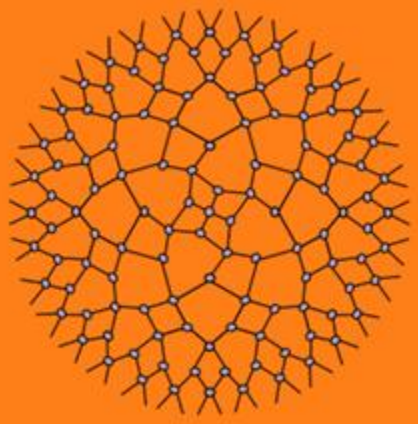
ML Algorithms

NEURAL NETWORKS



Class
A Detailed Look At Neural Networks

Topic
Inside a Linear Classifier

Inside a Linear Classifier

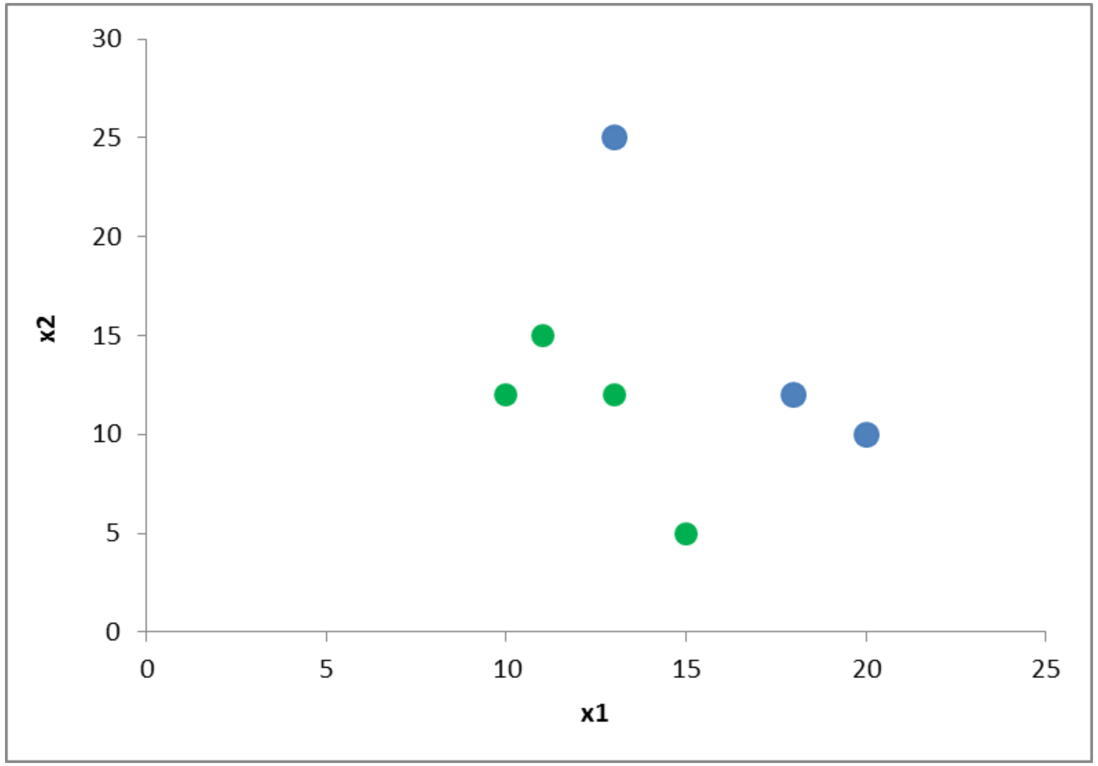
Estimating the parameters of a neural network:

- Neurons function like logistic classifiers
- Linear classifiers can be used to calculate a logistic classifier’s parameters

Inside a Linear Classifier

Given features x1 and x2

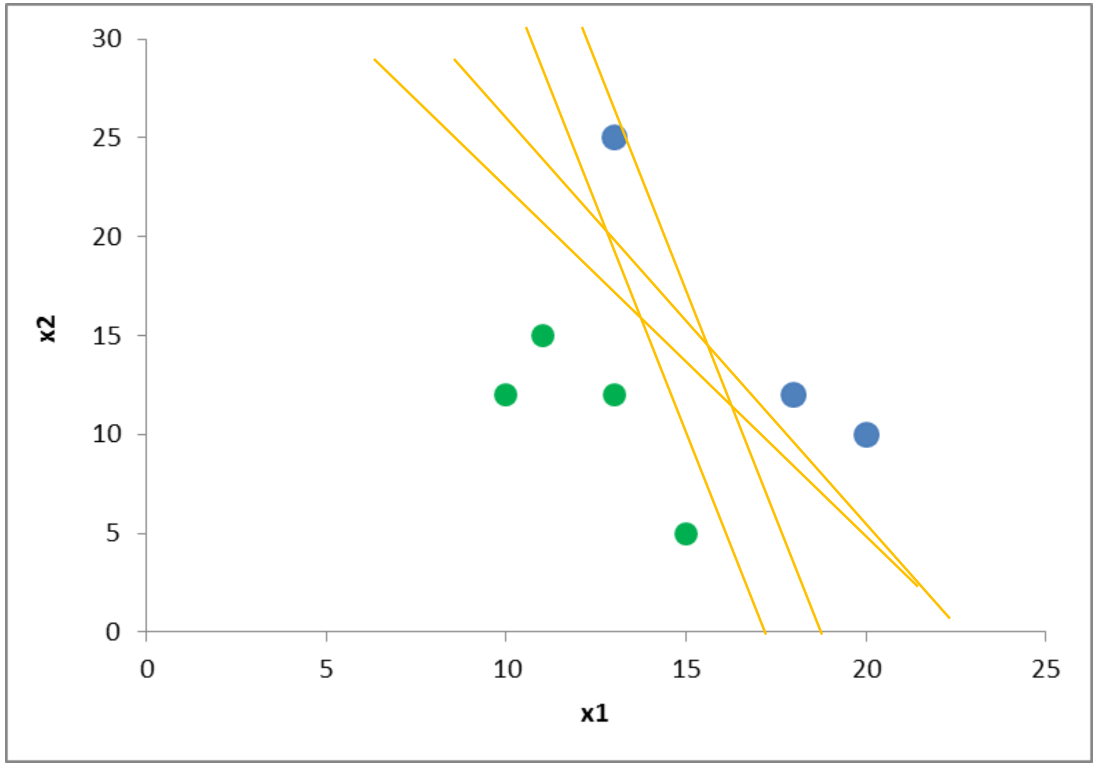
- Binary response: **green** or **blue**
- Task: To find a linear decision boundary that best separates the **green** & **blue** dots



Rule: All points to the left of the line will be **green** while all points to right will be **blue**

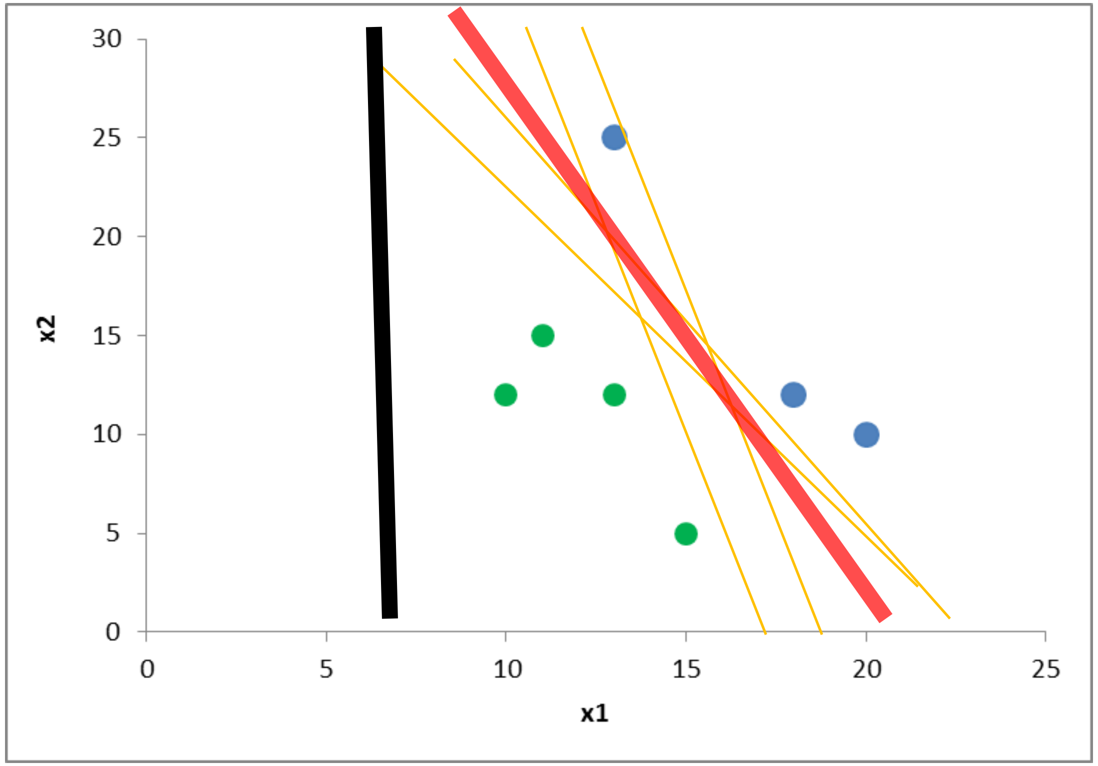
Inside a Linear Classifier

- An infinite number of lines is possible



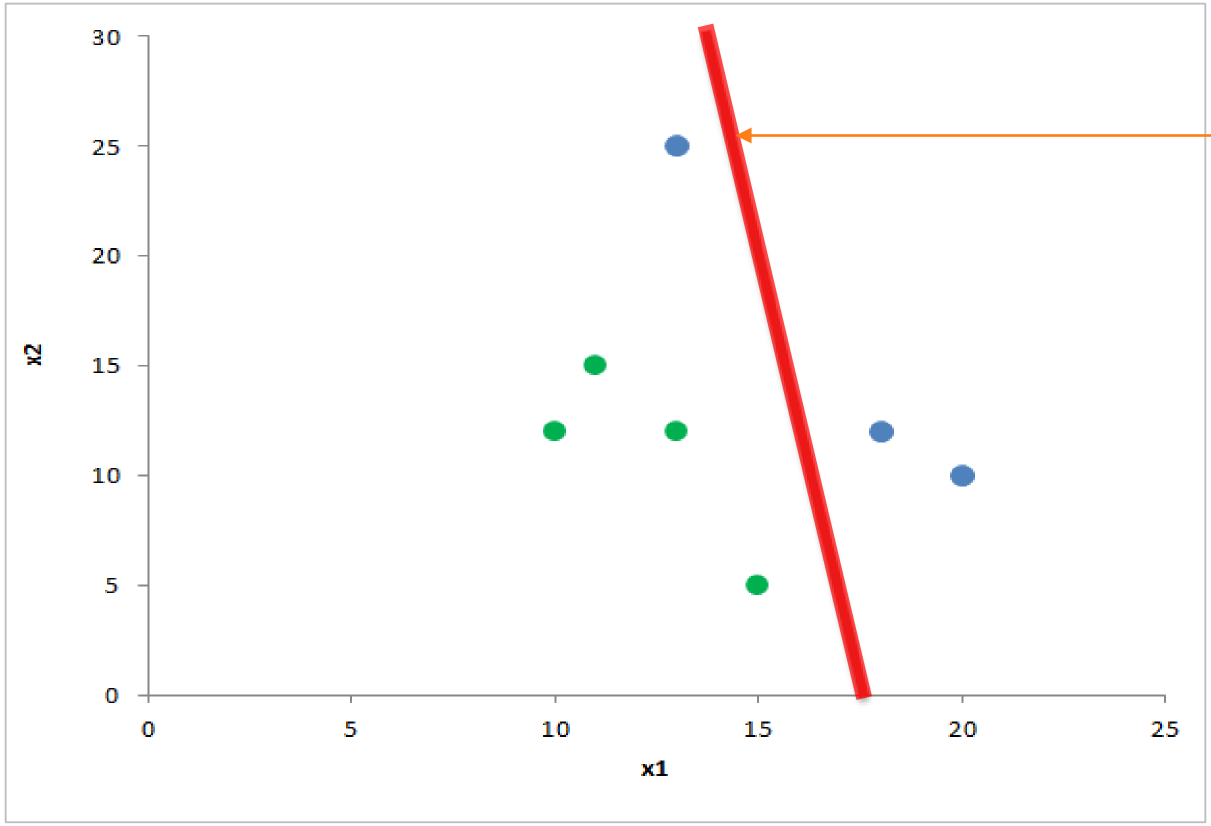
Inside a Linear Classifier

- An infinite number of lines is possible
- Is black or red the best choice for candidate decision boundaries?



Error for a Classifier

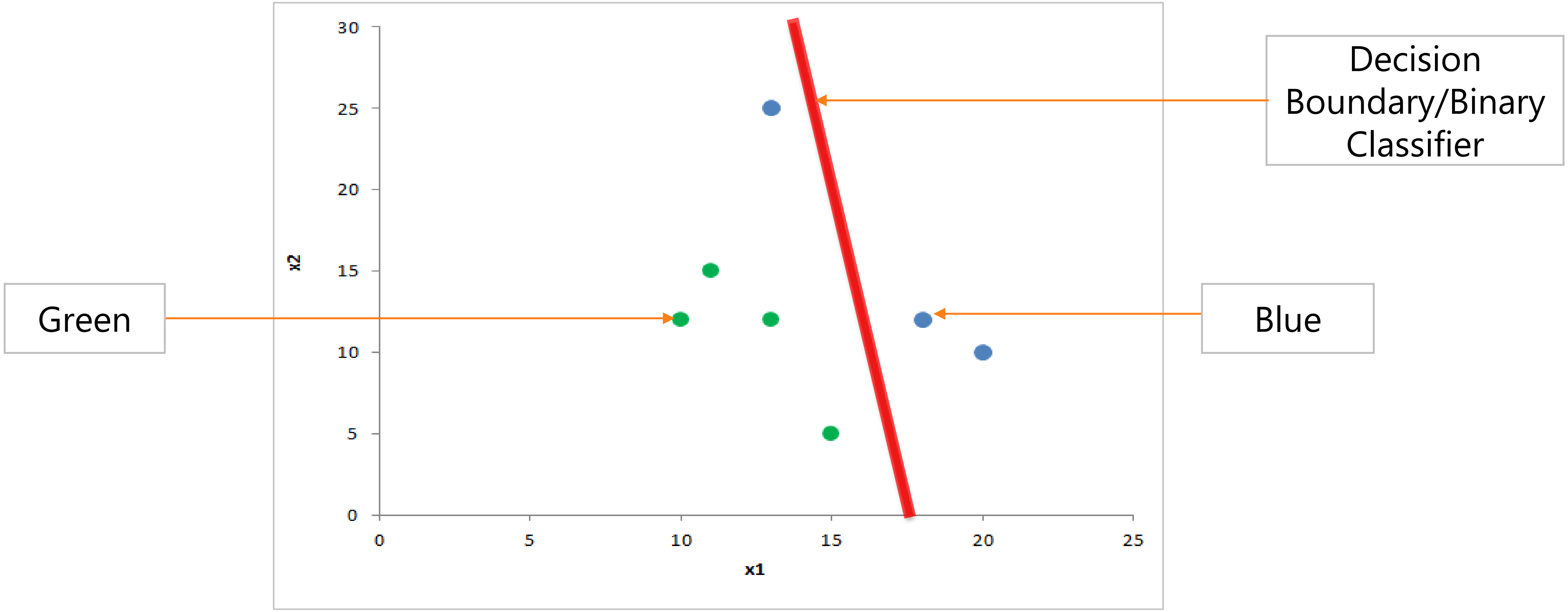
This red line functions as a decision boundary



Decision Boundary/Binary Classifier

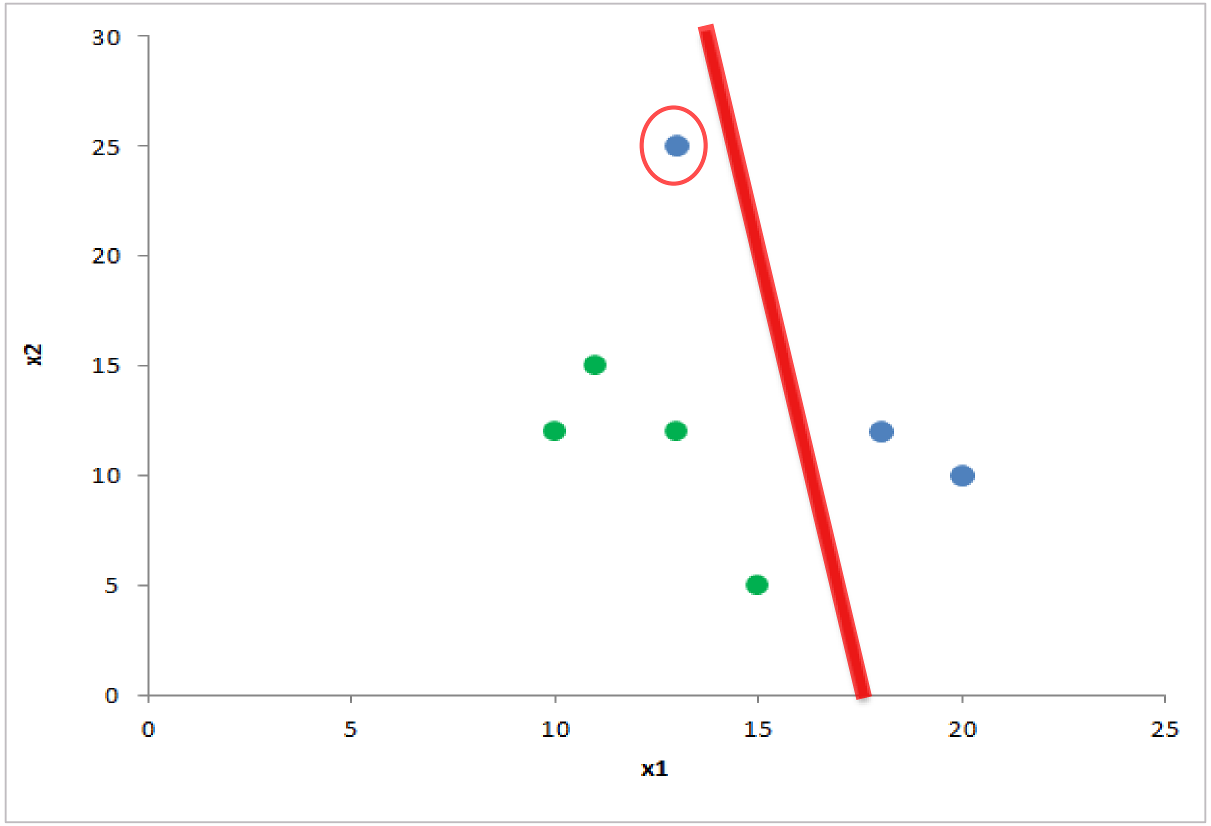
Error for a Classifier

A binary classifier assigns all points to its right as **blue** and all points to its left as **green**



Error for a Classifier

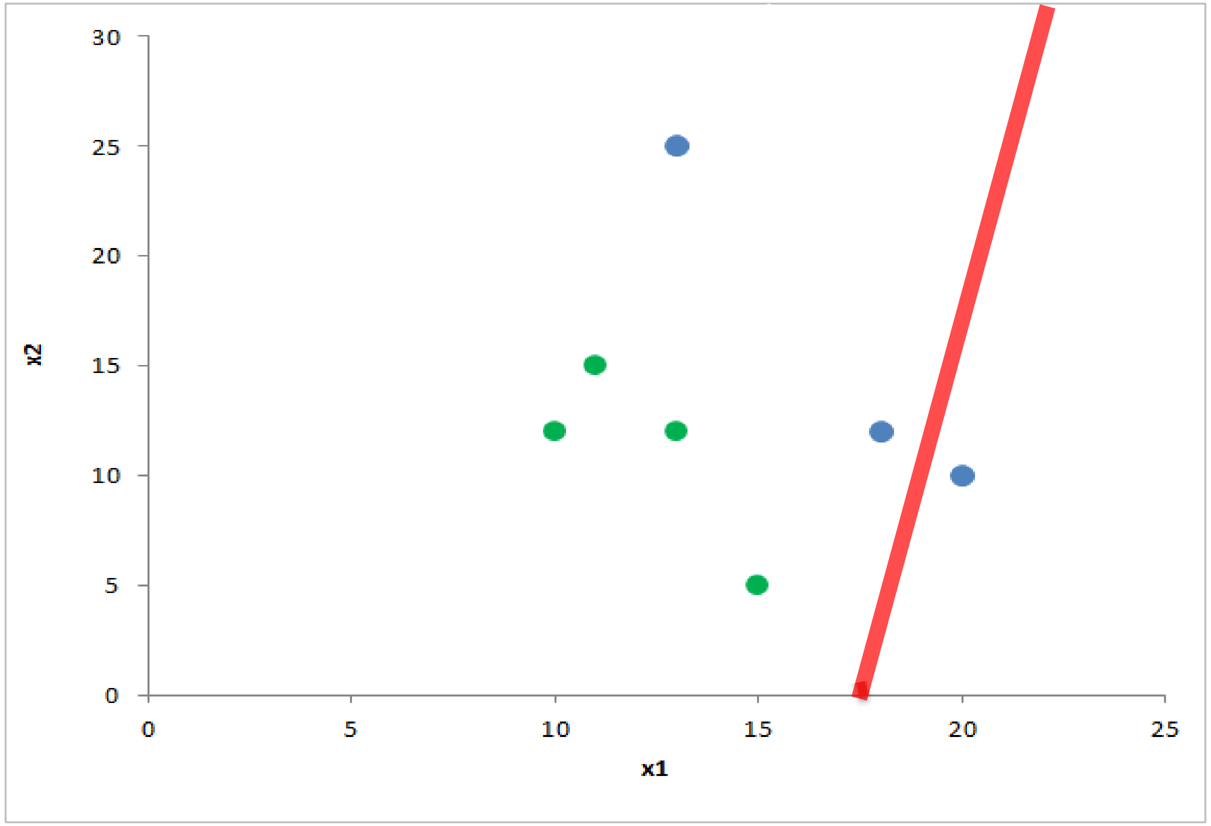
The classifier makes 1 error here



- Observed color for that point in data is blue
- Classifier thinks this point to be green

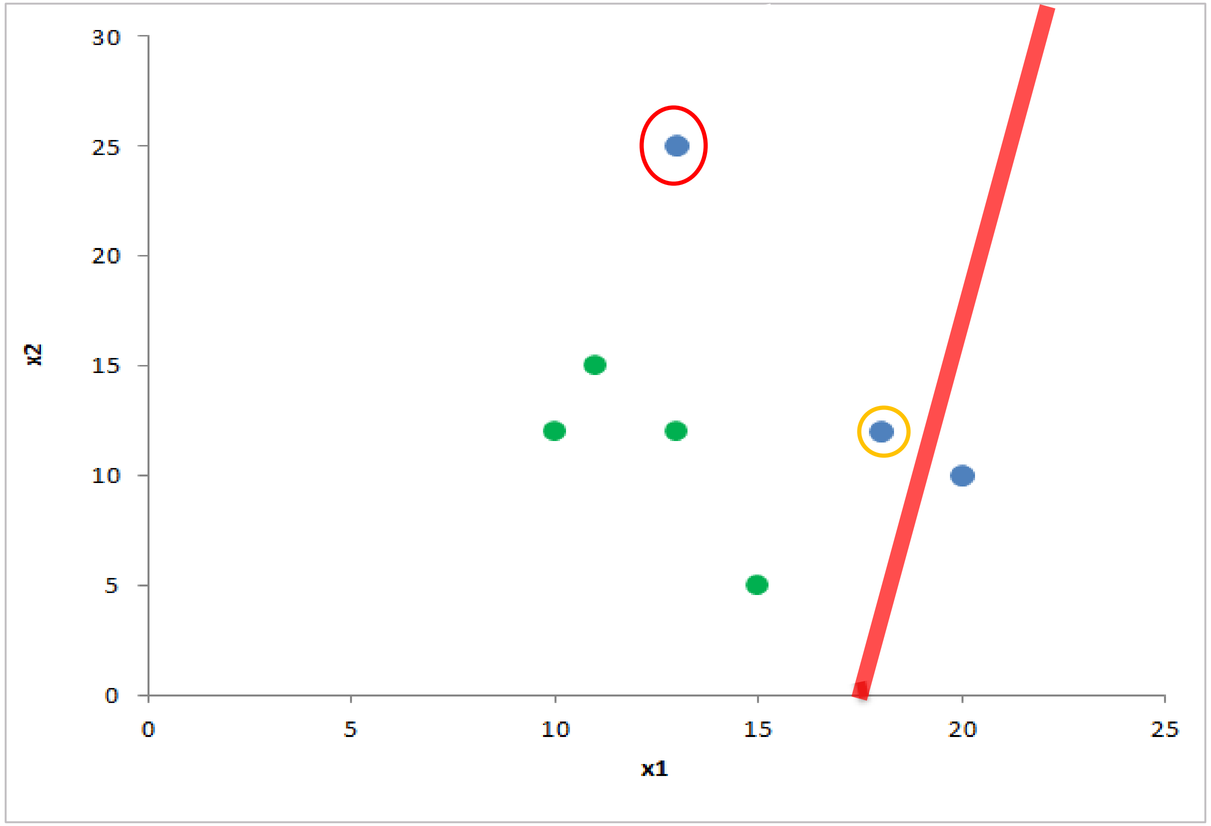
Error for a Classifier

Here's another classifier



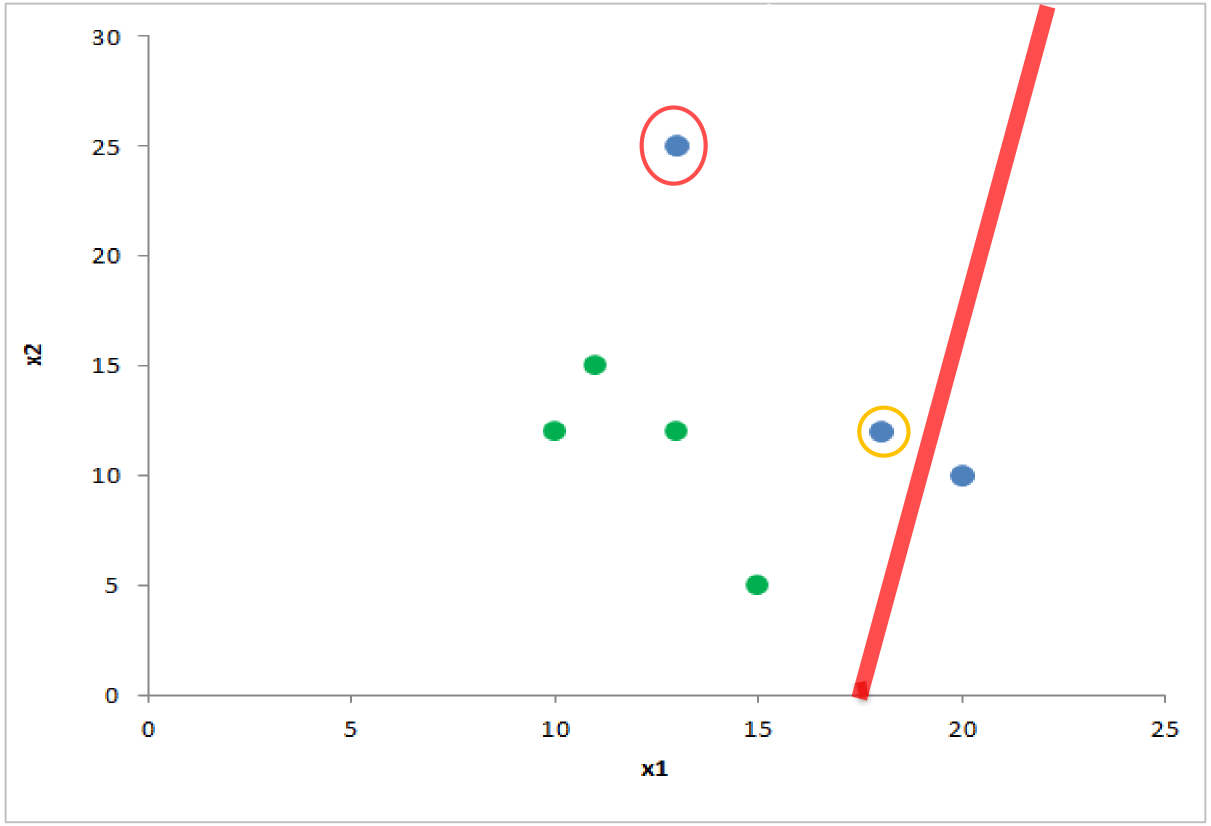
Error for a Classifier

The classifier has misclassified 2 points



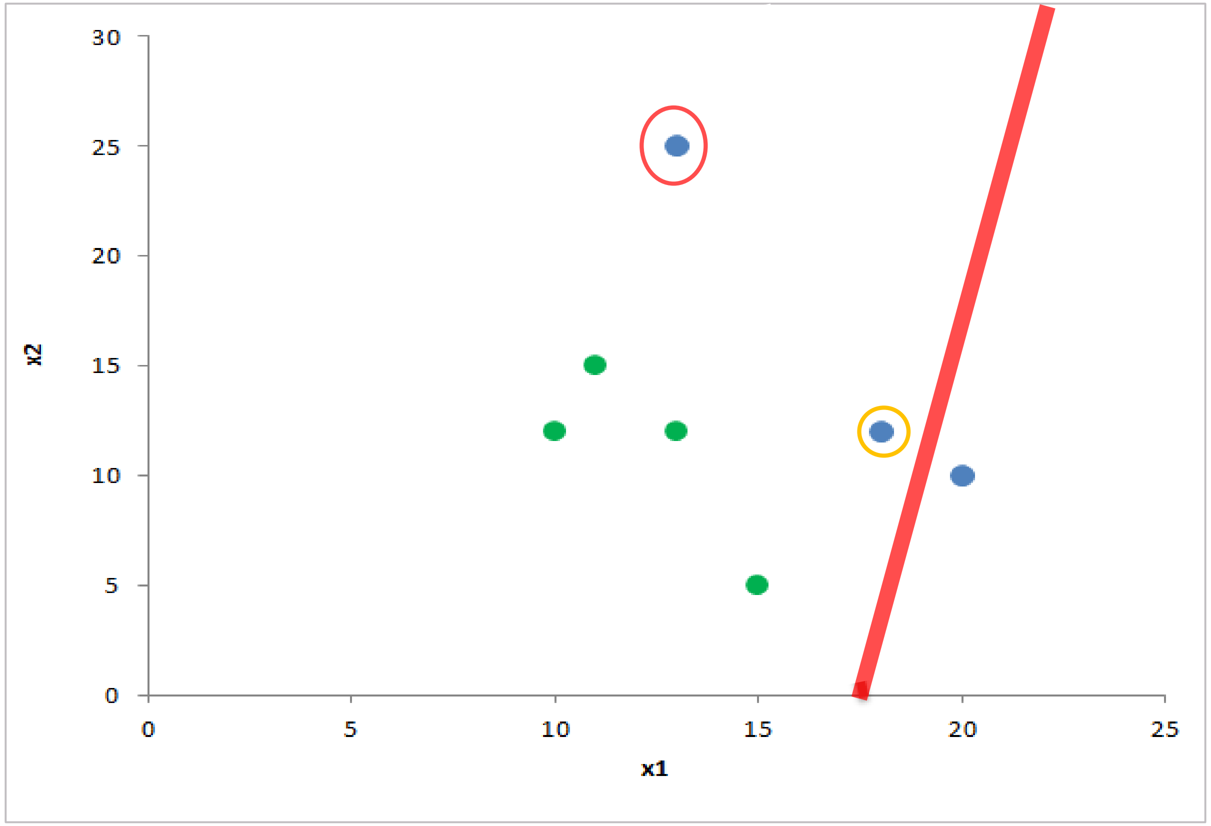
Error for a Classifier

- Error measure: The classifier has committed a bigger error with the red circle
- Misclassification measure: Both points are equally erroneously placed



Error for a Classifier

Qn. Is misclassifying a **green** point as **blue** the same as misclassifying a **blue** point as **green**?



Cost Function

Components of a logistic classifier	*y:* the response
	x: feature vectors
	w: weights
	$h(x) = \frac{1}{1+exp(-w.x)}$: the sigmoid activation function

Cost Function: $C = -y\ log\ h(x) - (1\ - y)\ log(1\ - h(x))$

Cost Function: Example 1

Observation	x	y
1	-2	0
2	5	1

$$w_0 = -2$$
$$w_1 = 1.5$$

$$C = -y \log h(x) - (1 - y) \log\big(1 - h(x)\big)$$

Cost Function: Example 1

Observation	x	y
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$$w_0 = -2$$
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Observation 1

$$h(x) = \frac{1}{1 + \exp(-(-2 + 1.5 \ X - 2))} = \frac{1}{1 + \exp(5)} = 0.01$$

$$Cost = -0 \ X \log(1 - 0.01) - (1 - 0) \log(1 - 0.01) = 0.02$$

Exercise: Calculate the cost for Observation 2

Cost Function: Example 2

Sum of the costs of all data points is 0.16

x1	x2	y	h(x)	Cost
-2	0.5	0	0.037327	0.02
0	-2	0	0.000123	0.00
2.5	3.5	1	0.999999	0.00
1.7	1	1	0.982876	0.01
2	0	1	0.731059	0.14

$w_0 = -2$
$w_1 = 1.5$
$w_2 = 3.5$

Cost Function

- Choose the classifier with the minimum cost
- The corresponding weight values are selected to construct the final classifier

- $C = y \log \frac{1}{1+e^{-w.x}} - (1 - y) \log \left(1 - \frac{1}{1+e^{-w.x}}\right)$
- $\boldsymbol{x}$ & $\boldsymbol{y}$ is known from the data
- Unknowns: $\boldsymbol{w} = [w_1, w_2 w_3, \ldots]$
- $C = C(w)$
- Optimum classifier: -$minimize\ C(\boldsymbol{w})\ w.r.t\ \boldsymbol{w}$

Minimizing the Cost Function

Solve the minimization problem to find the optimum logistic classifier

- Minimization Problem: $minimize\ C(\boldsymbol{w})\ w.r.t\ \boldsymbol{w}$
- Multivariate Optimization Function

$$C(\boldsymbol{w}) = \sum_{i=1}^{n} C_i(\boldsymbol{w}) = \sum_{i=1}^{n} y_i \log \frac{1}{1+\exp(\boldsymbol{w}.\boldsymbol{x_i})} - (1 - y_i) \log\left(1 - \frac{1}{1+\exp(\boldsymbol{w}.\boldsymbol{x_i})}\right)$$

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- Find the minimum value of this multivariate function
- Find those values for the weights for which Function C is minimum

Recap

- Inside a Linear Classifier
- Error for a Classifier
- Cost Function
- Cost Function: Example 1
- Minimizing the Cost Function

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