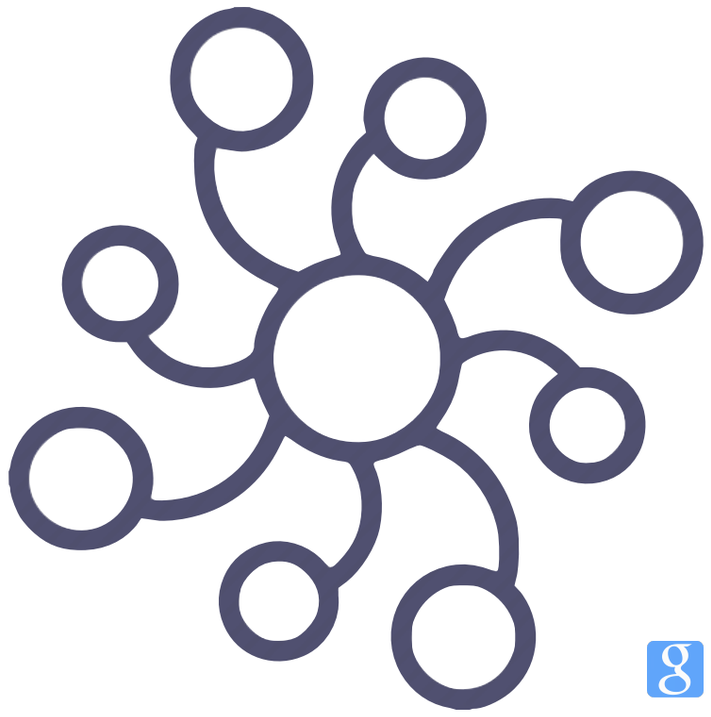


Perceptrons

By Vincenzo Marconi

Note

If you see a google icon in the corner of an image. It means I got the image from Google.

If it does not have the icon it is a diagram that I made.

Overview

<u>Background</u>

- Creator
- Inspiration
- Problem Statement
- Definition
- Idea of how mechanics work
- Methodologies and Vocabulary

<u>Mechanics</u>

- Labeling Function
- Learning Process
- Demo
- Problems
- Solutions

Frank Rosenblatt

- 1957 - Machine
- Neural Networks creation
- Applications
  - Boolean Logic Formula
  - Classification

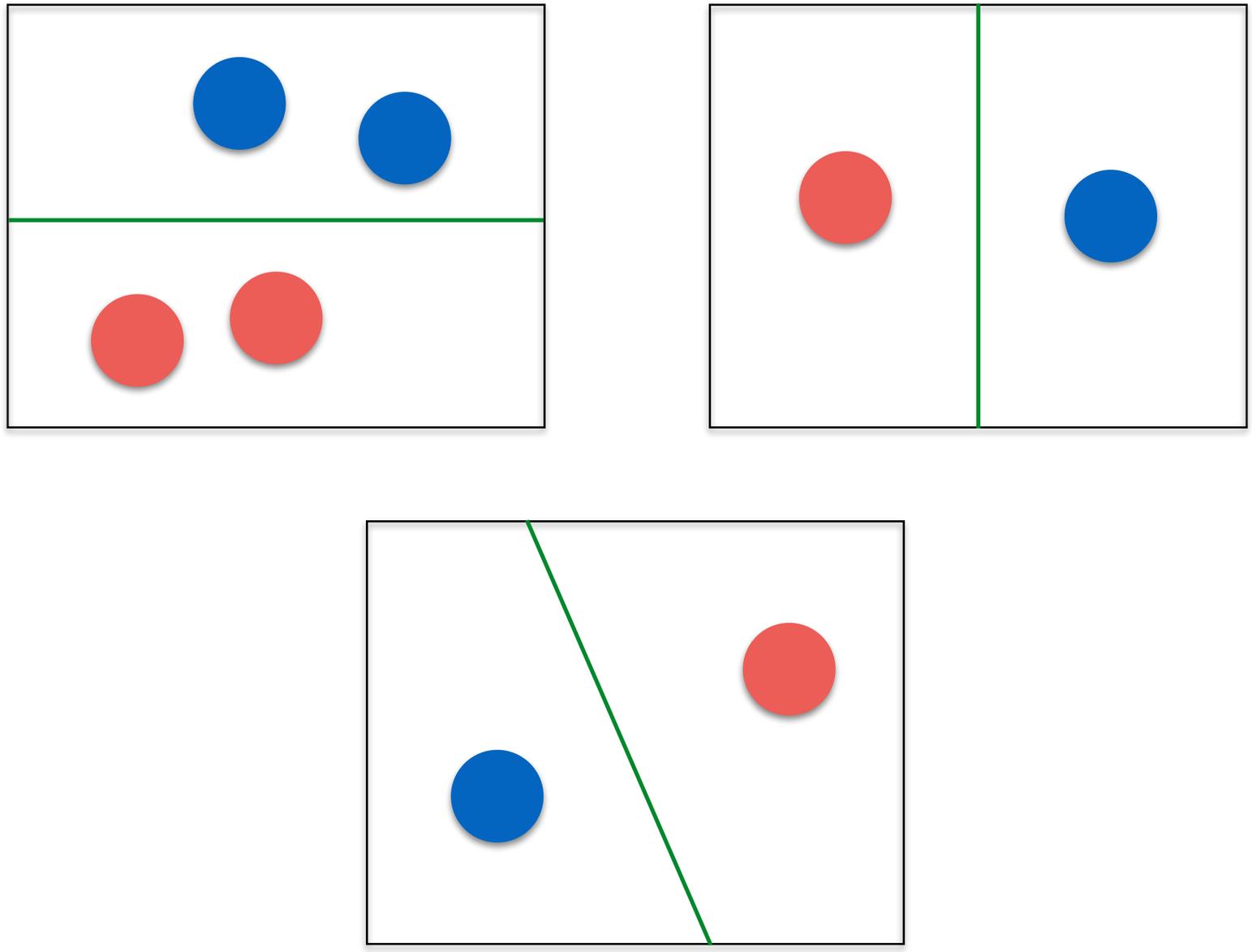
Problem

Montagues

Capulets

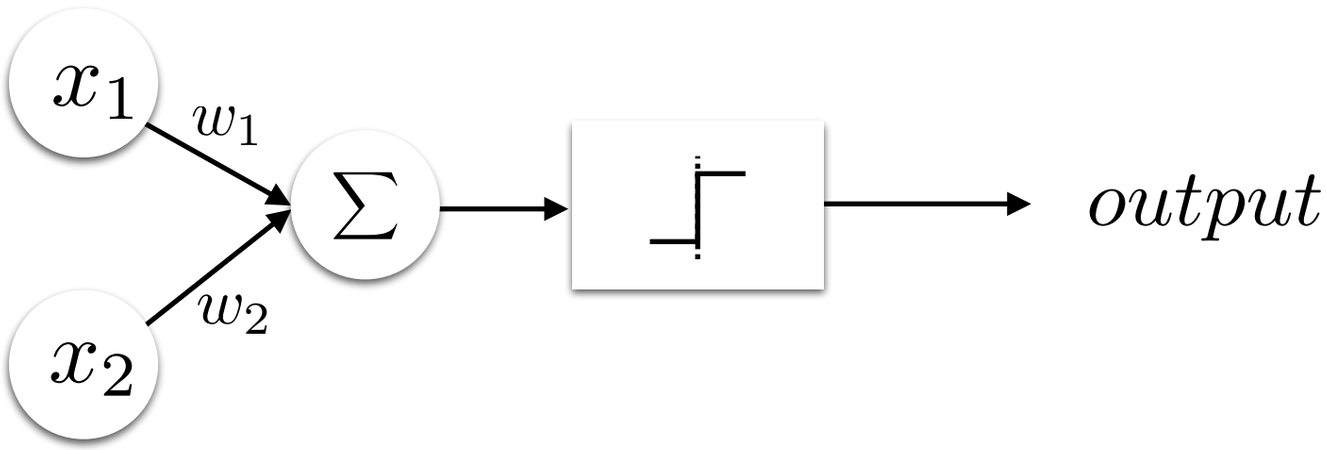
Romeo of the Montague and Juliet of the Capulets have broken up. Romeo has gone to WallStreet to get filthy rich and Juliet has moved to closer to the mall to enjoy more shopping and ice cream. Their families are torn up and need to be separated. Both families live in the same neighborhood in NYC and they have contracted you to build a wall that will separate the two families completely. Assuming they can be separated, how with each family members location can we build the wall?

Simpler Problem

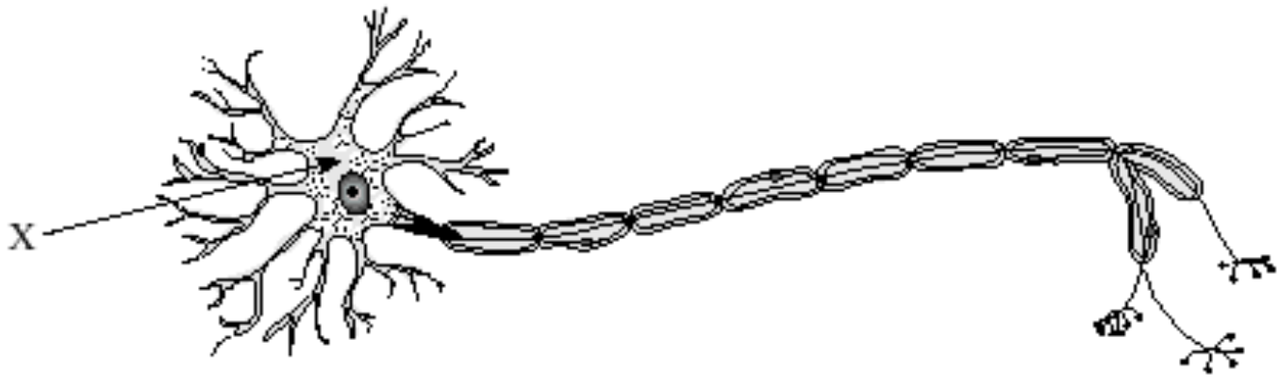


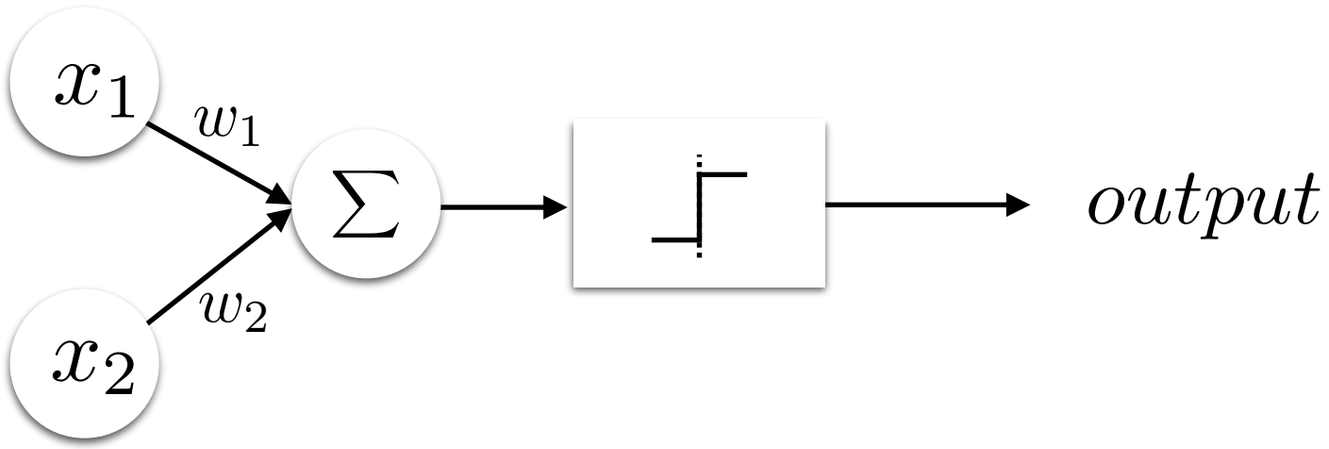
Definition of a Perceptron

"A computer model or computerized machine devised to represent or simulate the ability of the brain to recognize and discriminate."
-Oxford Dictionary



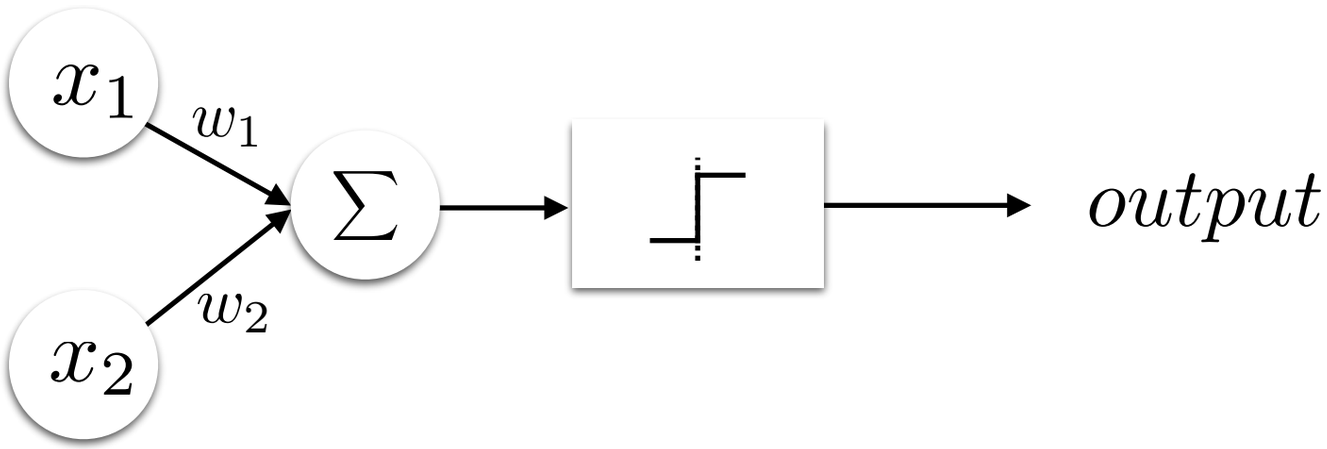
Neuron to Perceptron





Mathematical Definition

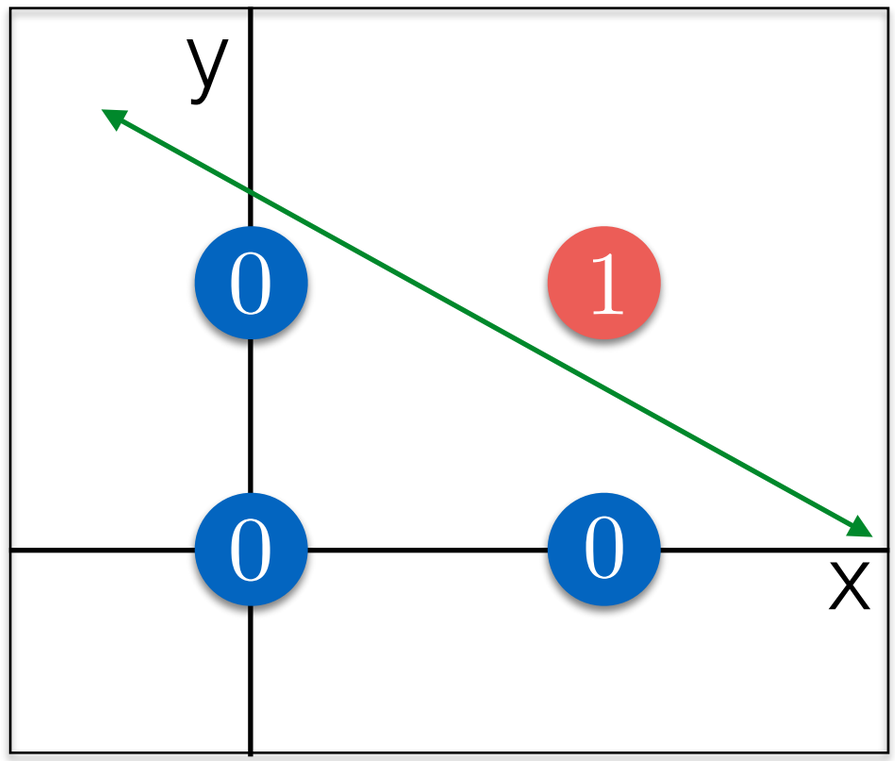
$$f(x_1, \ldots, x_n) = \begin{cases} label_1, & w_0 + w_1 x_1 + \cdots + w_n x_n \geq 0 \\ label_0, & w_0 + w_1 x_1 + \cdots + w_n x_n < 0 \end{cases}$$



Example Input

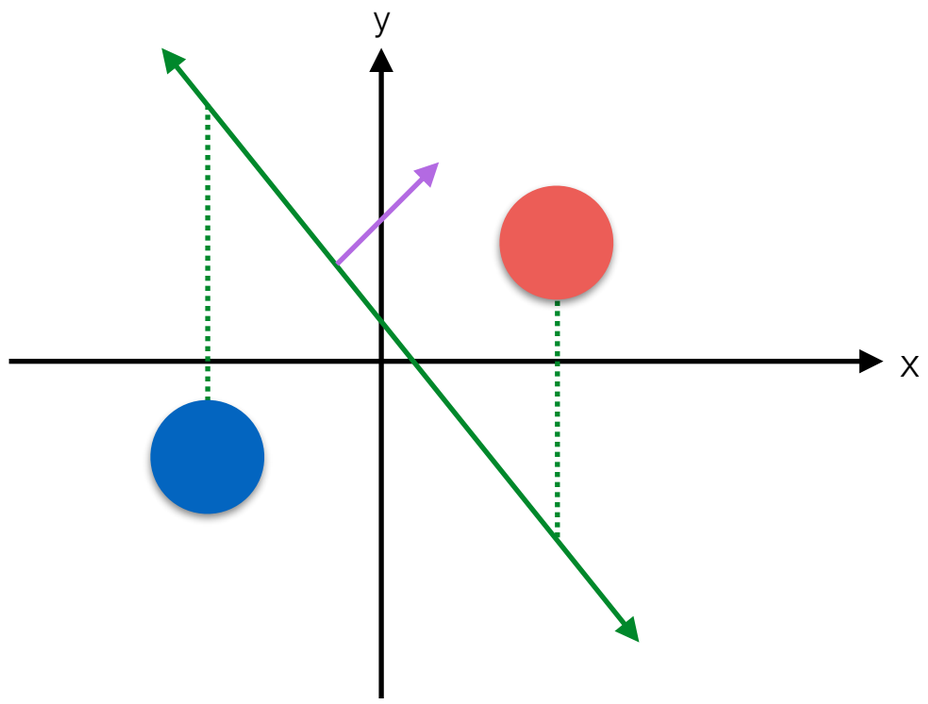
Consider the **and** function:

$$0 \ and \ 0 = 0$$
$$0 \ and \ 1 = 0$$
$$1 \ and \ 0 = 0$$
$$1 \ and \ 1 = 1$$



We say the blue points have label 0 and the red point has label 1. The question perceptrons answer is how can we separate the blue points from the red points. The green line is the boundary the perceptron creates. This boundary is what lets a perceptron classify information with labels. Note: typically 0 and 1 are used as labels.

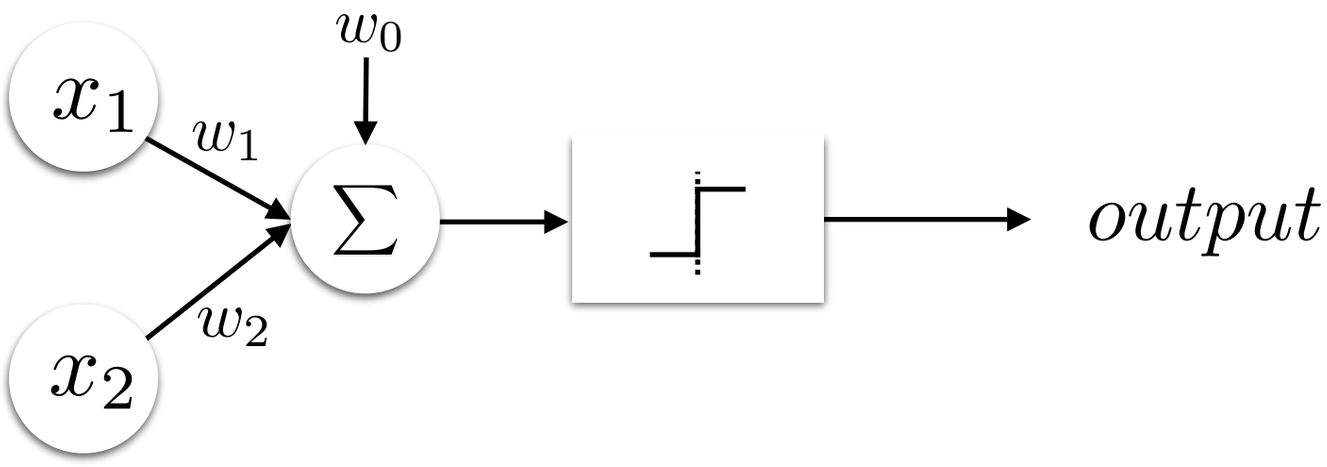
Our old friends



$$0 = w_0 + w_1 x + w_2 y$$

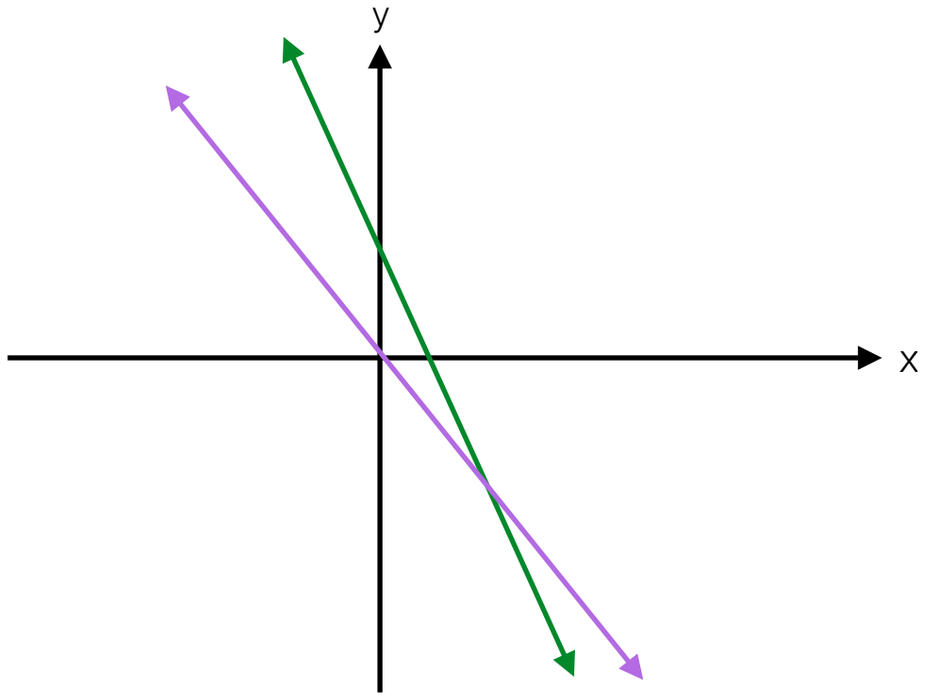
$$y = -\frac{w_0}{w_2} - \frac{w_1}{w_2} x$$

$$y = mx + b$$



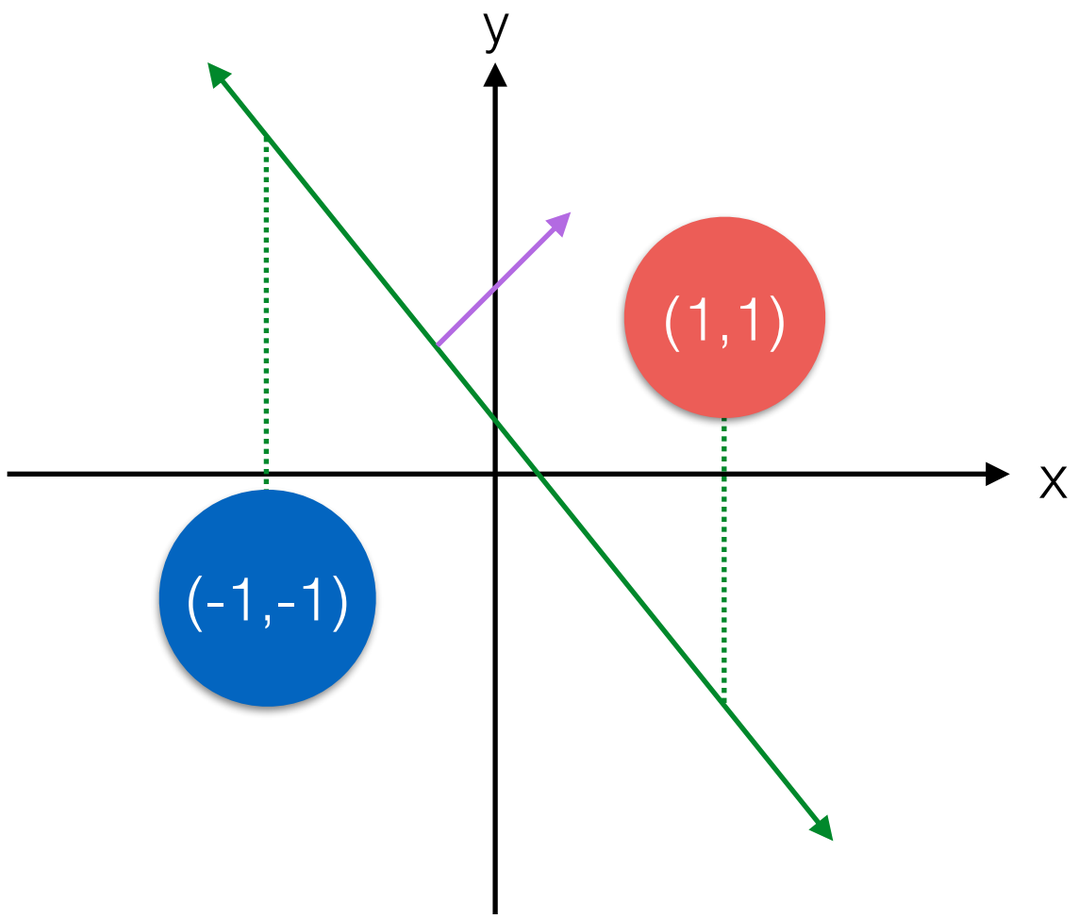
Methodologies and Vocabulary

$$-w_0 = w_1 x + w_2 y$$
$$0 = w_0 + w_1 x + w_2 y$$



- Hyperplane
- Training and Testing
- Iterations and Learning rate
- Overfitting
- Batch vs. Instance
- Bias and Threshold

Labeling Function



$$z = w_0 + w_1(1) + w_2(1)$$

$$z = w_0 + w_1(-1) + w_2(-1)$$

```
let z  = w0 + w1*x + w2*y
var fire
// Produce label
if ( z < 0 ) {
     fire = blue
} else {
     fire = red
}
```

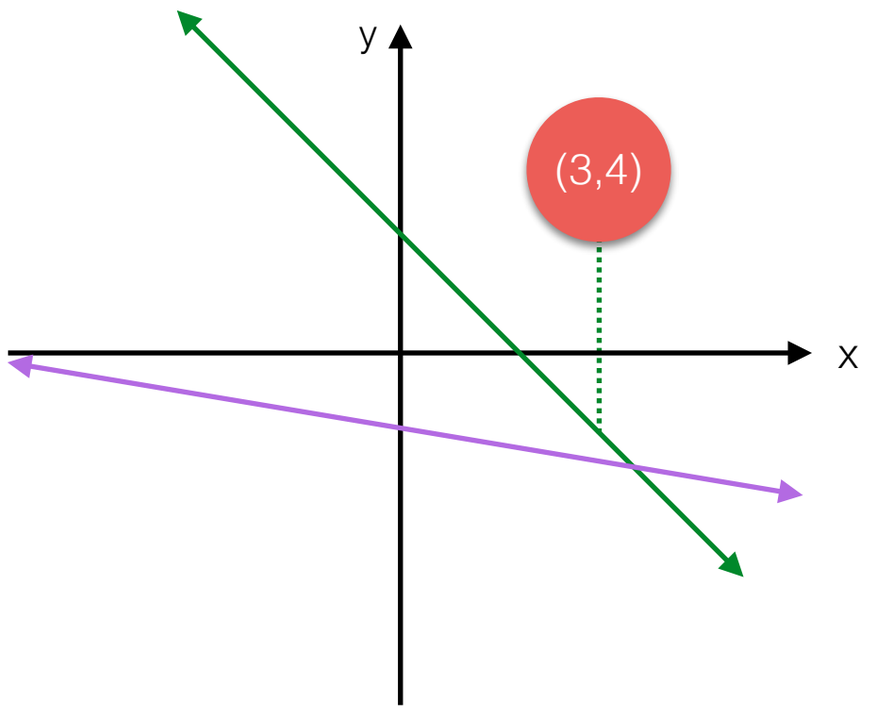
Learning Process

```
double learn(double x, double y, bool label){

    let z  = w0 + w1*x + w2*y

      // Produce label
    if ( z < 0 ) {
        fire = blue
        output = 0.0
    } else {
        fire = red
        output = 1.0
    }

      // Adjust weights
    if fire != label {
        w0 += learningRate * (label - output)
        w1 += learningRate * (label - output) * x
        w2 += learningRate * (label - output) * y
    }
}
```

To train the perceptron you have to make it learn a set of inputs a number of iterations that can start at just 100 iterations.

Example

$$\left.\begin{aligned} w_0 &= 1 \\ w_1 &= -1 \\ w_2 &= 1 \end{aligned}\right\} \begin{aligned} z &= w_0 + w_1 x + w_2 y \\ z &= 1 - x - y \\ y &= 1 - x \end{aligned}$$



Incorrect output

$$z \leftarrow 1 - 3 - 4 = -6$$

$$z \leftarrow blue$$

Adjustment

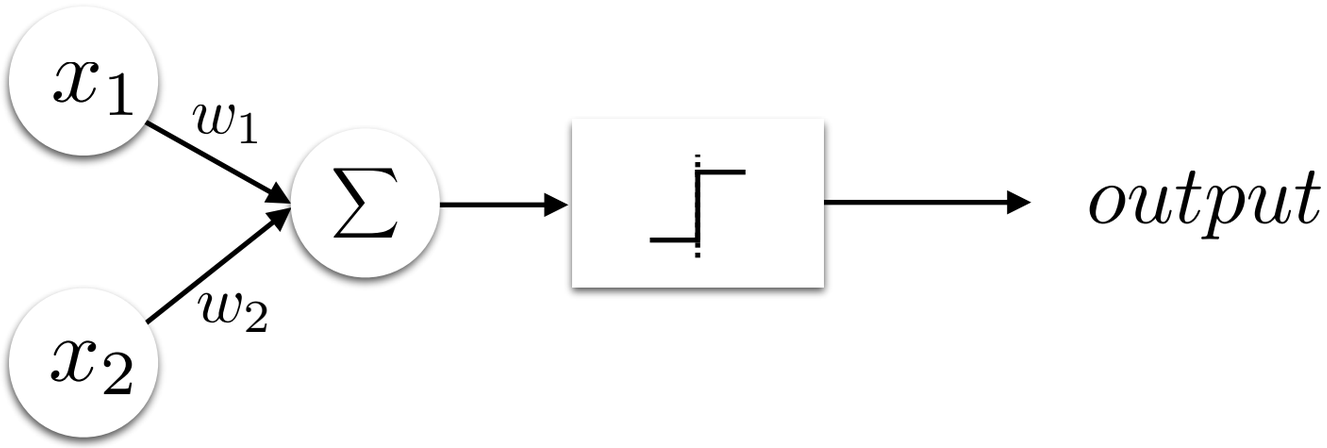
$$w_0 \leftarrow 1 + 0.4(1 - 0) = 1.4$$

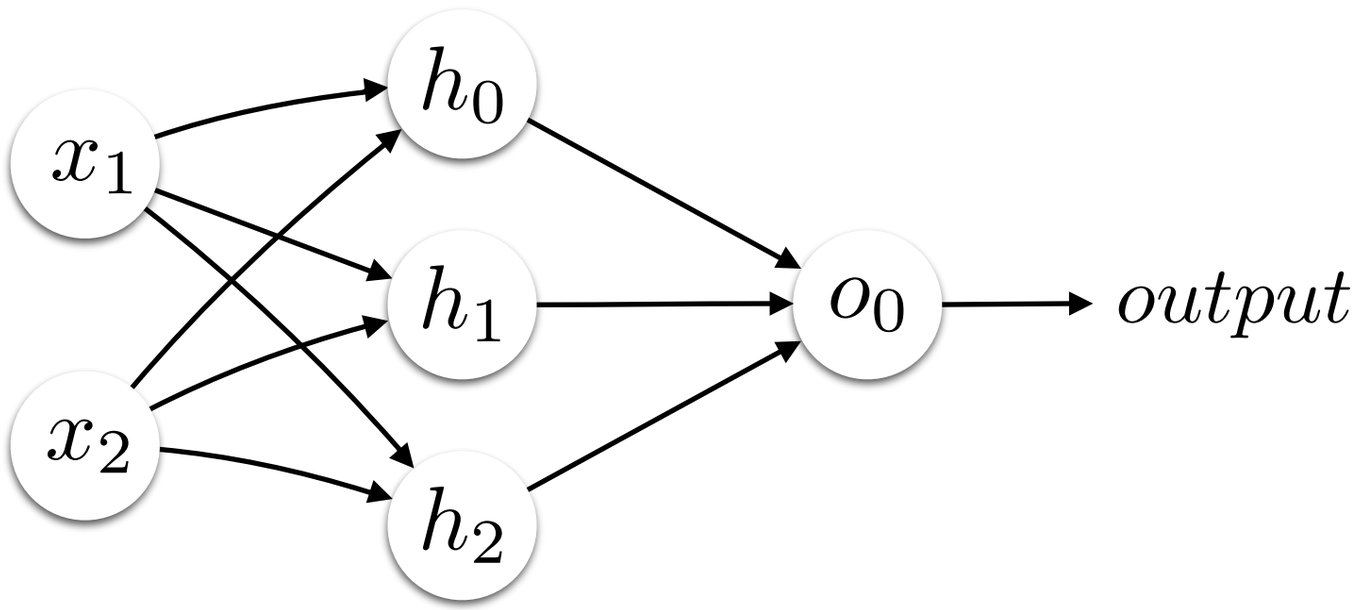
$$w_1 \leftarrow -1 + 0.4(1 - 0)3 = 0.2$$

$$w_2 \leftarrow 1 + 0.4(1 - 0)4 = 2.6$$

See Perceptron Visualization Software

Neural Network





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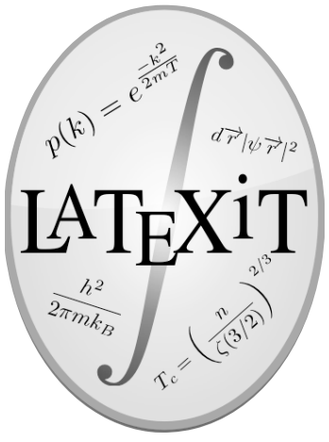
Support



Questions

Questions

- What does a perceptron mimic?
  - Neurons
- What does a perceptron create to classify data?
  - Boundaries (Hyperplanes)
- What is one example a perceptron cannot classify?
  - XOR
- What property makes an example be classifiable by a perceptron?
  - Data that is not linearly separable