Neural Networks and Genetic Algorithms

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Review

What do we mean by machine learning?

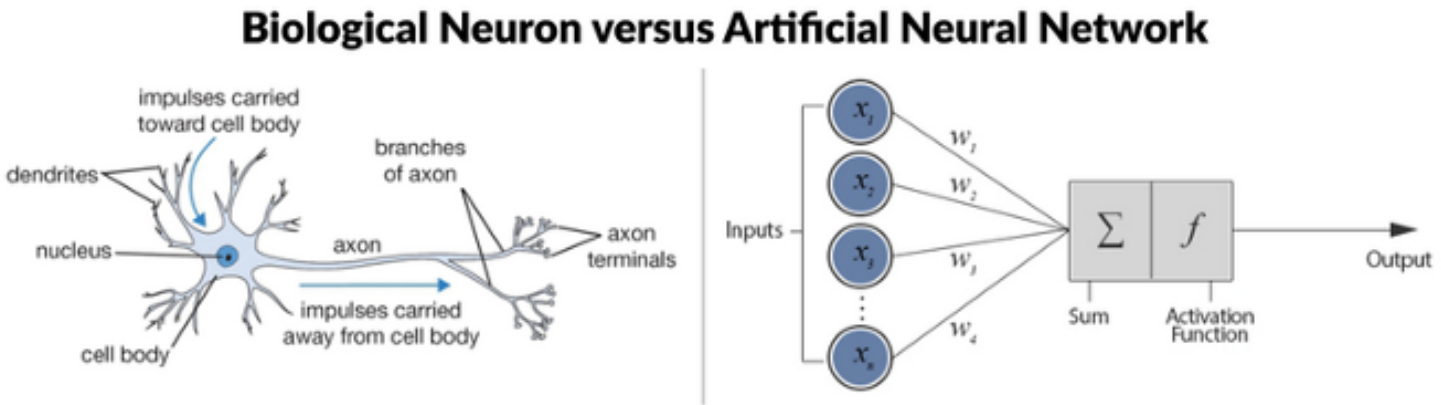
- We have a model. This is a function which takes some input observation and outputs some prediction.
- Models have parameters we can manipulate to change their predictions.
- Machine learning is just trying to find the parameters which give us the best predictions.

$$y = mx + c$$

This is a linear model. x is the observation (input), y is the prediction (output) and m and c are parameters.

Neural Networks

Neural networks are a family of models inspired by the biological structure of the brain.



These units can be chained together to form a network.

The calculations

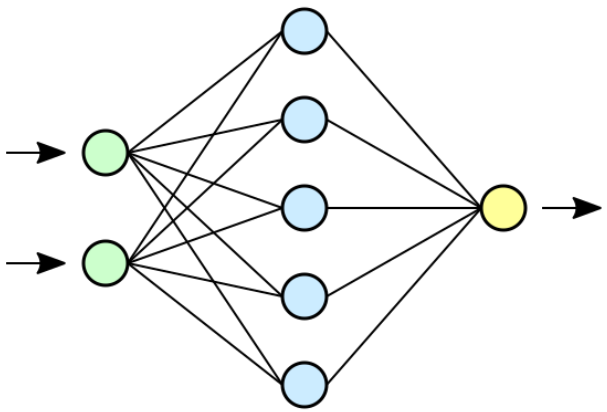
Each neuron calculates its value based on the neurons its connected to.

$$y = f(w_1 x_1 + w_2 x_2 + ... + w_n x_n + b)$$

$x_1 ... x_n$ are the values of the connected neurons.
$w_1 ... w_n$ are the weights, these control how much each connected neuron affects the value of the current neuron.
b is a bias, it just adds some constant offset.
f is the activation function, it takes the sum and does some transformation to it.

The calculations

Neurons are chained together to give a prediction, some neurons are inputs, we set these ourselves as the input to the function. Some neurons are outputs, we look a their values to get a prediction. There are also hidden neurons which represent intermediate steps in the calculation.
How the neurons are connected together is called the topology of the network.



Training Models

We want a way to adjust our parameters so that they improve the results of the model.
How can we do this?

Genetic Algorithms

We can take a model and modify it randomly.
Then we can see if this produces a better result than the original.
If it does we've trained, if not then throw it away and try again.

We can also take two models and mix up their parameters to produce a new model. Again we can test the result and see if it performs better.

Combining these steps we have a genetic algorithm.

More specific details

- We need a way to tell how good a model performs. This is called a fitness function. When we evaluate a network this function tells us how good it is.
- When we modify a network we need to specify how much to adjust the parameters by. This is called the mutation rate.
- We don't just evaluate networks one at a time then modify, we usually test a whole batch then pick from that. The size of the batch is called the population.
- We need a way to pick which models from the population to crossover. This is called the selection function.

Combining ideas

We want to use a genetic algorithm to train our neural network model.

Our weights and biases are our parameters that we are trying to tune to optimise our network.
We also have some hyperparameters:

- Population size
- Network topology
- Fitness function
- ...