

Neural Networks

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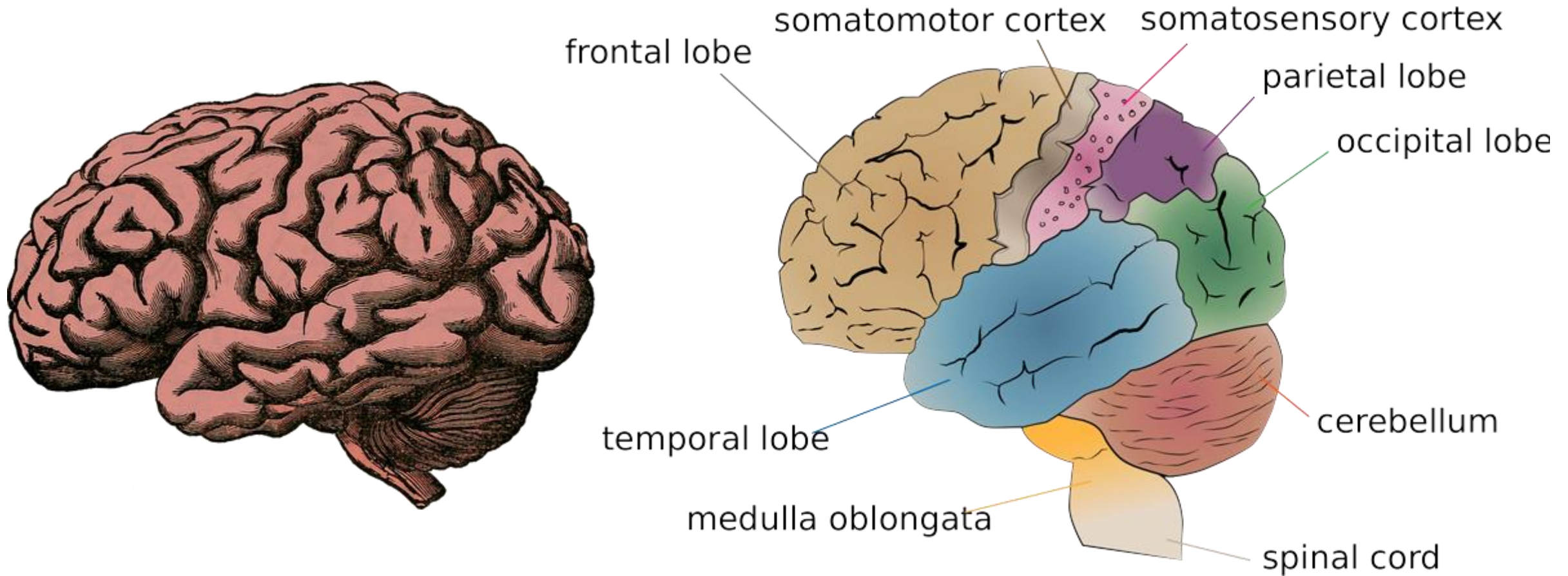


Lecture: 1



NEURAL NETWORKS

Neural Networks



Neural Networks

🖱️ We are born with about **100 billion neurons**

🖱️ A neuron may connect to as many as **100,000 other neurons**

Human Brain

- Number of neurons $\sim 10^{10}$, of > 20 types
- Connections per neuron $\sim 10^{4-5}$
- Scene recognition time $\sim 0,1$ second
- 100 inference steps doesn't seem like enough

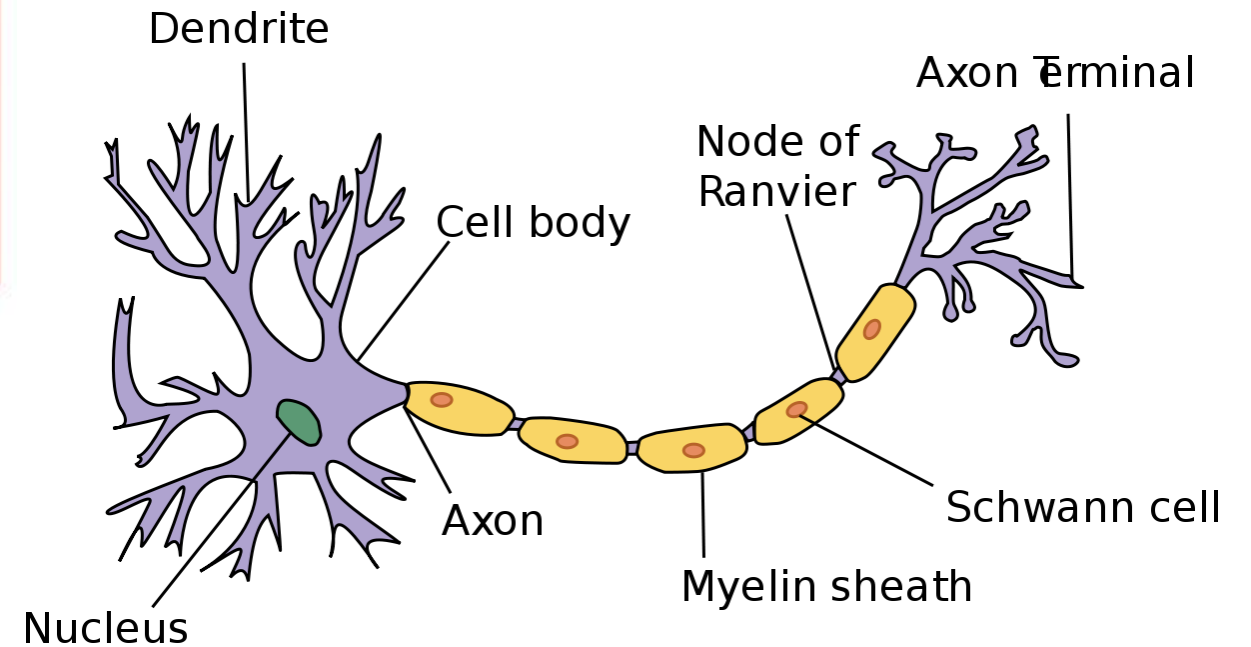
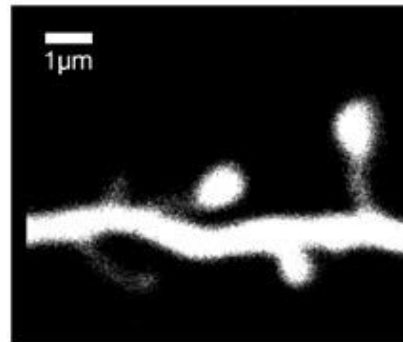
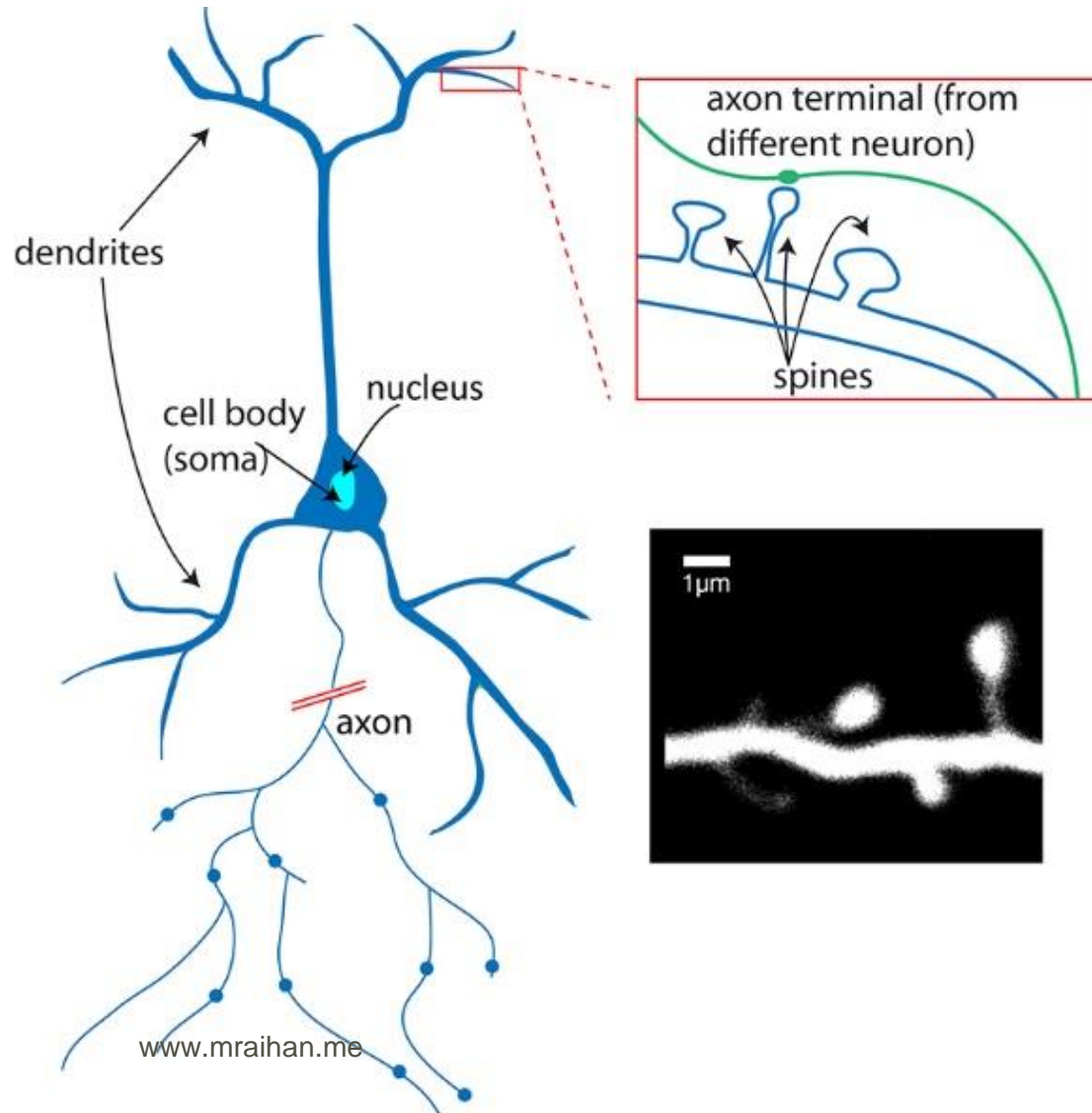
What is Neuron

- 🖱️ Neurons are the **fundamental units** of the **brain** and **nervous system**.
- 🖱️ The cells responsible for **receiving sensory input** from the external world
- 🖱️ For **sending motor commands** to our muscles
- 🖱️ For **transforming and relaying the electrical signals** at every step in between.

How does a Neuron look like

- 🖱️ A useful analogy is to think of a neuron as a **tree**.
- 🖱️ A neuron has **three main parts**: **dendrites**, an **axon**, and a **cell body** or **soma** which can be represented as the **branches, roots and trunk of a tree** respectively.
- 🖱️ A **dendrite** (tree branch) is where a neuron **receives input from other cells**.
- 🖱️ The **axon** (tree roots) is the **output structure of the neuron**; when a neuron wants to talk to another neuron, it **sends an electrical message** called an **action potential** throughout the entire axon.
- 🖱️ The **soma** (tree trunk) is where the **nucleus lies**, where the neuron's DNA is housed, and where proteins are made to be transported throughout the **axon and dendrites**.

Continue



Inspiration from Neurobiology

- 🖱️ A neuron: many-inputs / one output unit.
- 🖱️ Output can be **excited or not excited**.
- 🖱️ Incoming signals from other neurons determine if the neuron shall excite ("**fire**")
- 🖱️ Output subject to attenuation in the **synapses**, which are **junction parts** of the neuron

Hebb's Rule

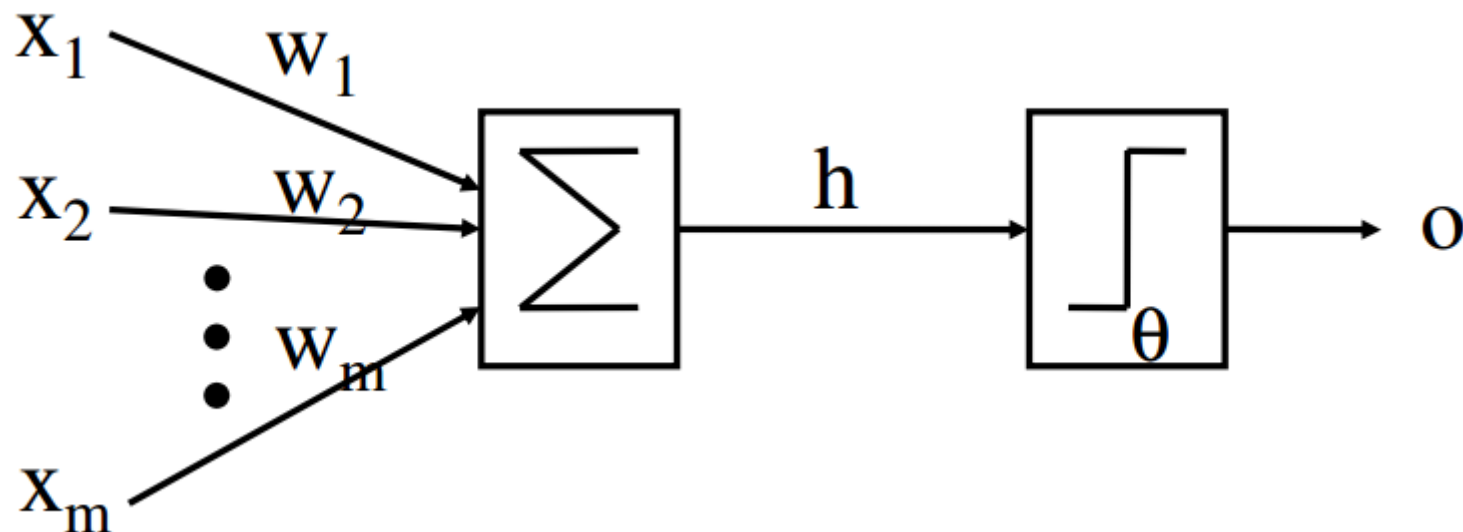
If an input of a **neuron** is **repeatedly** and **persistently** causing the **neuron to fire**, a **metabolic change happens** in the **synapse** of that **particular input** to **reduce its resistance**.

McCulloch and Pitts Neurons

- 🖱️ **McCulloch & Pitts (1943)** are generally recognized as the **designers of the first neural network**.
- 🖱️ Many of their ideas still used today (e.g. many simple units combine **to give increased computational power** and the idea of a **threshold**).

McCulloch and Pitts Neurons

- ☞ Greatly simplified **biological neurons**
- ☞ **Sum the inputs**
 - ☞ If total is **less than some threshold**, **neuron fires**
 - ☞ Otherwise does not



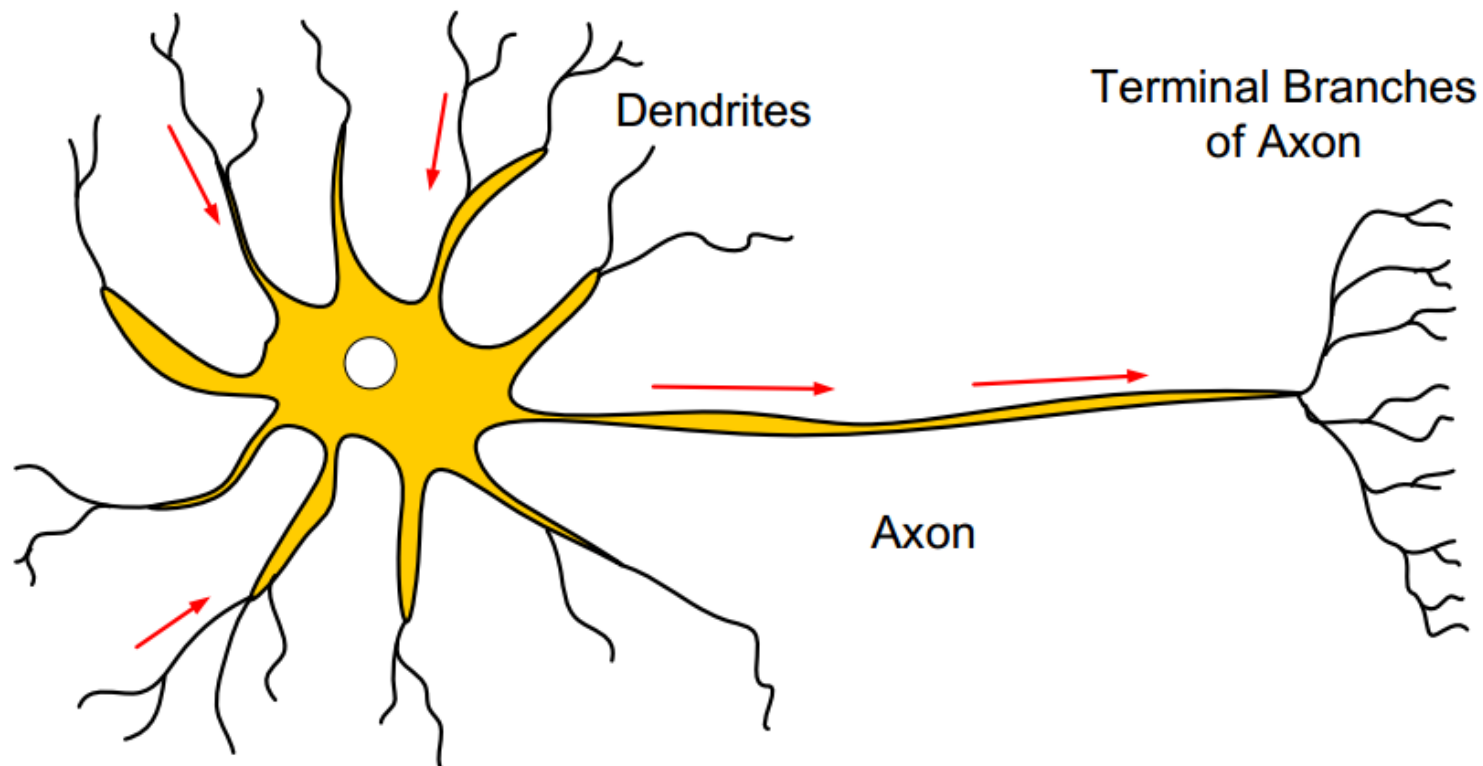
McCulloch and Pitts Neurons

- 🖱️ The weight w_j can be **positive** or **negative**
 - 🖱️ Inhibitory or excitatory.
- 🖱️ Use only a **linear sum of inputs**.
- 🖱️ No refractory period.
- 🖱️ Use a **simple output** instead of a pulse (spike train)

Biologically Inspired

🖱️ **Electro-chemical** signals.

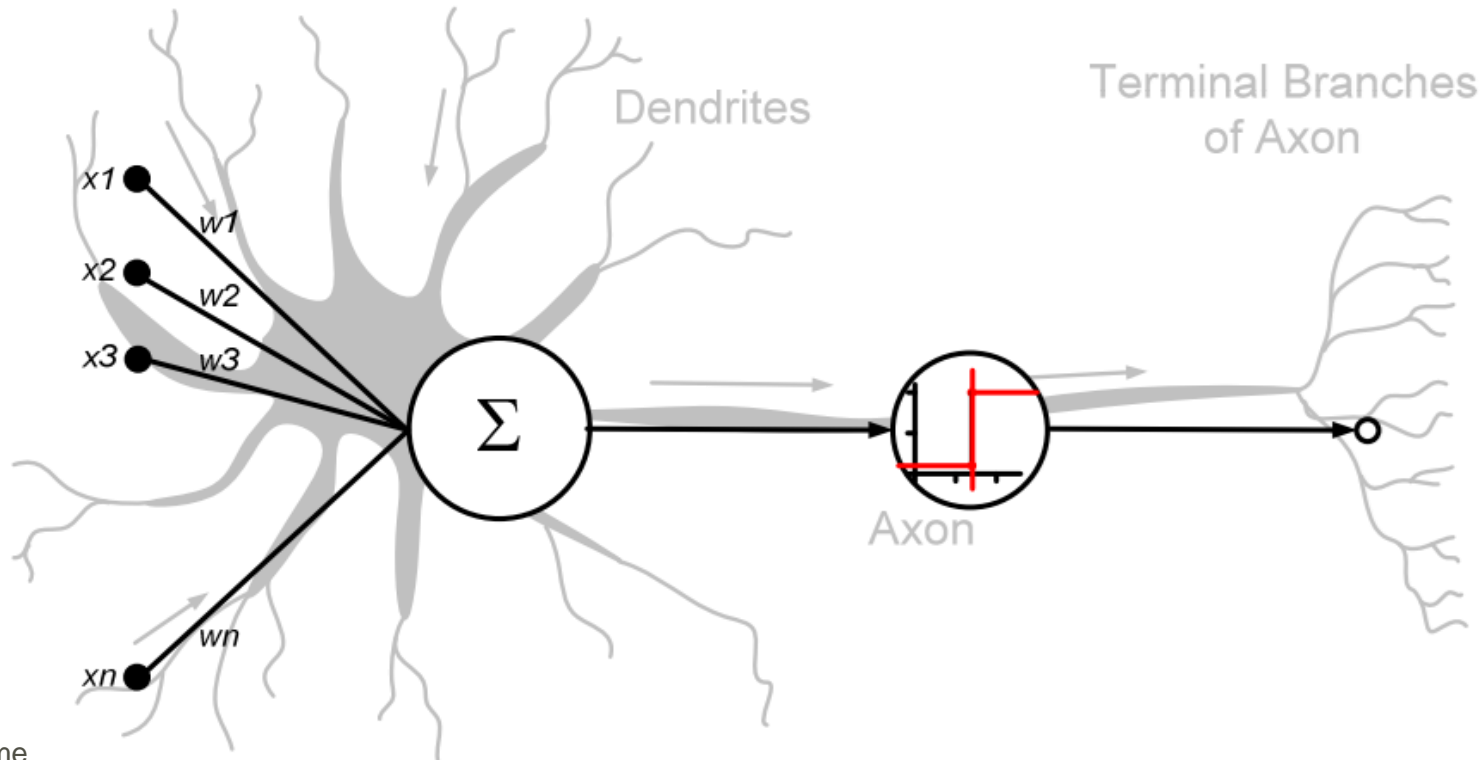
🖱️ **Threshold** output firing.



The Perceptron

🖱️ **Binary classifier** functions.

🖱️ **Threshold activation** function.



Limitations of (McCulloch and Pitts Neurons Model)

- How realistic is this model?
- Not Very.
 - Real neurons are much more complicated.
 - Inputs to a real neuron are not necessary summed linearly.
 - *Real neuron do not output a single output response, but a SPIKE TRAIN.*
 - Weights w_i can be positive or negative, which has not been biologically.

Thank You