A Plane Deep Network – A Summary

A plane deep neural network is an army of nodes arranged in a straight, plain-like structure. This type of neural network is able to solve complex tasks because they process data with the help of multiple network layers of nodes which are interconnected to each other. To understand how plane deep networks work, some key concepts first need to be explained:

Typically, every node of a deep network consists of two key elements which are an activation function and a linear transformation. The linear transformation is a mathematical operation which multiplies the input with weights and adding a bias. Next, its output is passed through the activation function which introduced non-linearity to the network. Non-linearity describes a statistical term that describes the relationship between dependent and independent variables, a link that can't be projected with a straight line. In our context non-linearity is essential for the network to learn complex relationships between the input data and their predictions. Otherwise, the networks learning ability and complex tasks would be severely limited.
A network layer is a structure consisting of nodes connected to the nodes of the previous layer. The network layer processes the information of the previous layer (weighted input), transforms it and then passes it as output to the next layer. At the least, neural networks are made up of the input layer, the output layer and one hidden layer.
Variables whose values are learned from the data and updated during the training are called parameters. The parameters of a deep network are the weights and biases used in every layer for the input data transformation. These parameters are learnt in the training process where the weights and biases are adjusted to minimize error function. The error function is a mathematical function that measures the difference between the network's predictions and the true label of the data. During the training of the model, this error function is minimized. Network output is the last layer in the neural network and is a representation of the data point through a vector with numerical values whereas a label is the true expected label that the input belongs to and is a single numerical value or categorical label like *positive* or *negative*. So, a network output represents the network's prediction or estimate of the target variable for the input and a label represents the actual value or label associated with the input in the training set.
Having explained the main concepts of a plane deep network, the focus can now be shifted at the mathematical notation for neural networks. In a neural network, each layer performs a vector-matrix multiplication:

$$\boldsymbol{h} = \boldsymbol{x}\boldsymbol{W}$$

x = the input vector
W = a matrix where W_{ij} is the weight of the i-th neuron in the input row j

The mathematical notation for a perceptron with a single neuron is the following:

$$\mathrm{NN}_{\mathrm{Perceptron}}(\boldsymbol{x}) = \boldsymbol{x}\boldsymbol{W} + \boldsymbol{b}$$

$$\boldsymbol{x} \in \mathbb{R}^{d_{in}}, \quad \boldsymbol{W} \in \mathbb{R}^{d_{in} \times d_{out}}, \quad \boldsymbol{b} \in \mathbb{R}^{d_{out}},$$