Prediction with a Single Neural Node (perceptron-like) – A Summary

Artificial Neural networks are a subfield of machine learning and deep learning and work similarly to the human brain. Artificial neural networks consist of an input layer, a hidden layer and an output layer where each neuron (also called node) is connected to one another. To understand how an artificial structure, similarly built to a brain, is able to solve complex problems, we will look at the oldest yet simplest concept which was developed in the early 1950s and 1960s; the perceptron – the smallest unit of a neural network. This is necessary because multiple perceptrons combined make up a neural network.

A perceptron (also called a single-layer neural network) is an algorithm that mathematically models a biological neuron in the human brain. It takes multiple inputs and produces one output as shown in the figure below.

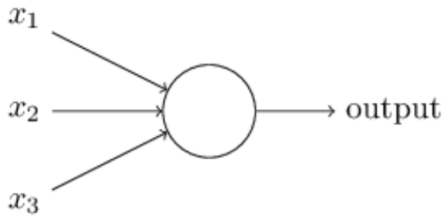

Figure 1: http://neuralnetworksanddeeplearning.com/chap1.html#perceptrons

The input instance space is the set of all possible inputs that could be given to the perceptron. Each input is a vector and each element of the vector describes one feature of the input.
A perceptron performs classification tasks by creating a decision boundary in the space with the help of weights and biases. The separation line geometrically represents this decision boundary and separates the input space into two regions (e.g. positive and negative regions) based on the perceptron's prediction. To create the separation line, weight vectors are first randomly initialized in the beginning and are assigned an initial value. The weights need to be changed to rotate the separation line. A bias is an additional input that is added to the dot product of the inputs and their weights to shift the output to the negative or positive region. It is important to note that the separation line is by definition perpendicular to the weight vector and has a dot product of zero. In the next step, the dot product, along with the bias, is given to the activation function that determines the output of the perceptron. The activation function calculates the weighted sum and adds the bias and depending on the results a perceptron is either activated or not.
When activated, the preceptron's output is a single number representing the prediction for the input. When it comes to binary classification, the output can either be e.g. 0 or 1. Another option could also be a continuous prediction instead an of a binary. Both can be distinguished by their output values as well as their output layers. Binary predictions only have outputs of zeros and ones, that means results like 0.5 are rounded up to a 1. Continuous predictions have a different activation function which all inputs a value somewhere between zero and one. The output layer of binary predictions only have a single neuron that either produces one or zero. The continuous prediction on the other hand of one or more neurons that put out numerical values (so not only 0s and 1s). Finally, labels need to be set to the output and they determine how the output needs to be interpreted. For example, the output 1 get labeled as positive.

Clustering and classification are different techniques that try to make sense of data: Clustering involves the grouping of inputs based on their features/ similarities whereas classification assigns inputs to predefined labels. Clustering doesn't need training and testing and is less complex than classification. Classification on the other hand needs training and testing is more complex than clustering. Perceptrons are usually used for classification of data.

Taking a look at the bigger picture, each perceptron in a multi-layers neural network is connected to other perceptrons which forms a network of interconnected nodes. The output of each perceptron is fed into the next layer of perceptrons until a final output is calculated. The neural network can learn to perform the task it was designed for by adjusting both the weights and the biases of the connections between perceptrons during training.