

# Deep Learning

Paolo Bettelini

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## 1 Simplified brain neurons

## 2 Linear neurons

A linear neuron is very simple and computationally limited in what it can do.

$$y = b + \sum_i x_i w_i$$

The output  $y$  is given by the bias  $b$  plus the sum of all the input connections  $x_i$  multiplied by their weight  $w_i$ .

## 3 Binary threshold neurons

Binary threshold neurons output a 1 or a 0 depending on its weighted value.

Given a threshold  $\theta = -b$

$$z = b + \sum_i x_i w_i$$
$$y = \begin{cases} 1 & \text{if } z \geq 0 \\ 0 & \text{otherwise} \end{cases}$$

## 4 Rectified Linear Neurons or Linear threshold neurons

They compute a linear weighted sum of their inputs.

The output is a non-linear function of the total input.

Given a threshold  $\theta = -b$

$$z = b + \sum_i x_i w_i$$
$$y = \begin{cases} z & \text{if } z > 0 \\ 0 & \text{otherwise} \end{cases}$$

## 5 Sigmoid neurons

They give a real-valued output that is a smooth and bounded function of their total input.

The logistic function is often used.

Given a threshold  $\theta = -b$

$$z = b + \sum_i x_i w_i$$
$$y = \frac{1}{1 + e^{-z}}$$

This function has smooth derivatives that change continuously.

This characteristic makes the learning process easier.