Welcome to the computational cognitive modelling workshop!

Part 2: Artificial neural networks

Part 2: **Artificial neural networks**

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What is a neural network?

A mathematical model

- Inspired by the nervous system
- A set of *units*, connected by *weights*
- The network *runs* by passing *activations* from the *input* (to the *hidden*) to the *output* units

What is a neural network?

A mathematical model

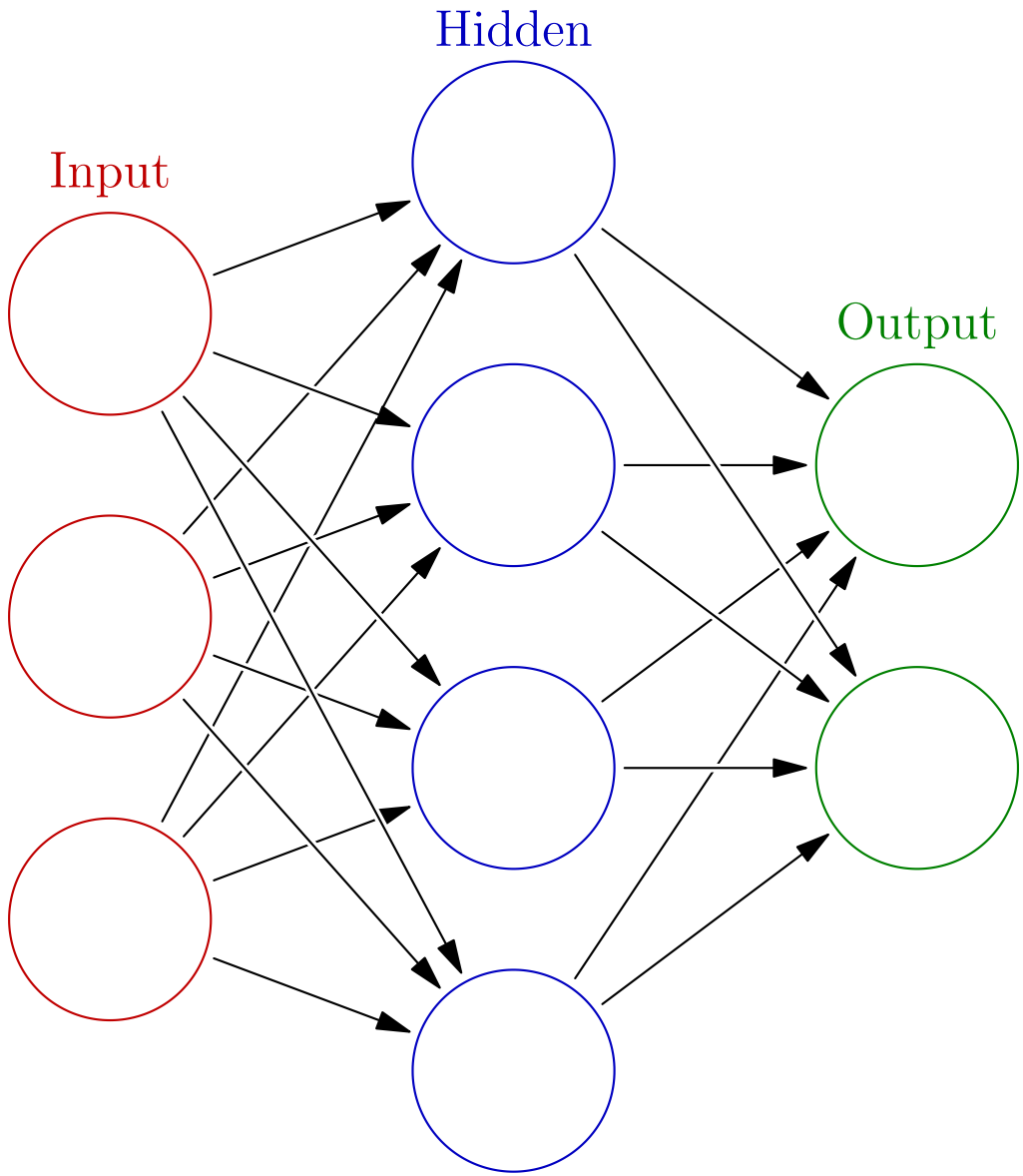


Figure: Glosser.ca / CC-BY-SA-3.0

Why use artificial neural networks for modelling?

Some aspects of their behaviour are like their namesake!

- Learn pretty much any input-output data
- Uncover rules on their own about data
- Generalise from what they have learnt
- Cope with noise and damage

How does an artificial neural network run?

By using maths, predictably!

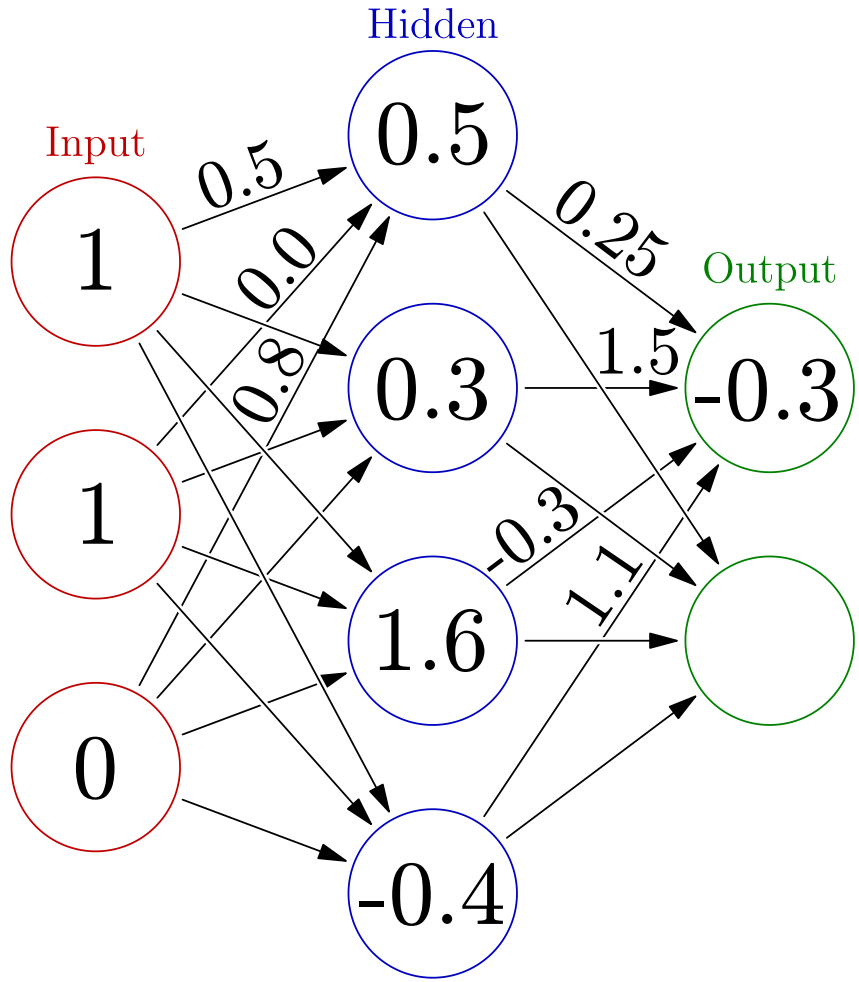
Input units are set to a *pattern*

Calculate hidden units' states:

$$\begin{array}{rll} 1 \times 0.5 = & 0.5 & \\ 1 \times 0.0 = & 0.0 & \\ 0 \times 0.8 = & 0.0 & + \\ \hline & 0.5 & \end{array}$$

Same for output units:

$$\begin{array}{rll} 0.5 \times 0.25 = & 0.125 & \\ 0.3 \times 1.5 = & 0.45 & \\ 1.6 \times -0.3 = & -0.48 & \\ -0.4 \times 1.1 = & -0.44 & + \\ \hline & -0.345 & \end{array}$$



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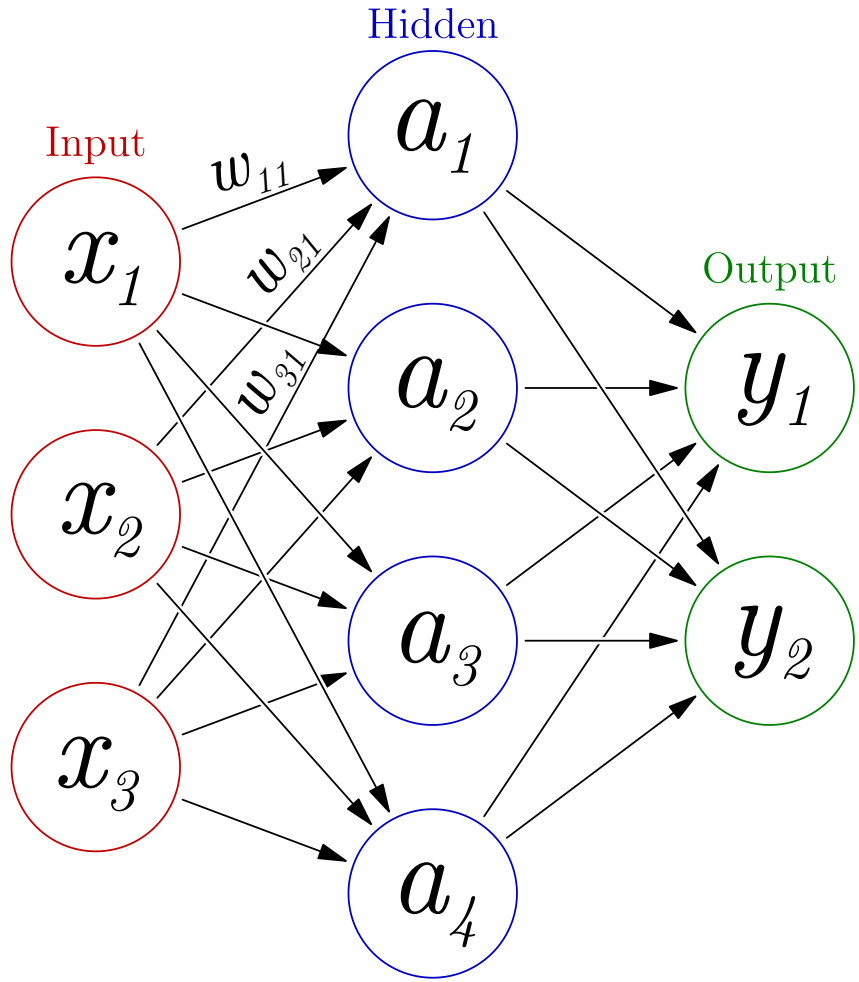
How does an artificial neural network run?

By using maths, predictably!

But we/programmers are lazy:

$$a_i = f\left(\sum_1^N x_j w_{ji}\right)$$

where a_i is the unit whose state we want to calculate, N are the units on the previous layer, w_{ji} is the weight on the connection between i and j, and f is a function that we will discuss later.



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How do networks learn?

Cunning!

- Many options: Hebbian learning, back-propagation of error, Boltzmann machine learning, self-organising map algorithm, etc.
- All learning algorithms work by changing the connection weights
- Learning can be divided into *supervised*, *unsupervised*, and *reinforcement*

Hebbian learning

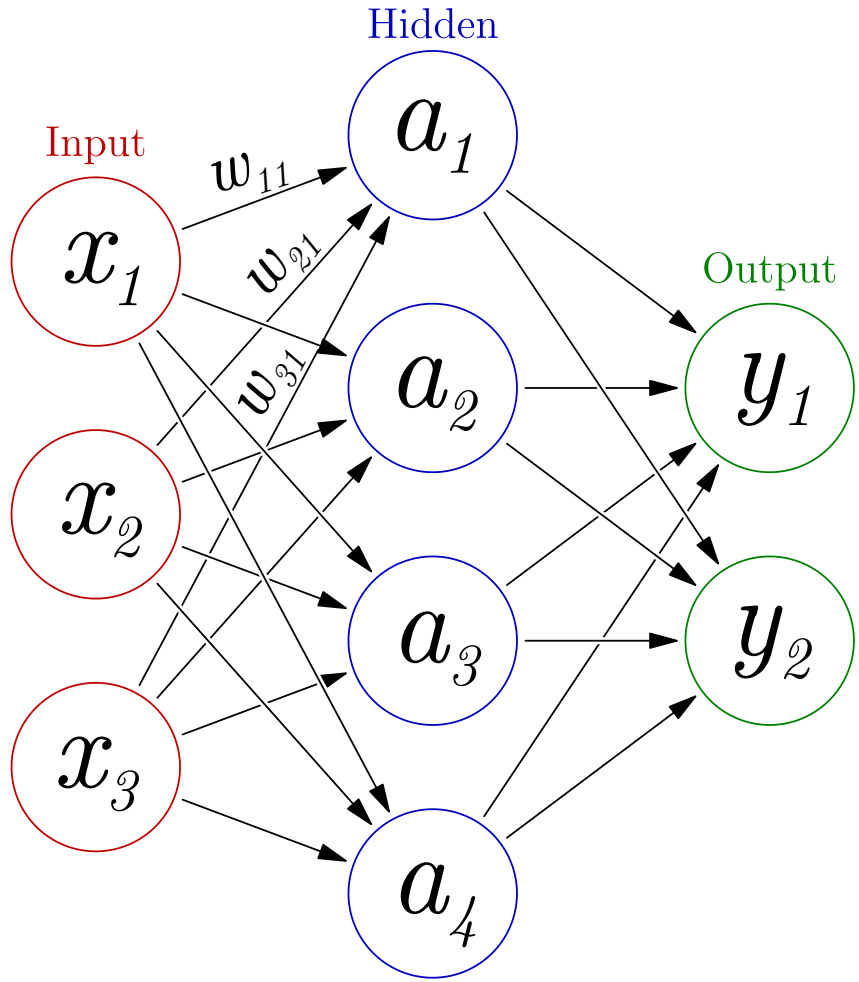
"Cells that fire together, wire together" — Carla Shatz

Hebb's rule is very simple and very unstable!

$$\Delta w_{ij} = \eta \sum_{i}^{N} x_i a_j$$

which means each weight, w_{ij} is changed by a small in/decrement (called Δw_{ij}).

This ensures that if either x_i or a_j is on, then the other will also be on.



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The perceptron

A simple classifier