Chapter 2 - Neural Network

Neural Network

We know that different sections of the human brain are wired to process various kinds of information. These parts of the brain are arranged hierarchically in levels. As information enters the brain, each layer, or level, of neurons does its particular job of processing the incoming information, deriving insights, and passing them on to the next and more senior layer. For example, when you walk past a bakery, your brain will respond to the aroma of freshly baked bread in stages:

- Data input: The smell of freshly baked bread
- Thought: That reminds me of my childhood
- Decision making: I think I'll buy some of that bread
- Memory: But I've already eaten lunch
- Reasoning: Maybe I could have a snack
- Action: Can I have a loaf of that bread, please?

This is how the brain works in stages. Artificial neural networks work in a similar manner.

Neural networks try to simulate this multi-layered approach to processing various information inputs and basing decisions on them.

An artificial neural network in its most basic form has three layers of neurons. Information flows from one to the next, just as it does in the human brain:

- The input layer: the data's entry point into the system
- The hidden layer: where the information gets processed
- The output layer: where the system decides how to proceed based on the data

More complex artificial neural networks will have multiple layers, some hidden.

The neural network functions via a collection of nodes or connected units, just like artificial neurons. These nodes loosely model the neuron network in the animal brain. Just like its biological counterpart, an artificial neuron receives a signal in the form of a stimulus, processes it, and signals other neurons connected to it.

Perceptron

The layers are made of nodes. A node is just a place where computation happens, loosely patterned on a neuron in the human brain, which fires when it encounters sufficient stimuli. A node combines input from the data with a set of coefficients, or weights, that either amplify or dampen that input, thereby assigning significance to inputs with regard to the task the algorithm is trying to learn; e.g., which input is most helpful is classifying data without error? These input-weight products are summed and then the sum is passed through a node's so-called activation function, to determine whether and to what extent that signal should progress further through the network to affect the ultimate outcome, say, an act of classification. If the signals pass through, the neuron has been "activated." Earlier versions of neural networks such as the first perceptron were shallow, composed of one input and one output layer, and at most one hidden layer in between.

A multilayer perceptron (MLP) is a deep, artificial neural network. It is composed of more than one perceptron. They are composed of an input layer to receive the signal, an output layer that makes a decision or prediction about the input, and in between those two, an arbitrary number of hidden layers that are the true computational engine of the MLP. MLPs with one hidden layer are capable of approximating any continuous function.

Applications of Neural Networks

Neural networks are universal approximators. They happen to work best if the system has a high tolerance for error.

Neural networks are useful:

- For understanding associations or discovering regular elements within a set of patterns
- Where the data is enormous either in volume or in the diversity of parameters
- Relationships between variables are vaguely understood
- Where conventional approaches fall short in describing relationships

This beautiful, biology-inspired paradigm is one of the most elegant technological developments of our era.