (or alter) dimension to ease classification
- Also known as “kernel machine”



https://www.hackerearth.com/blog/machine-learning/simple-tutorial-svm-parameter-tuning-python-r/

Ex. Gaussian Kernel

- For each group, pick landmarks, $l^{(i)}$
- Distance from landmark determines likelihood

$$f_i = similarity(x, l^{(i)}) = e^{-\frac{||x - l^{(i)}||^2}{2\sigma^2}}$$

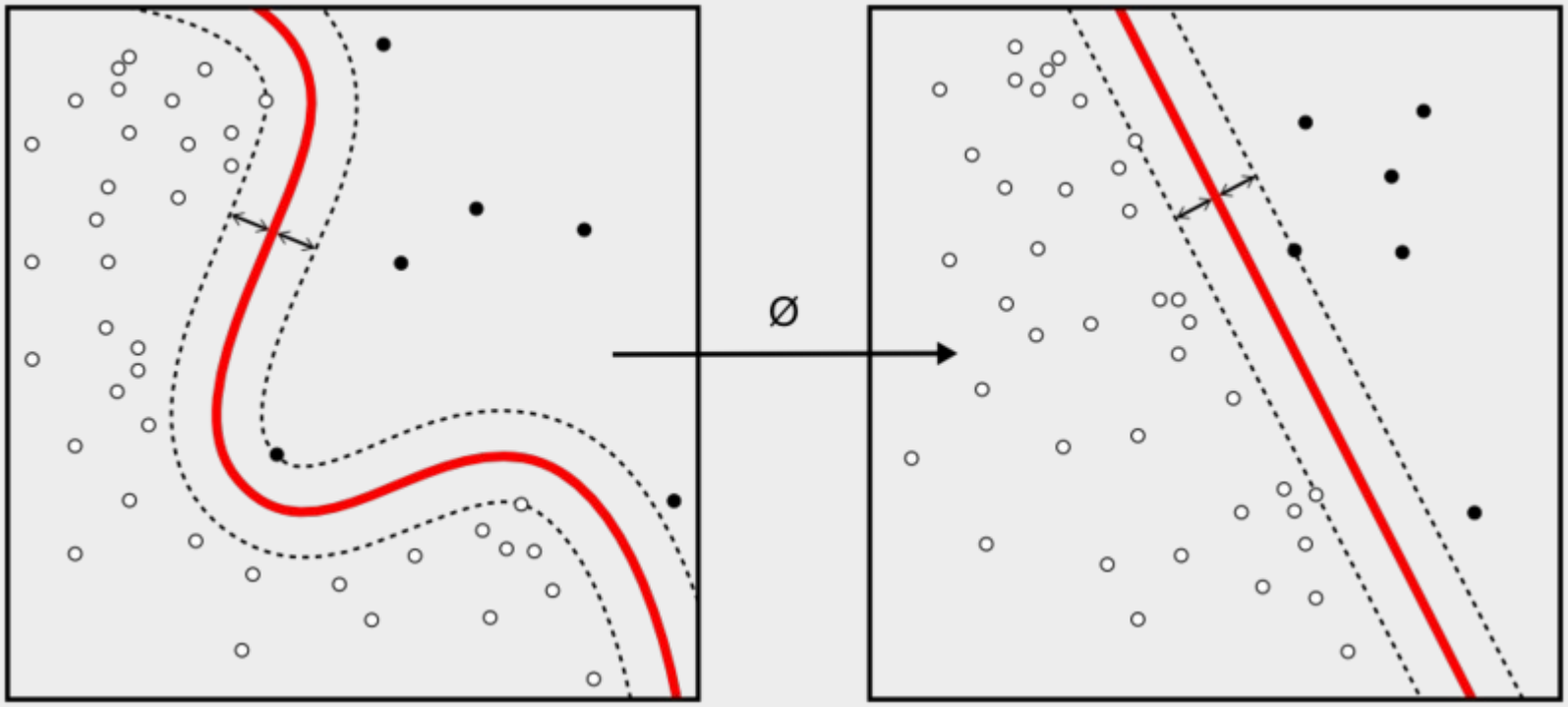
- Hypothesis in terms of similarity functions

$$\theta^T x \rightarrow \theta^T f$$
$$\theta^T f = \theta_0 + \theta_1 f_1 + \cdots + \theta_n f_n$$

- Must pick $l^{(i)}$ and σ
  - Arbitrarily pick?
  - Compute mean and variance?

Support Vector Machine

- Employing kernal trick and margin:



https://en.wikipedia.org/wiki/Support_vector_machine

Good Sources

- Ritchie Ng:
  - https://www.ritchieng.com/
  - https://www.ritchieng.com/machine-learning-svms-support-vector-machines/
- Wikipedia:
  - https://en.wikipedia.org/wiki/Support_vector_machine
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