Human brains

- A brain is a set of densely connected neurons.

- Components of a neuron: dendrites, soma, axon, synapse

    - *Dendrites* receive input signals from other neurons.

    - *Soma* controls activity of the neuron.

    - *Axon* sends output signals to other neurons.

    - *Synapses* are the links between neurons.

- Depending on the input signals, the neuron performs computations and decides to fire or not.

$\rightarrow$ Conventional models of neurons have few complex components. Neural networks have many simple components.
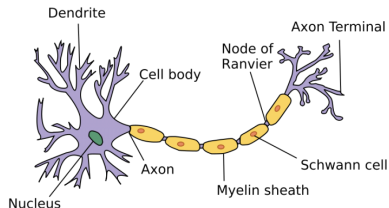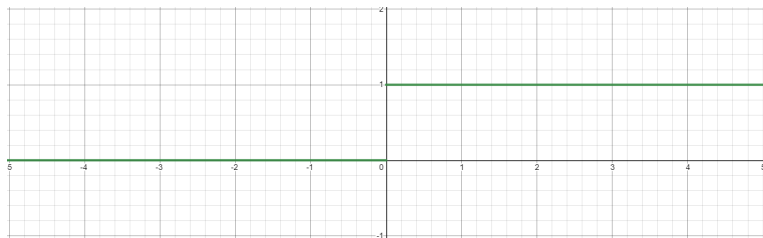
A simple mathematical model of a neuron

- ► McCulloch and Pitts 1943.

- ► A linear classfier — it "fires" when a linear combination of its inputs exceeds some threshold.
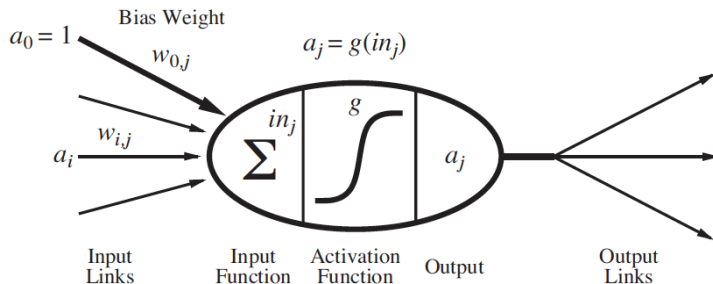
Common activation functions

▶ **Step function:** $g(x) = 1$ if $x > 0$. $g(x) = 0$ if $x \leq 0$.

    ▶ Simple to use, but not differentiable.

    ▶ Not used in practice, but useful to explain concepts.

Perceptrons

▶ Single-layer feedforward neural network

▶ The inputs are connected directly to the outputs.

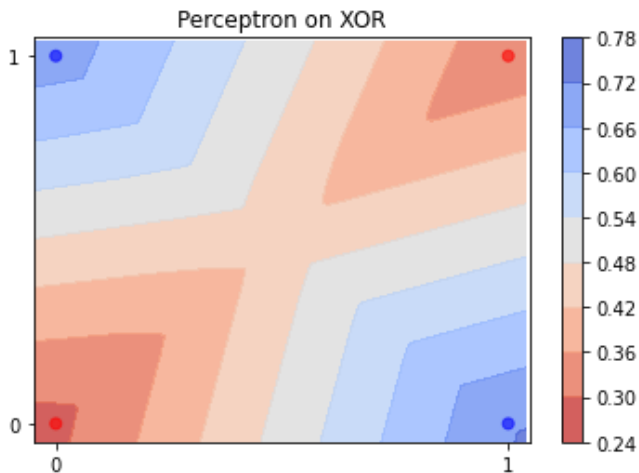▶ Can represent some logical functions, e.g. AND, OR, and NOT.

$\rightarrow$ A big deal at the time. People believed that AI is solved if computers could perform formal logical reasoning.
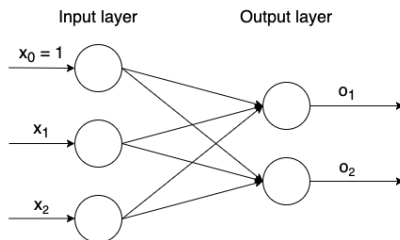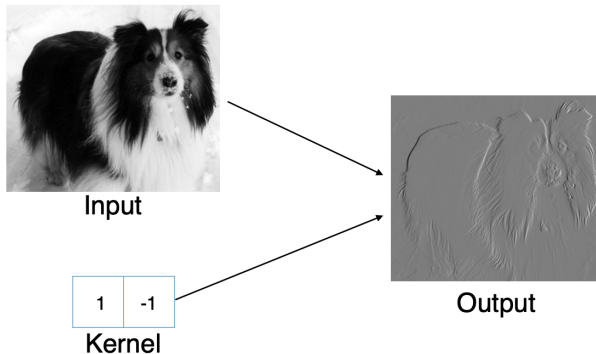

$\rightarrow$ Learn the perceptron for each output separately.

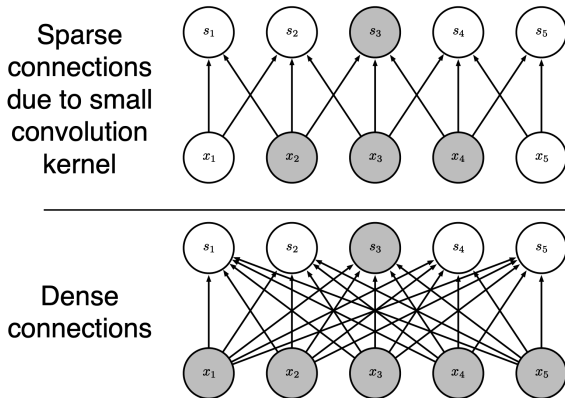# XOR function

The decision boundary of XOR network:

Perceptron on XOR

Convolution Kernel

Convolutional 1x1 Kernal:

Input

| 1 | -1 |

Kernel

Output

Sparse Connection

Sparse Connection to share weights:

Sparse connections due to small convolution kernel

Dense connections

Modeling Language

Example: Character-level Language Model Sampling

Vocabulary: [h,e,l,o]

At test-time sample characters one at a time, feed back to model