Science Fair

Research Reference Document

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What is a Neural Network?

Before describing what a neural network is and how it functions, just keep in mind that the explanation will be significantly short and simple. This is to help you, the reader, to better visualize the inner-workings of our machine-learning friends; however, there is still a lot of information left out, and it is highly encouraged that you explore the uncovered wonders of machine-learning on your own.

Simple Definition

- **A Neural network is essentially a series of mathematical algorithms designed to recognize patterns within data.** When interpreting data, they can classify or cluster it. Although they can be used to recognize patterns in real-world data such as images, sound, and text, they can only recognize patterns in numbers within vectors, so the real-world data will have to converted or translated.

Behavior

- Neural networks are able to find correlations within data. When finding correlations, they can either classify and cluster the data.

- Classification is when a neural network groups certain data under a set of labels. These labels will have to be defined by humans in order for the neural network to determine the correlation between these labels and the data. This is also referred to as supervised learning.
    - For example, you can provide a neural network with a set of geometric shapes as labels, such as squares, triangles, hexagons, etc. Each shape will have their own set of features, like how a square has 4 sides and 4 corners. Knowing the characteristics of these shapes, the neural network can then group the data into those shapes/labels.

- In some cases, the labels used in classification can be used to label events happening in time. You can assign labels to world events that took place in the past and future. Based on these events/labels and a sufficient set of a data, the neural network can now make correlations between past, present, and future events.
    - For example, if you have a set of recorded events that have happened to a person suffering from a medical disease, you can have the neural network train on this data and predict health breakdowns.

- Clustering is essentially the detection of similarities within data. When clustering, a neural network isn't classifying data based on labels or predefined characteristics. Instead, it is trying to find raw similarities and differences in the data. This is also referred to as unsupervised learning.
    - For example, contrasting with the example for classification, you wouldn't provide the neural network with any of the characteristics or labels of a given list of geometric shapes; instead, the neutral network will point out what similarities and generalizations in the data IT sees.

Structure

- A neural network is made up of layers of nodes. These nodes are where the computations take place.
- When receiving inputs, a node will take these inputs and combine it with their corresponding weights to either amplify or dampen it. These weights are based on their input's relative importance to the other inputs, which could be adjusted by humans to favor different inputs. The combined values are then summed up to be passed through the node's activation function. The activation function will determine if and to what certain extent the signal should be sent down the neural network. If the signal is sent out, then the node has been "activated".
- These nodes then make up node layers, with each layer's output also being the input of the next layer.
- With this in mind, Deep Neural Networks or Deep Learning are defined literally as neural networks with 3 or more hidden layers (the layers that are neither the input or output layers). To keep things simple, Deep Learning concepts will not be directly discussed or defined.

Recurrent Neural Networks

Explaining Feed-Forward Networks

- Before going over Recurrent Neural Networks, it is crucial that you understand what Feed-Forward Networks are first.
- A Feed-Forward Network (FFN) is a neural network where the nodes feed information straight through the network: the information will never touch a given node twice. To contrast, Recurrent Neural Networks (RNN) cycles information in a loop, hence the word “recurrent” in the name. This will be elaborated upon soon.
- FFN’s transform their input examples to create an output, and in the case of supervised learning or classification, that output would be a label to categorize the input.
    - For example, going back to the example with geometric shapes mentioned earlier, the FFN will map it’s input or raw incoming data to categories, so when receiving raw data that relates to shapes (e.g. # of sides, corners, etc.), it will try to label the incoming data based on the it’s previous knowledge of the characteristics of certain shapes.
    - A Feed-Forward Network will train on labeled data until it minimizes the error made when guessing the categories of that data. When minimizing the error, it will try to adjust the weights of its nodes based on the correctness of its guesses.
- Once the FFN is trained on a dataset, like the example data relating to a set of specific geometric shapes, it can then be used to categorize data that it has never seen before.
    - However, when categorizing that data, an FFN will not attempt to classify a piece of data based on how it classify another. For example, when regarding geometric shapes, if it classifies a piece of data as a triangle, it will not classify another piece as a rectangle, square, or circle because of the triangle. Due to this, a Feed-Forward Network does not recognize the order of the data based on time, hence the “feed-forward” part of its name.

Explaining Recurrent Neural Networks

- To contrast, a Recurrent Neural Network doesn’t just input the current piece of data given to them, but it also inputs their previous classifications/decisions; therefore, a decision made on one moment will affect the decision made on the next moment. This loop of cycling information is the main difference between FFN’s and RNN’s.
- The sequential pieces of data are kept in the hidden state of an RNN, retaining relevance for several “time steps” as it affects the decision made for each new piece of data.

What is a Virtual Machine?

Simple Definition

- Before considering what a virtual machine is, first consider a typical personal computer, such as a laptop, gaming computer, etc. Now, on that computer, picture an app running that has a little virtual, mini computer running within a window.
    - That is essentially what a virtual machine is: a virtual system that is being emulated by a host system. A portion of the host system's resources, such as the CPU, GPU, RAM, Storage Medium, and so on will be used to power the virtual system. The virtual system is isolated from any other program, process, or service running on the host system.
- To create, manage, and use virtual machines, a virtual machine "hypervisor" program needs to be installed on your operating system.
    - Using the hypervisor, the specifications of a virtual machine can be tweaked and adjusted, similar to modifying a real computer. You can decide exactly how many CPU threads will be used, or RAM, or GPU video memory, etc. Furthermore, you can install whatever operating system (e.g. Windows 7, Windows 10, Mac OS X, Android) you please on that virtual machine.
    - In the case of the scientific experiment for the science fair, the CPU execution cap will be adjusted between two virtual machines, which is basically the maximum amount of time that the host machine's CPU will spend emulating the virtual machine's CPU.

Sources Used

https://skymind.ai/wiki/neural-network

https://becominghuman.ai/making-a-simple-neural-network-classification-2449da88c77e

http://www.mit.edu/~9.54/fall14/slides/Class13.pdf

https://ujjwalkarn.me/2016/08/09/quick-intro-neural-networks/