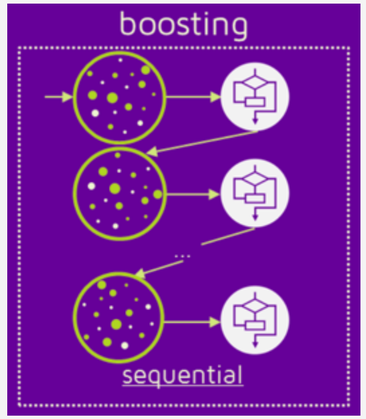
Build a boosting classifier from scratch



Requirements:

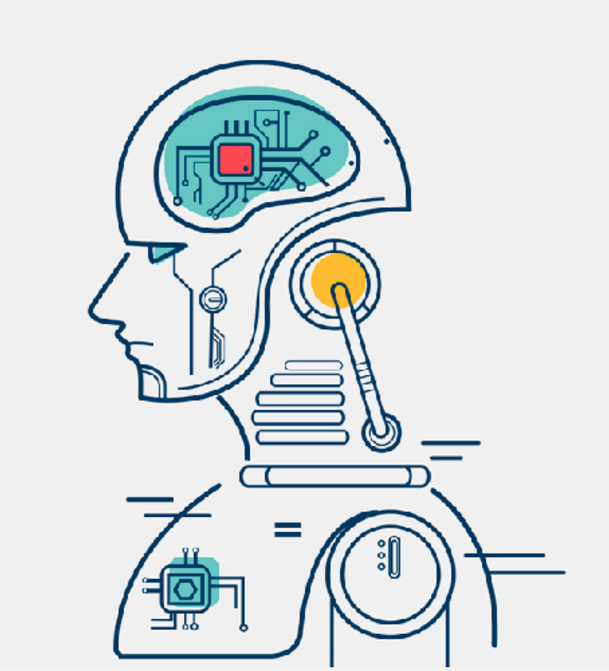
Evaluate it using MNIST & Fashion MNIST DATASET.

Compare the results with

Bagging; Random Forest; AdaBoost (sklearn version)

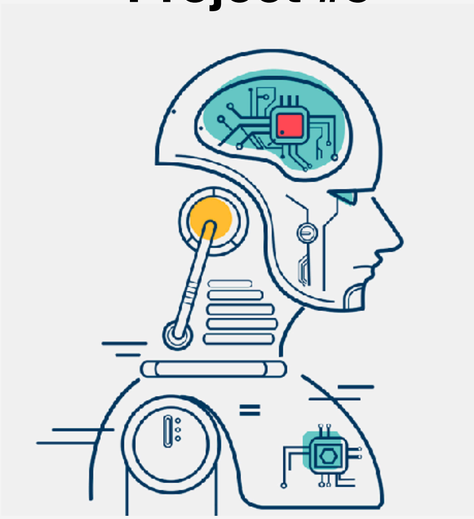
Score:

4 points



Project #4

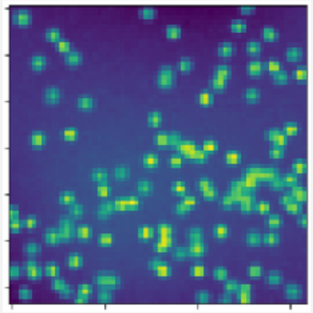
Project #5



Neural Networks for **Learning to Count Problem**

The **output** is the **number of instance of an object** that appears in that image ->

In this image appears 126 dots

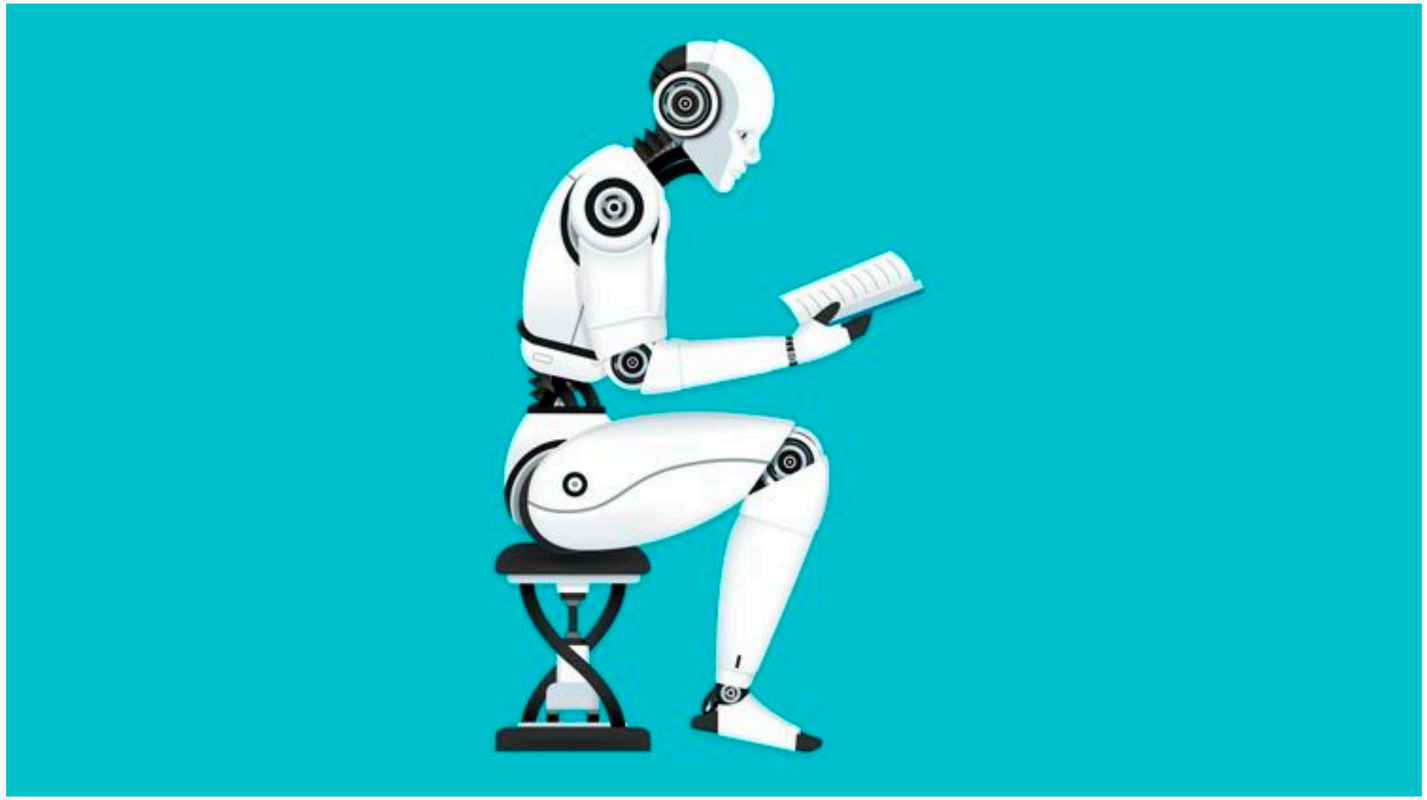


Score:
If the problem is solved with convolutional networks:
Up to 3 points

If the problem is solved with convolutional networks + Smart Data Augmentation:
Up to 4 points

If the problem is solved with complex networks + Smart Data Augmentation + Smart ideas:
Up to 6 points

UNIVERSITAT DE BARCELONA



Neural Networks

Machine Learning | Enginyeria Informàtica

Santi Seguí | 2021-2022

What is a Neural Network

- It is a system **biologically inspired** that tries to emulate **human brain**.
- **Why**

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?

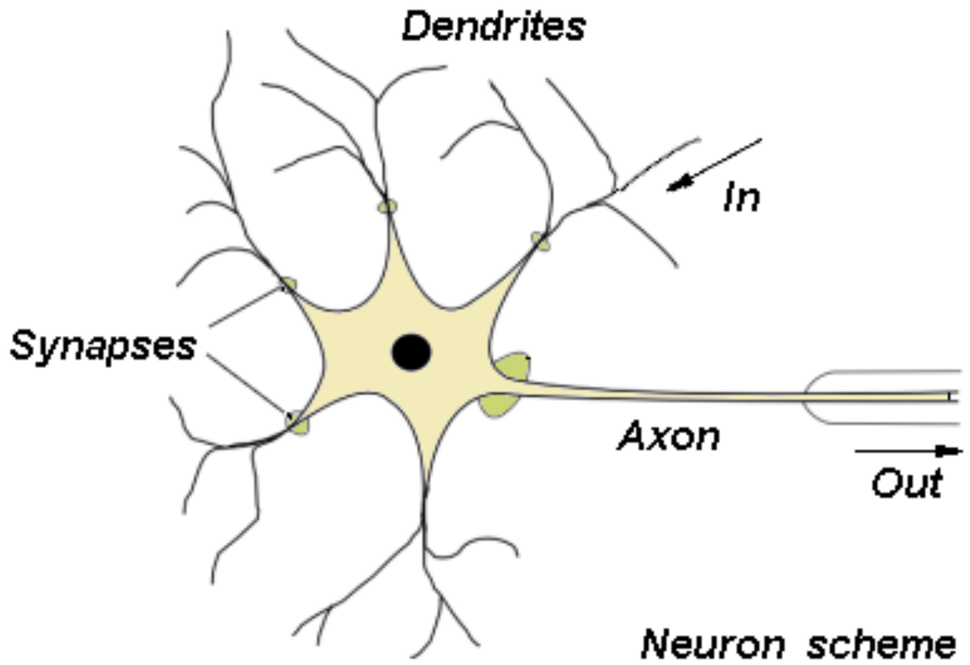
What is a Neural Network

- 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!!

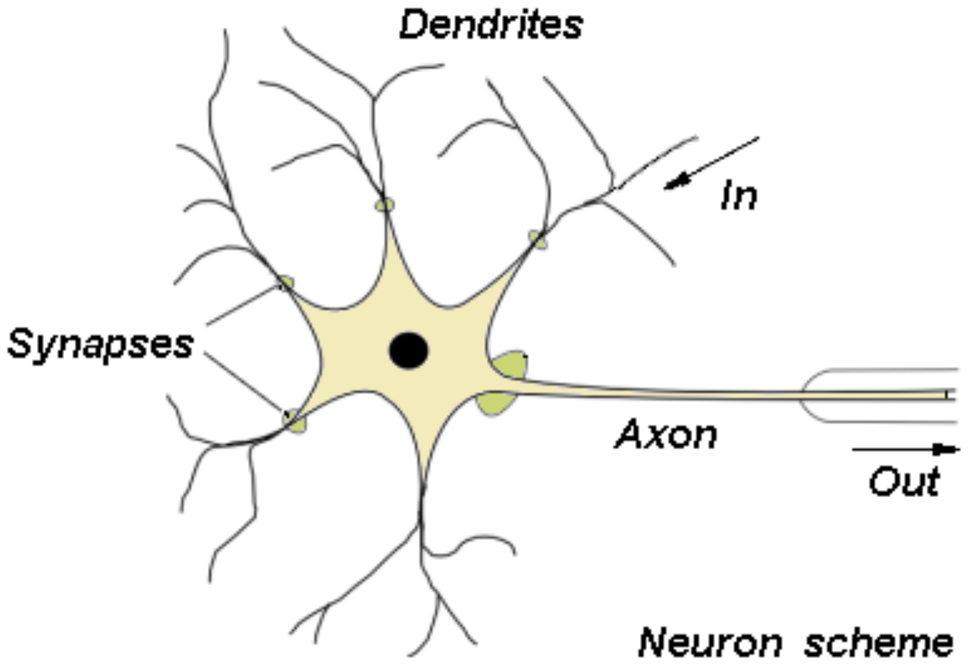
What is a neuron?

What is a neuron?



What is a neuron?

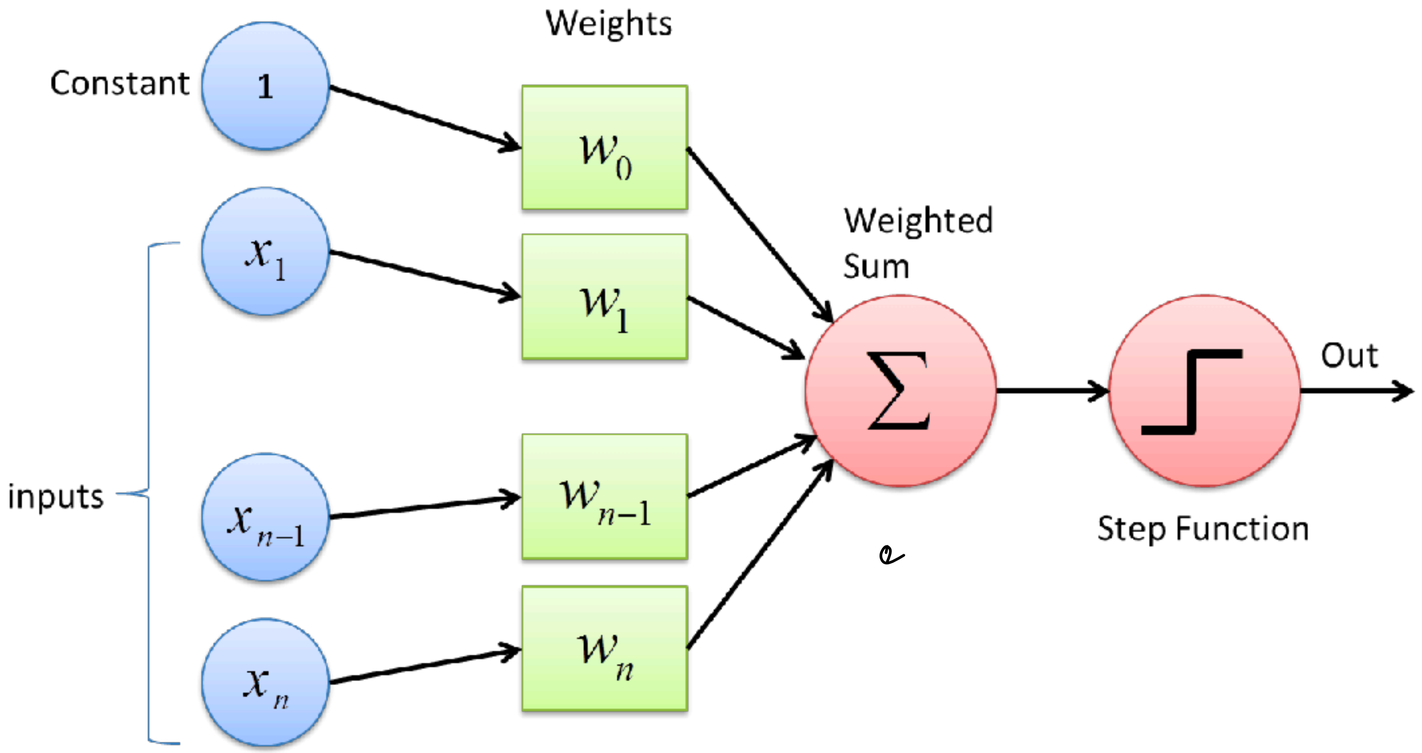
- In the human brain, a **typical neuron** collects signals from others through a host of fine structures called **dendrites**.
- The neuron **sends out spikes** of electrical activity through a long, thin stand known as an **axon**, which splits into thousands of branches.
- At the end of each branch,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



Neuron scheme

How the brain works (with one slide!)

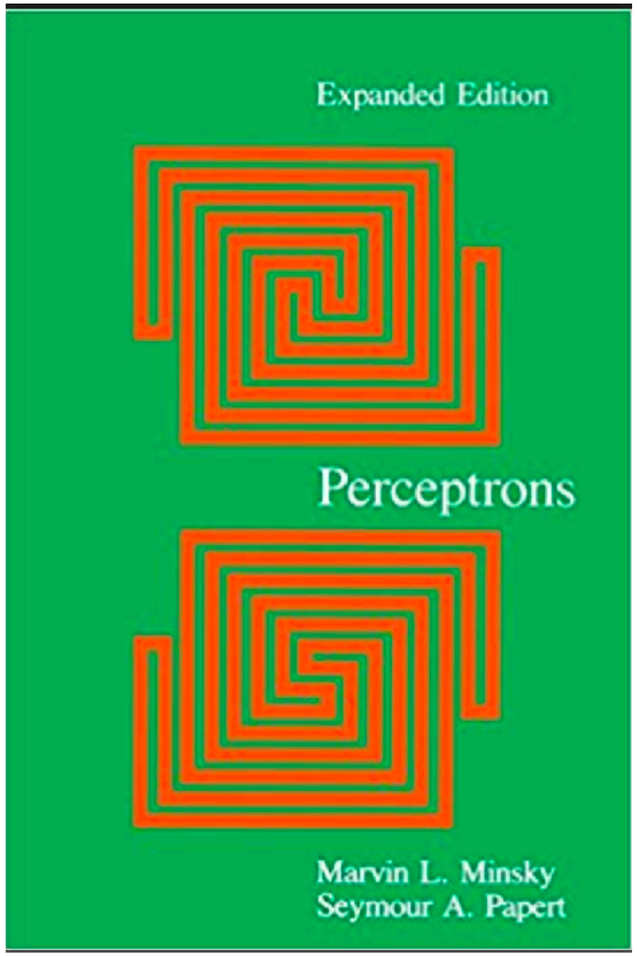
- Each neuron receives inputs from other neurons
  - A few neurons also connects to receptors
  - Cortical neurons use spikes to communicate
- The effect of each input line on the neuron is controlled by a synaptic weight
  - The weights can be positive or negative
- The synaptic weight adapt so that 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.

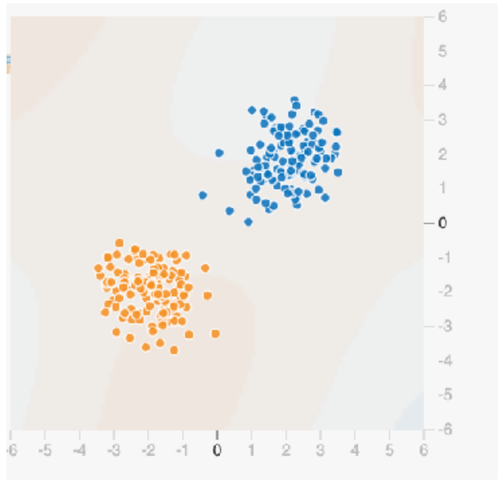
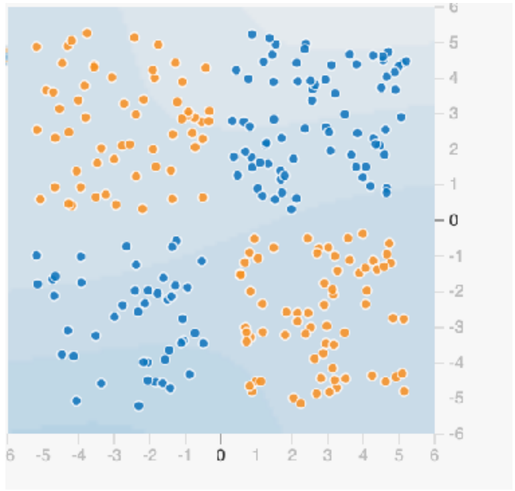
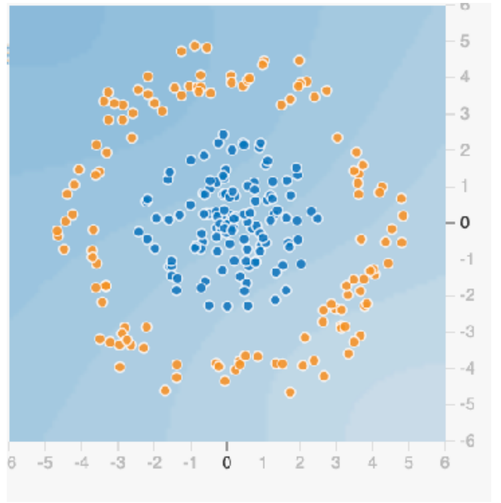


Perceptron

Perhaps the first AI model

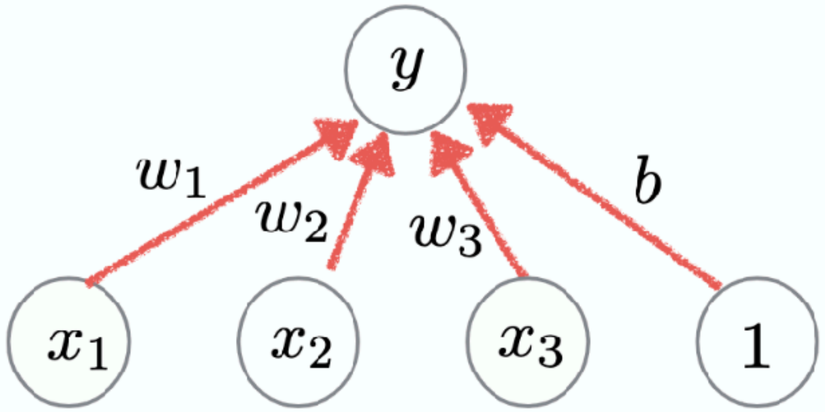
The Book: Perceptrons



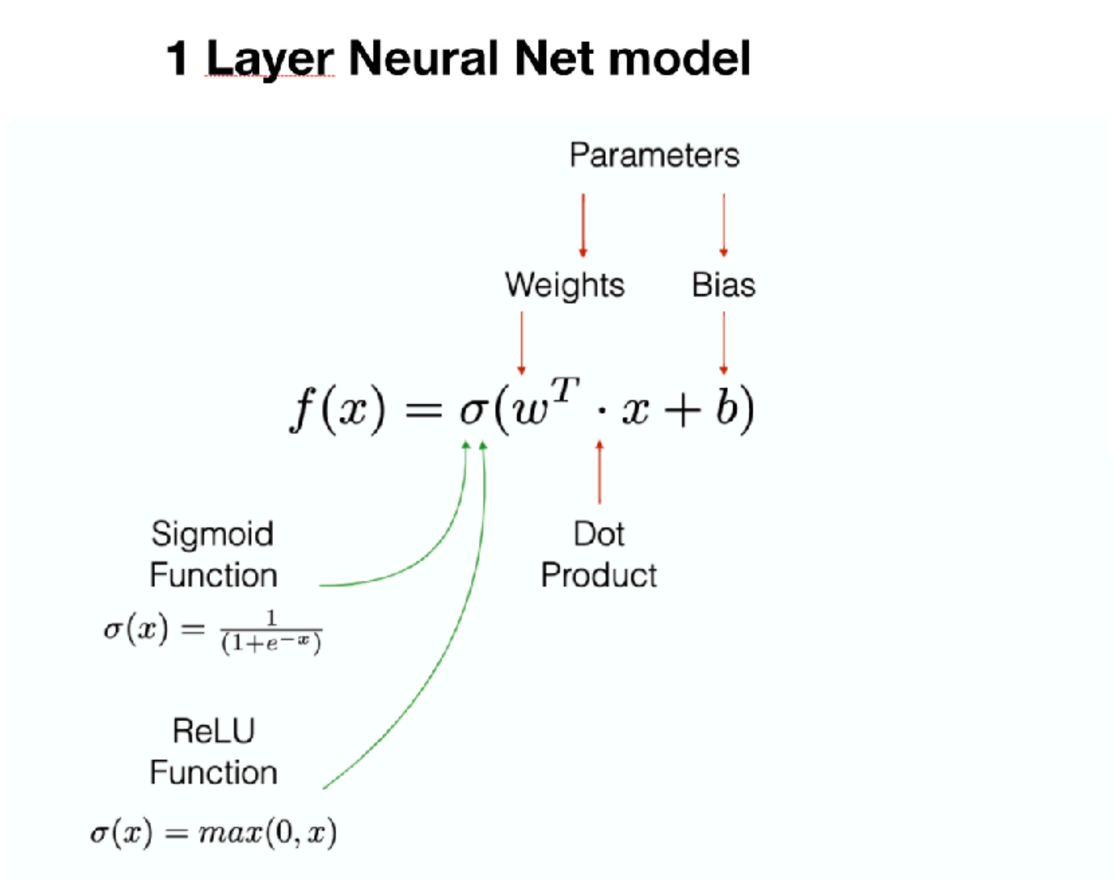
1 Layer Neural Net model

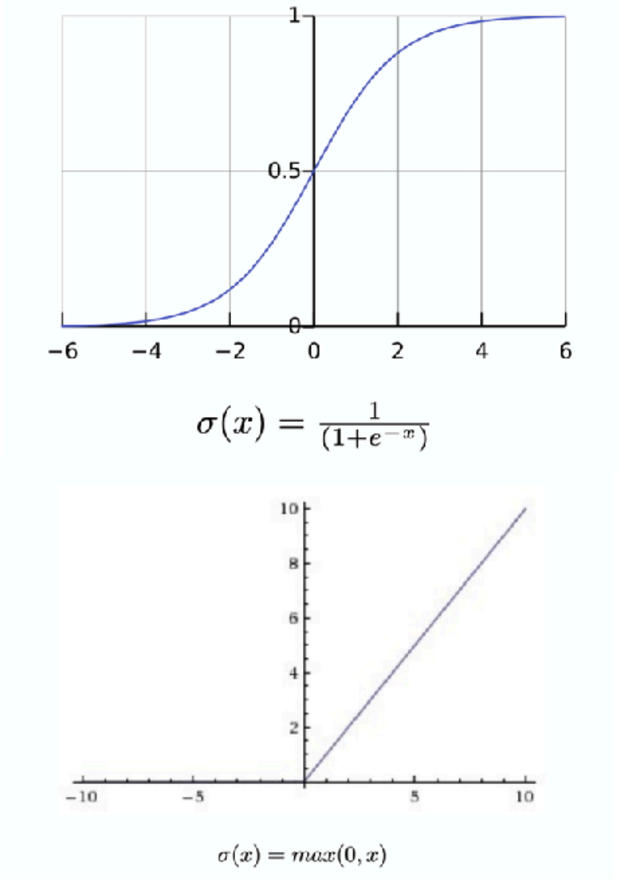
$$f(x) = \sigma(w^T \cdot x + b)$$



Graphical Representation

Neural Networks





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

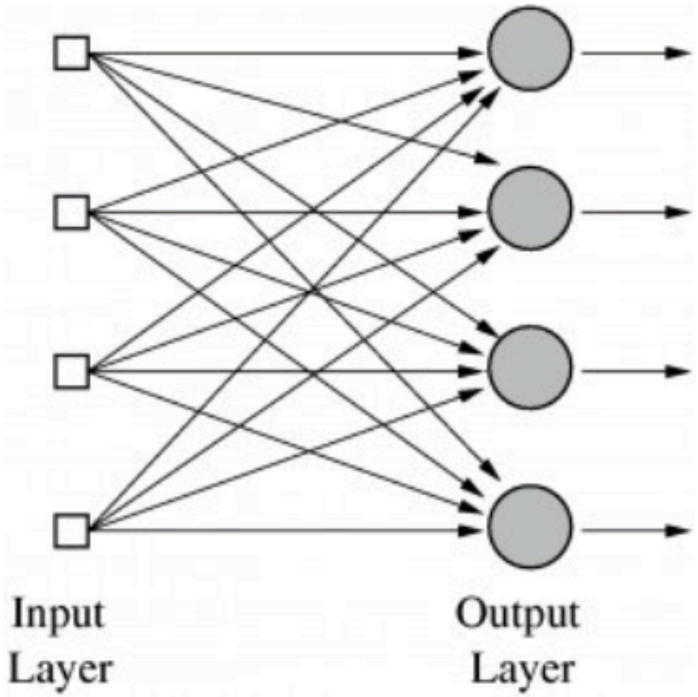


Figura 4: Modelo del perceptrón para clasificación múltiple

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

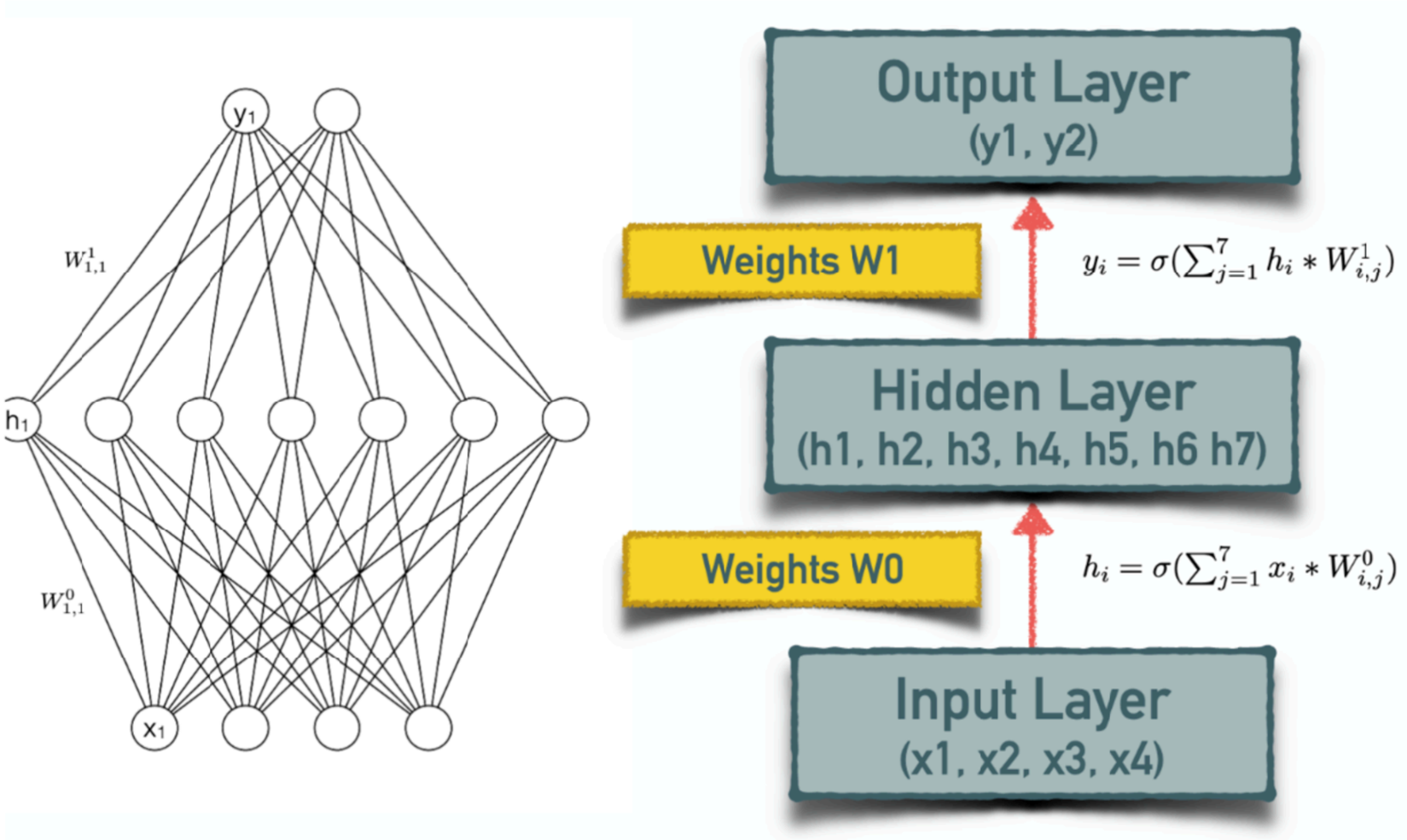
Types of Neural Networks

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

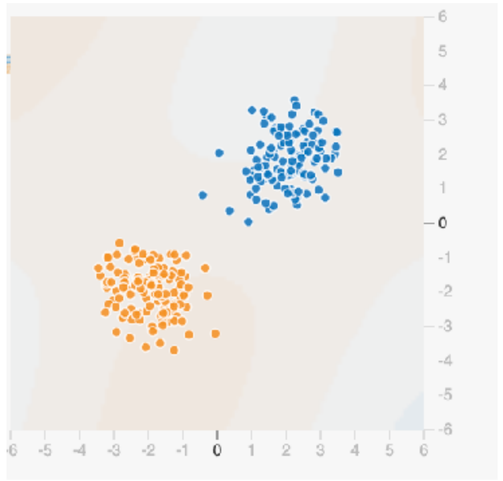
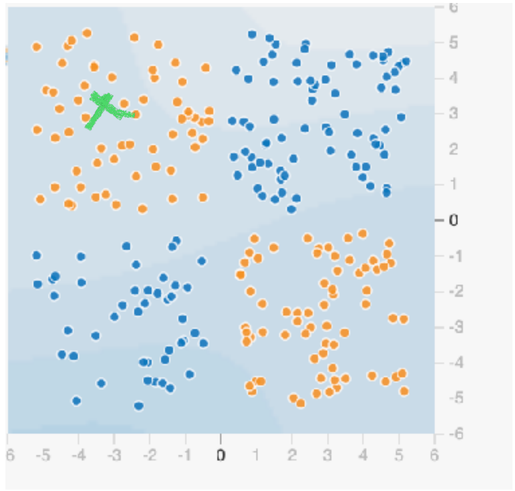
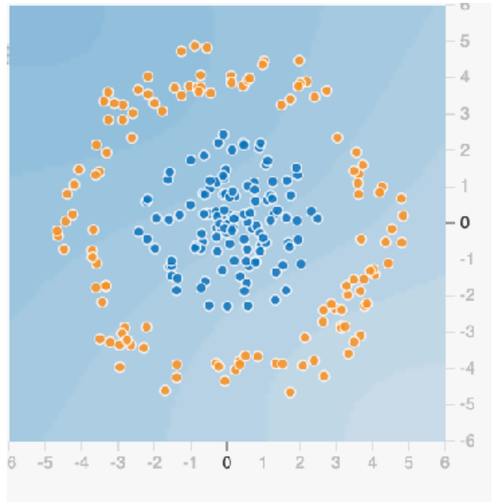
Feed-Forward Neural Network

- 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

Let’s play a little bit! :)

- http://playground.tensorflow.org/