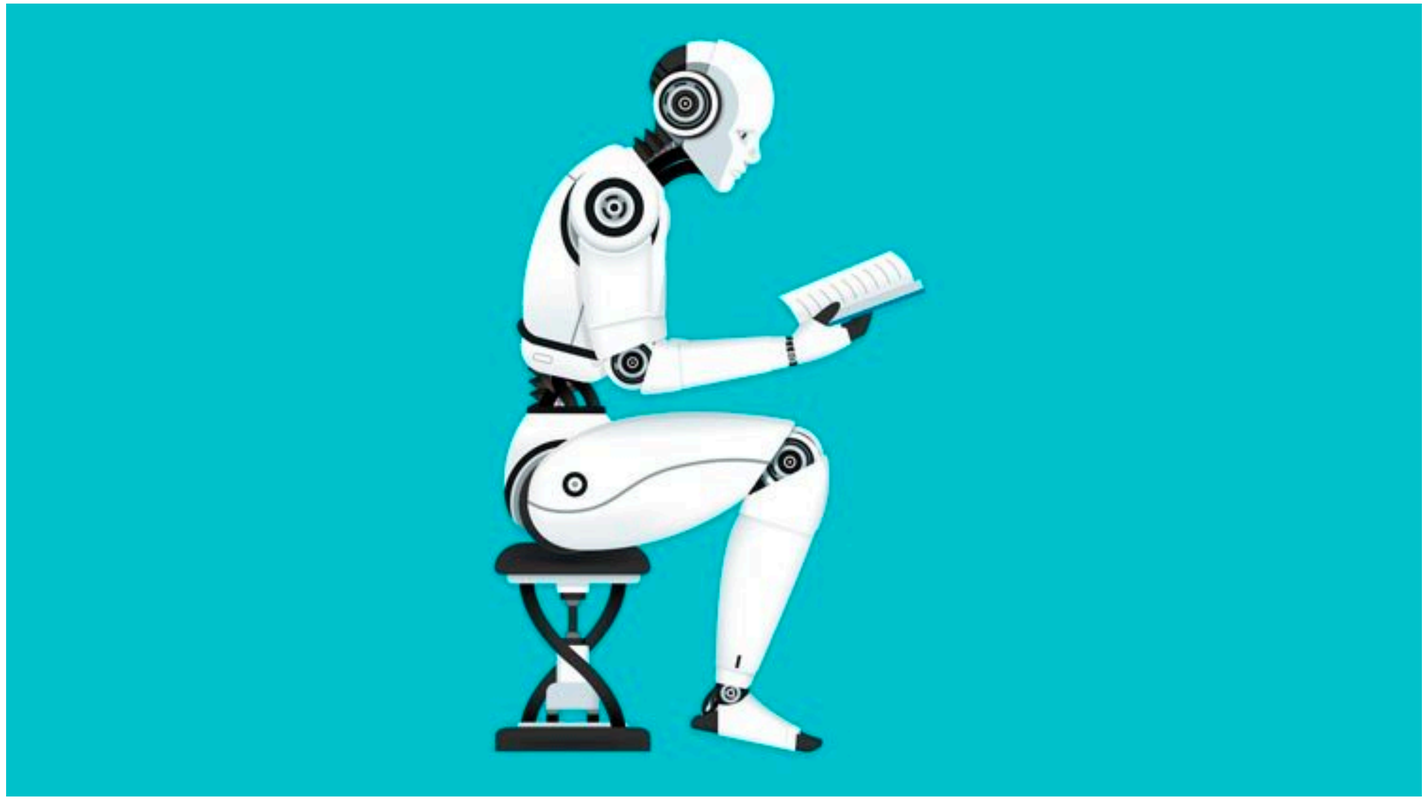
UNIVERSITAT DE BARCELONA



Neural Networks

Machine Learning | Enginyeria Informàtica

Santi Seguí | **2020-2021**

What is a Neural Network

- It is a system **biologically inspired** that tries to emulate **human brain**.
- **Why** is it a good idea to try to **emulate** the **brain** when solving a recognition task?

The human brain is the **best system** that we know of!!

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- **Why** is it

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What is a neuron?

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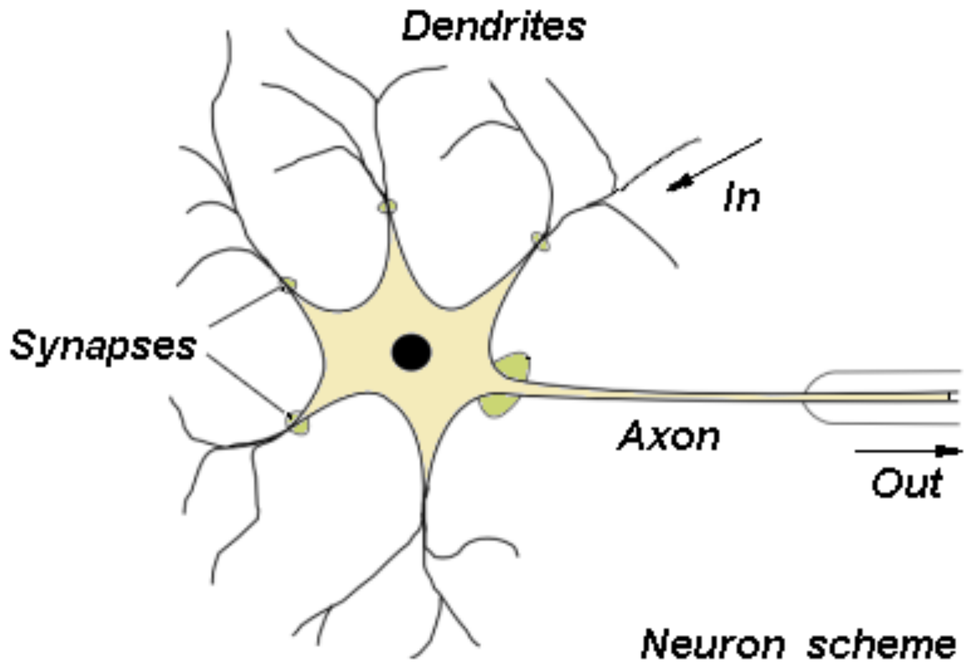
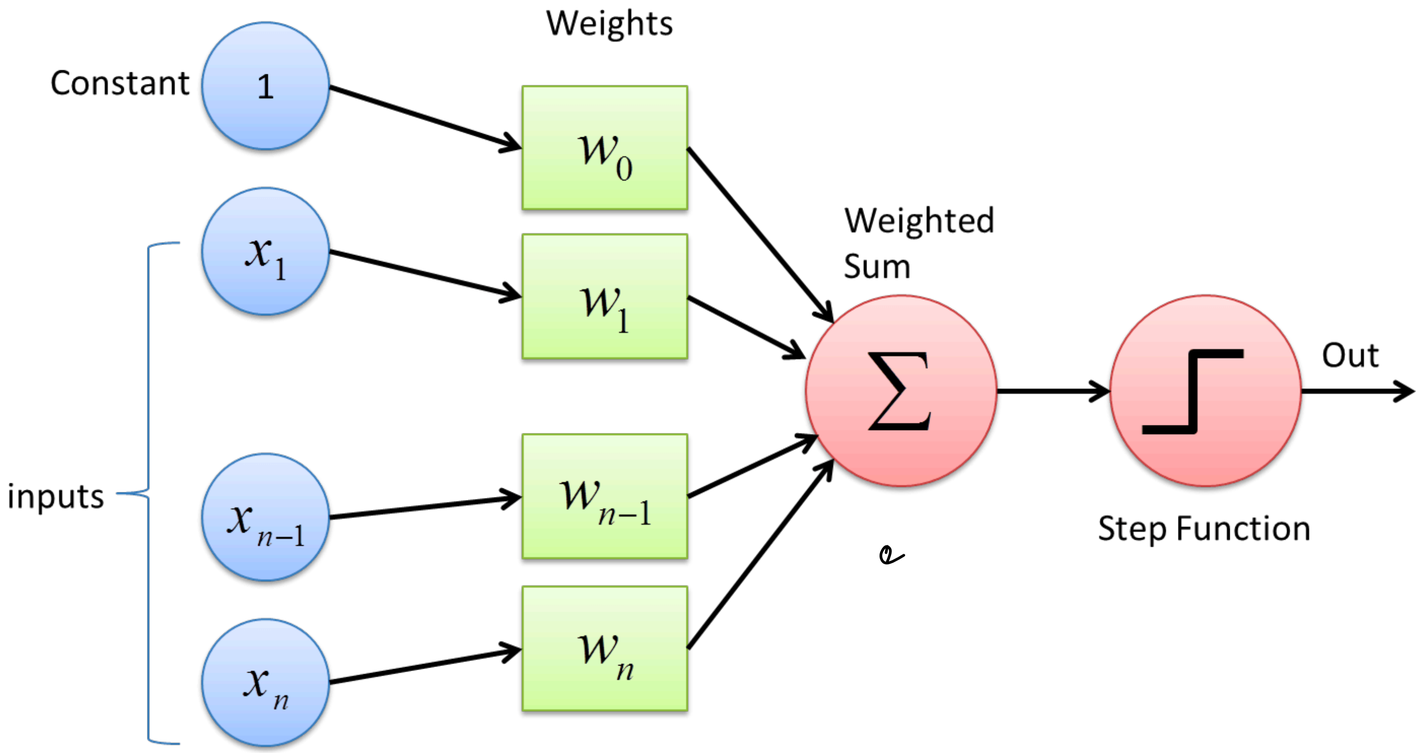


What is a neuron?

- In the human brain, a typical neuron collects signals from others through a host of fine structures called dendrites.
- The neuron sends out spikes of electrical activity through a long, thin stand known as an axon, which splits into thousands of branches.
- At the end of each branch, a structure called a synapse converts the activity from the axon into electrical effects that inhibit or excite activity in the connected neurons.

How the brain works (with one slide!)

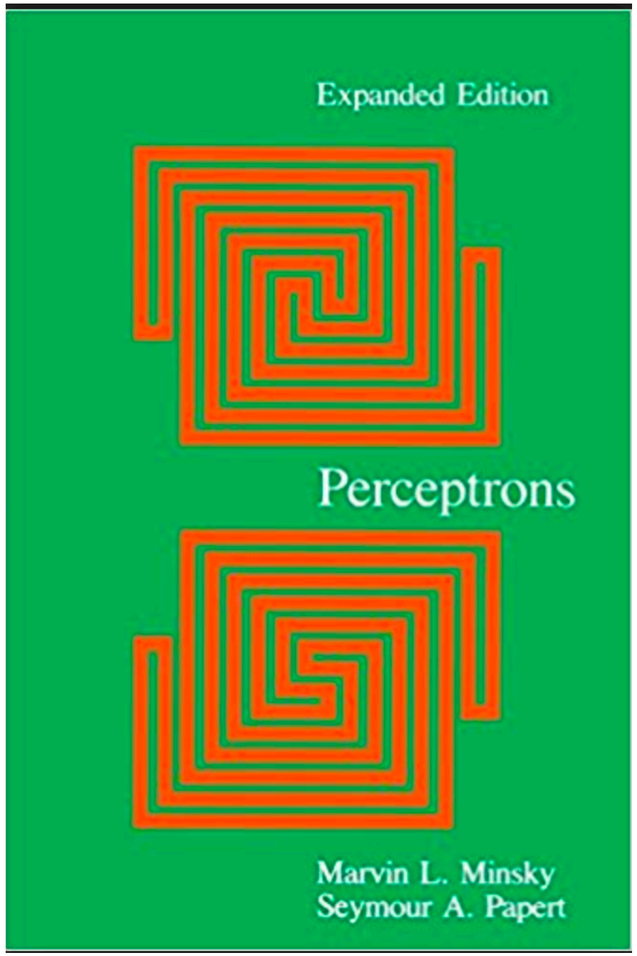
- Each neuron receives inputs from other neurons
  - A few neurons also connects to receptors
  - Cortical neurons use spikes to communicate
- The effect of each input line on the neuron is controlled by a synaptic weight
  - The weights can be positive or negative
- The synaptic weight adapt so that the whole network learns to perform useful computations
  - Recognizing objects, understanding language, making plans, controlling the body.
- You have about 10^{11} neurons each with about 10^{4} weights.
  - A huge number of weights can affect the computation in a very short time. Much better bandwidth than a workstation.

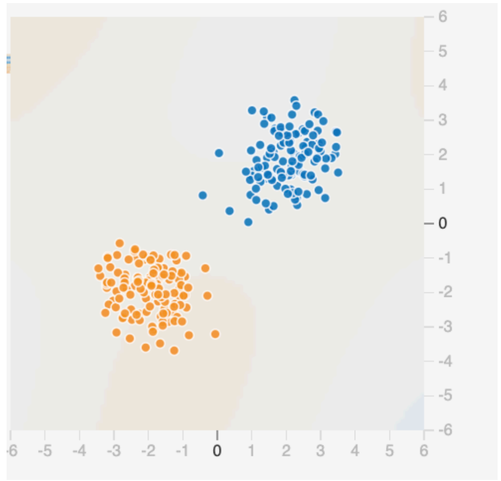
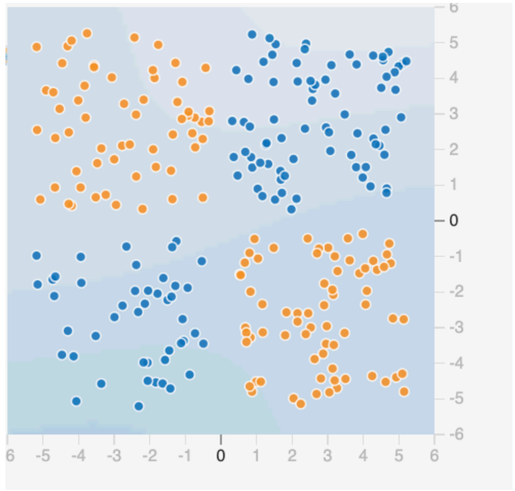
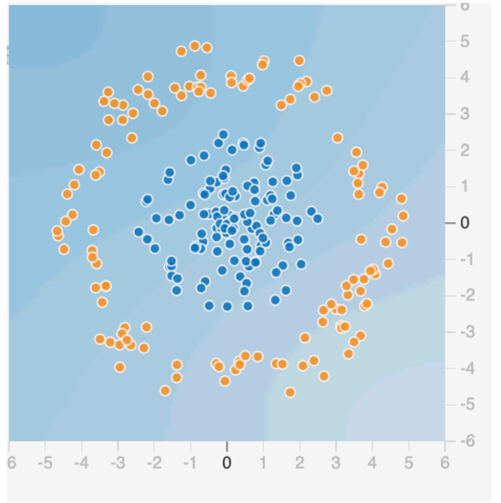


Perceptron

Perhaps the first AI model

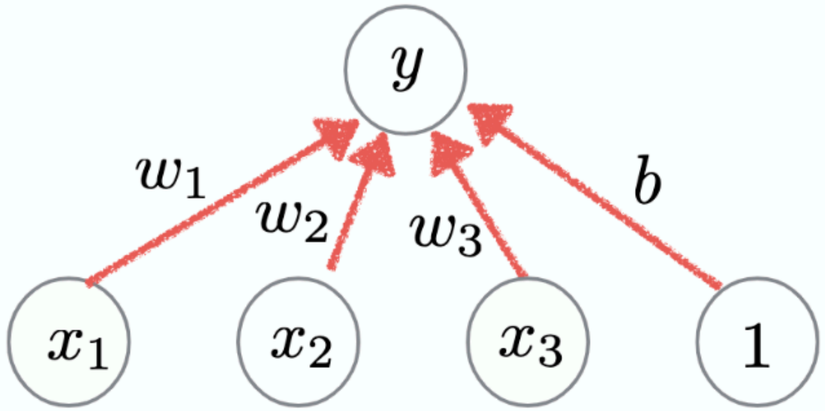
The Book: Perceptrons



1 Layer Neural Net model

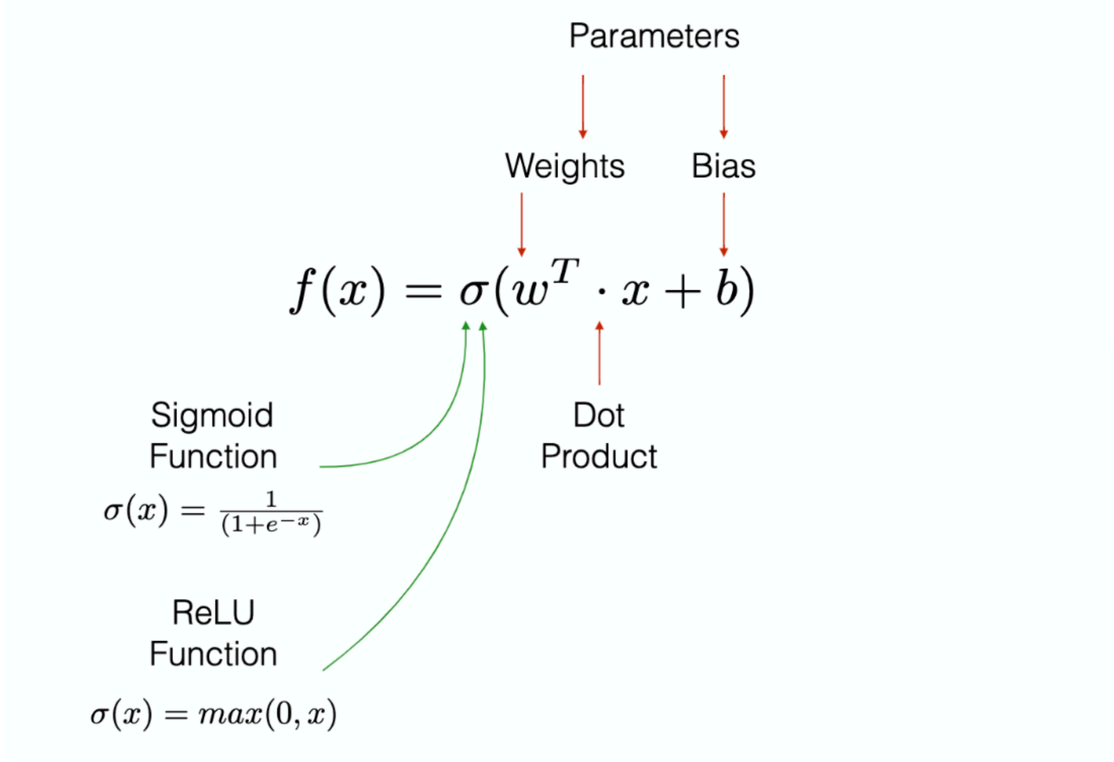
$$f(x) = \sigma(w^T \cdot x + b)$$

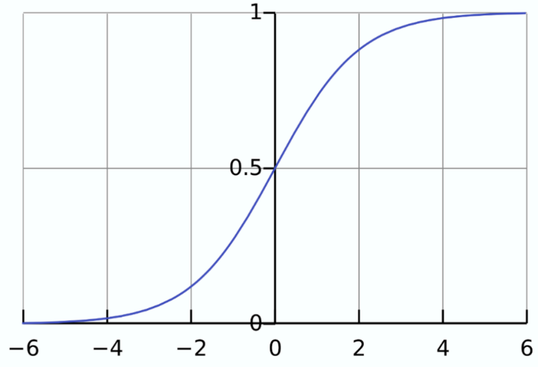


Graphical Representation

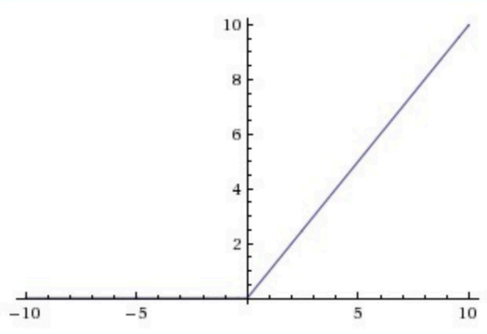
Neural Networks

1 Layer Neural Net model





$\sigma(x) = \frac{1}{(1+e^{-x})}$



$\sigma(x) = max(0, x)$

Different types of Neurons

- Linear Neurons
  - These are one of the most simple neurons models computationally limited

$$y = \beta + \sum_{i} X - i\beta_i$$

Different types of Neurons

- McCulloch-Pitts (Binary threshold neurons):
  - First compute a weighted sum of the inputs
  - Then send out a fixed size spike of activity if the weighted sum exceeds a threshold.

$$y = \beta_0 + \sum_i x_i \beta_i$$

$$y = \begin{cases} 1, & \text{if } z \geq 0 \\ 0, & \text{otherwise} \end{cases}$$

Different types of Neurons

- Rectified Linear Neurons (ReLu)
  - It computes a linear weights sum of their inputs.
  - The output is a non-linear function of the total input.

$$y = \beta_0 + \sum_i x_i \beta_i$$

$$y = \begin{cases} z, & \text{if } z \geq 0 \\ 0, & \text{otherwise} \end{cases}$$

Different types of Neurons

- Sigmoid neurons
  - These five a real-valued output that is a smooth and bounded function of ther total input. Logistic function is typically used.

$$y = \beta_0 + \sum_i x_i \beta_i$$

$$y = \frac{1}{1 + e^{-z}}$$

Perceptron Multiclasse

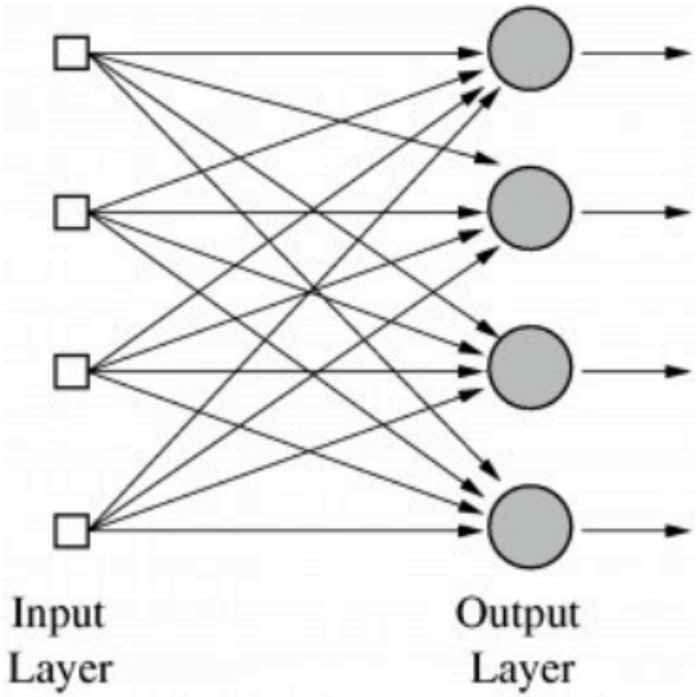


Figura 4: Modelo del perceptrón para clasificación múltiple

Exercice

- Suppose we have a 3-dimensional input $x = (x_1, x_2, x_3)$ connected to a neuron with weights $w = (w_1, w_2, w_3)$ where :

  $x_1 = 2 \quad w_1 = 1$

  $x_2 = -1 \quad w_2 = -0.5$

  $x_3 = 1 \quad w_3 = 0$

  and a bias $b = 0.5$.

- For each of the types of neurons discussed so far, we calculate the output y using the input x, weight w and bias b. If the activation function is:
  - Linear
  - Logistic Sigmoid
  - Binary Threshold
  - Rectified Linear

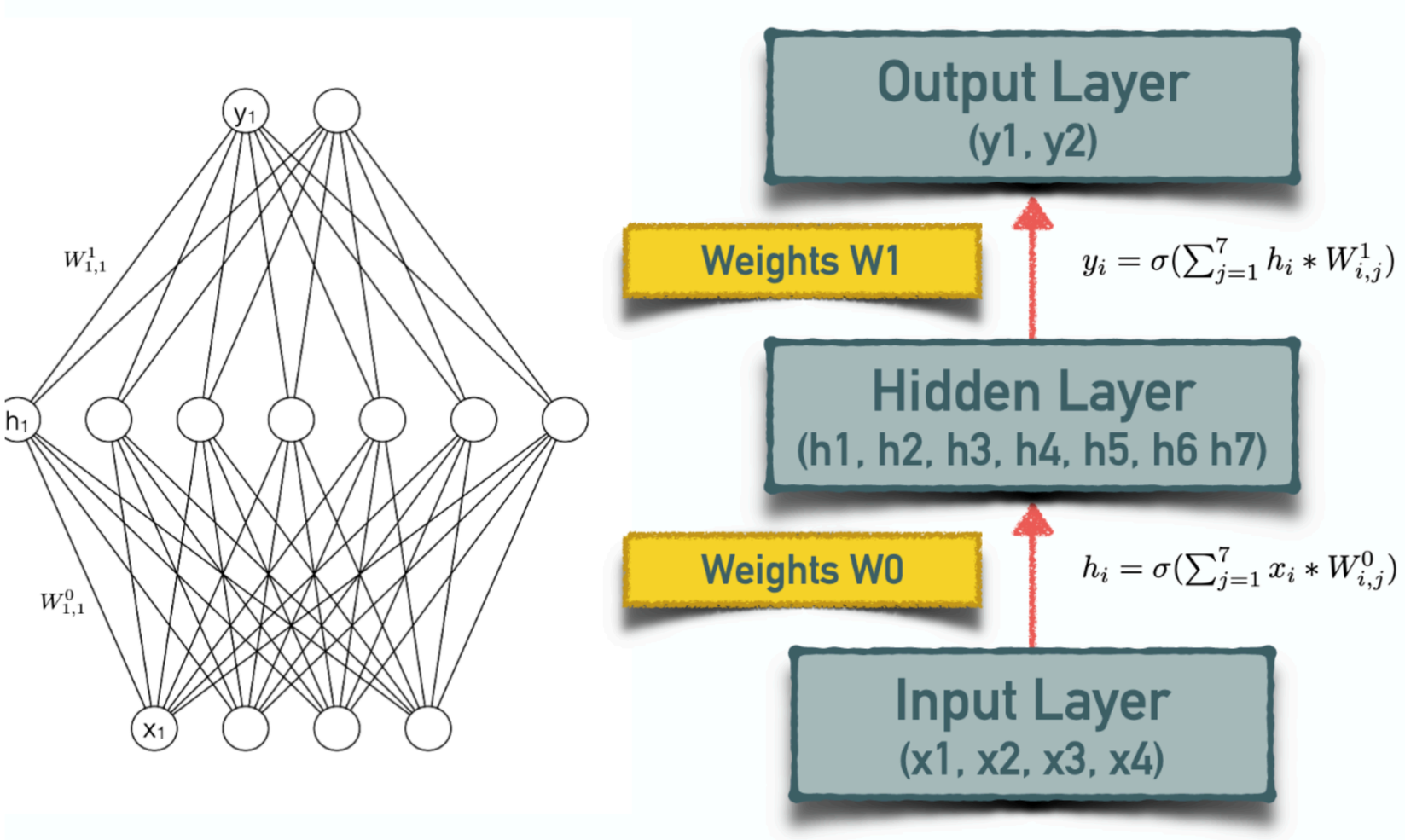
Types of Neural Networks

- Feed Forward Neural Networks
- Convolutional Neural Networks
- Recurrent Neural Networks

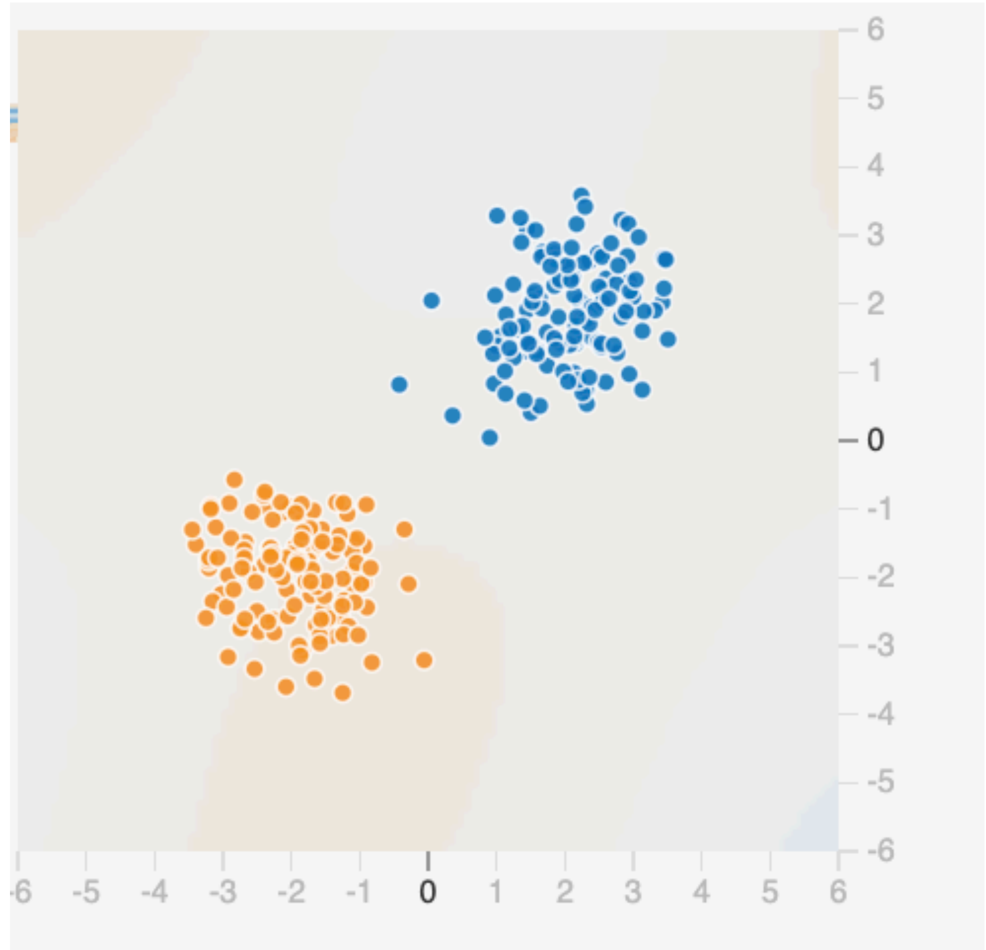
Feed-Forward Neural Network

- These are the commonest type of neural networks in practical applications
  - The first layer is the input and the last layer is the output
  - If there is more than one hidden layer, we call them "deep" neural networks!

- They compute a series of transformations that change the similarities between cases.
  - The activities of the neuros in each layer are non-linear functions of the activites in the layer below.



2 Layers Neural Net model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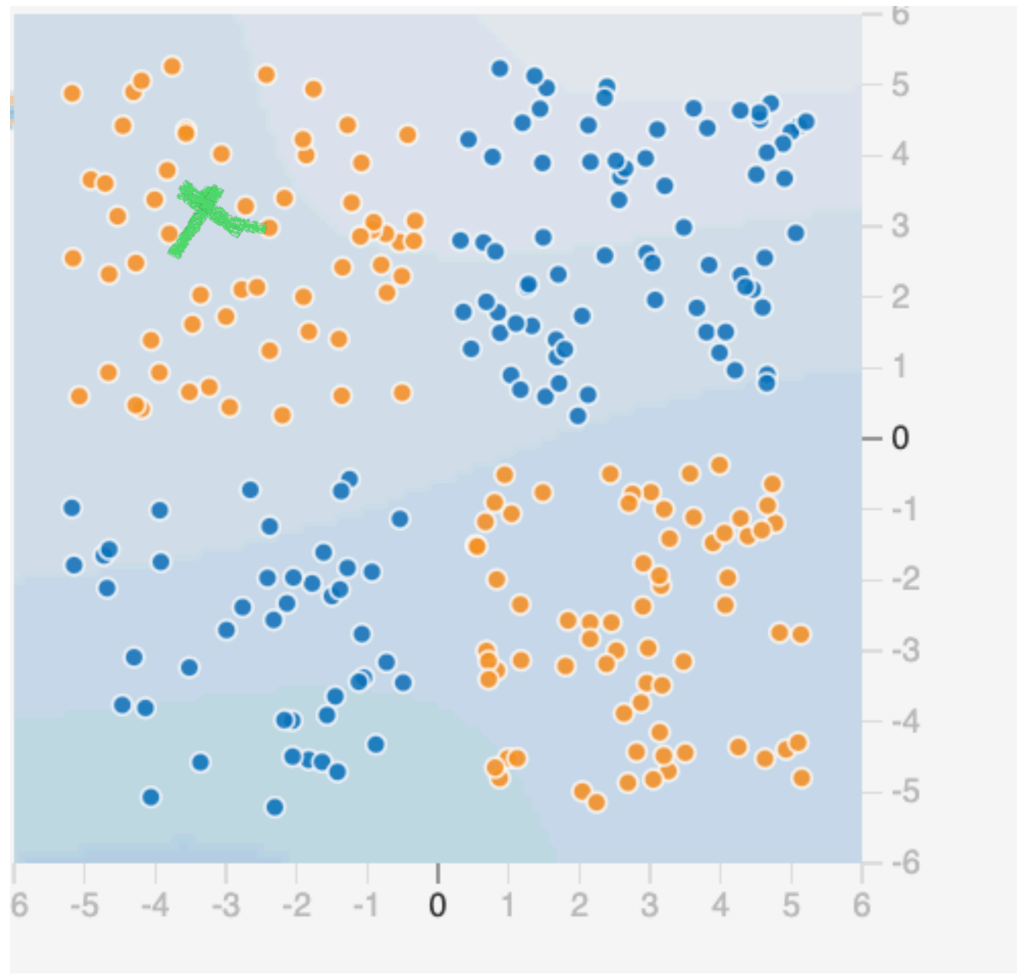
6 5 4 3 2 1 0 -1 -2 -3 -4 -5 -6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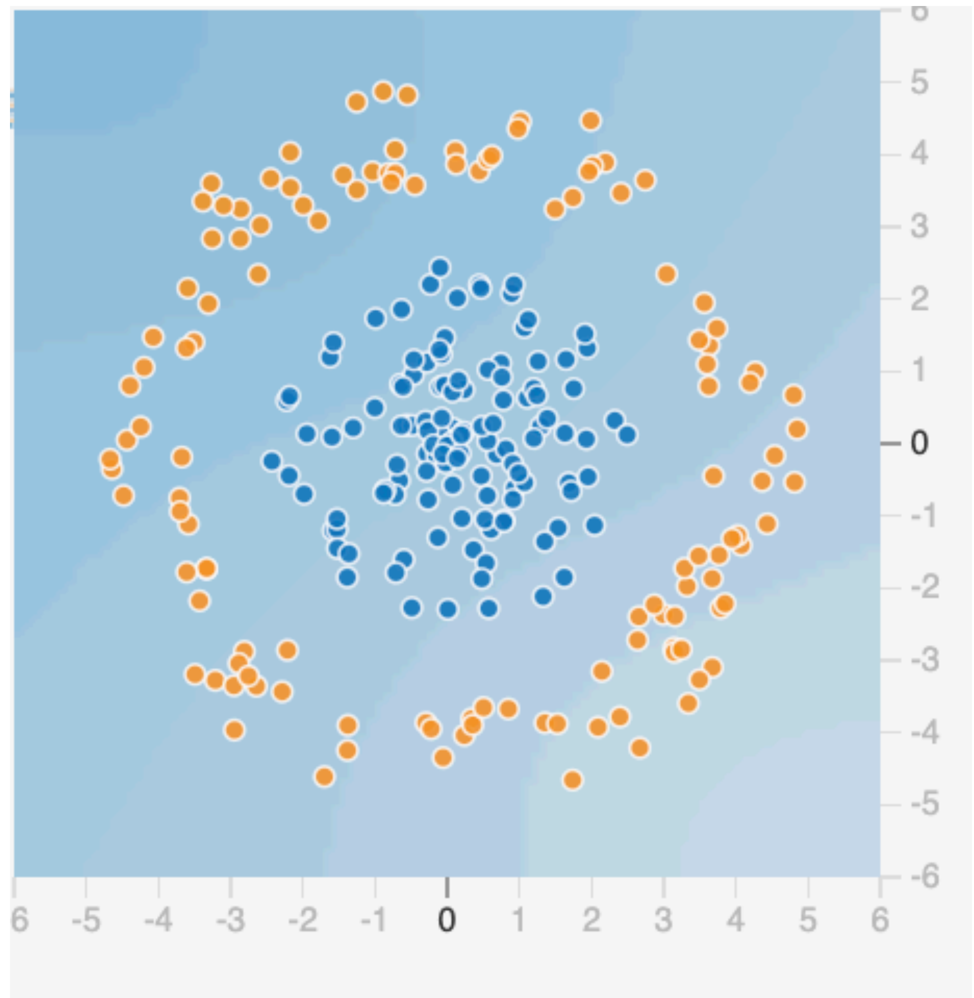
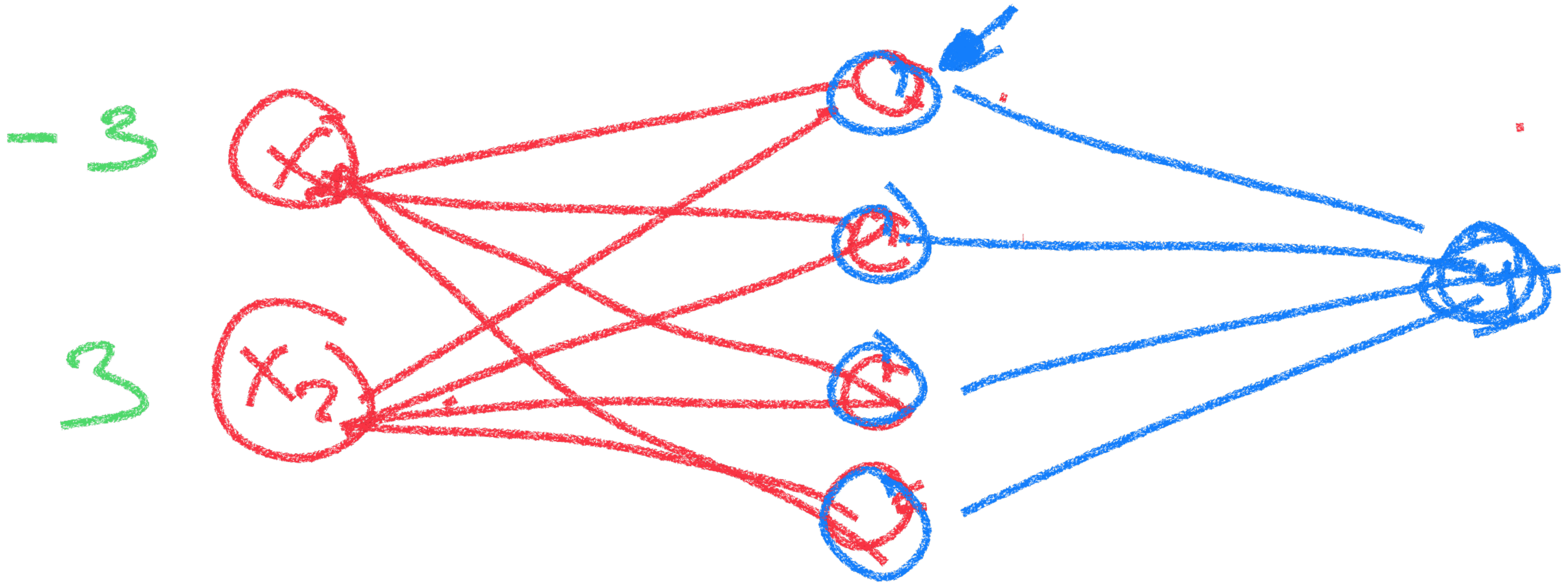
6 5 4 3 2 1 0 -1 -2 -3 -4 -5 -6


-6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6
6 5 4 3 2 1 0 -1 -2 -3 -4 -5 -6


-3
3
x_1
x_2

Let’s play a little bit! :)

- http://playground.tensorflow.org/