Day 1 - Introduction to Artificial Neural Network

Tags	Artificial Neuron	Dense Layer	Fully Connected Layer	Perceptron	Step function	TLU

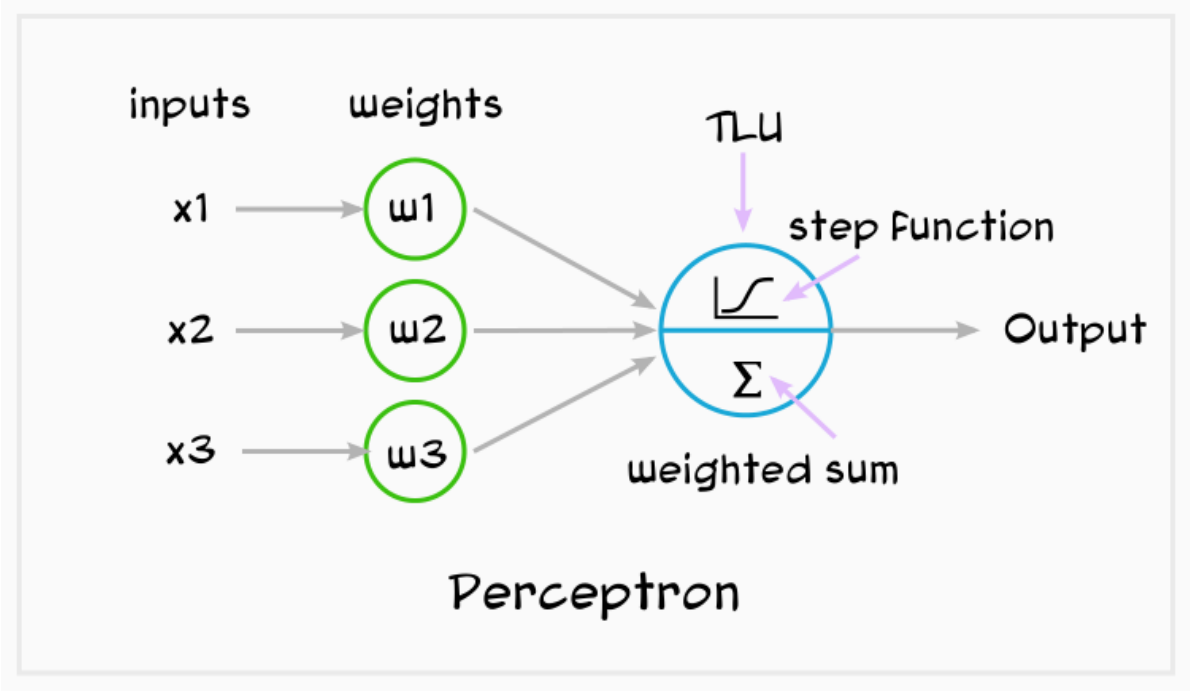
Introduction to Artificial Neural Network

Artificial Neurons

- Introduced in 1943 by the neurophysiologist Warren McCulloch and the mathematician Walter Pitts.
- ANNs looked promising but couldn't perform as expected, so funding went somewhere else.
- It faded during 1980s. Other powerful ML algorithms like Support Vector Machine were invented.
- ANN is back; It is here to stay because of:
    - Huge quantity of data available to train neural networks
    - Increase in computing power
    - Accessible to everyone with cloud platforms

Perceptron

- One of the simplest ANN architecture, invented in 1957 by Frank Rosenblatt.
- It is based on Threshold Logic Unit (TLU) (also called Linear Threshold Unit - LTU)
    - TLU is an artificial neuron.
    - There are other artificial neuron units like TLU such as ReLU (Rectified Linear Unit)
- A Perceptron is composed of a single layer of TLUs.
- **A Simple Perceptron Architecture**

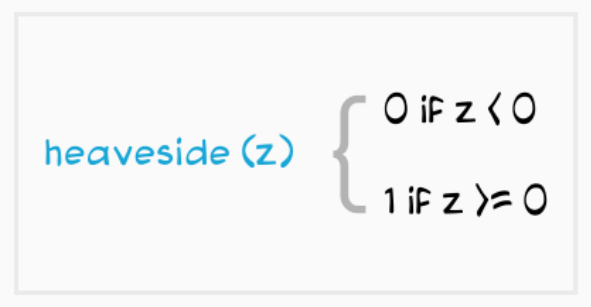


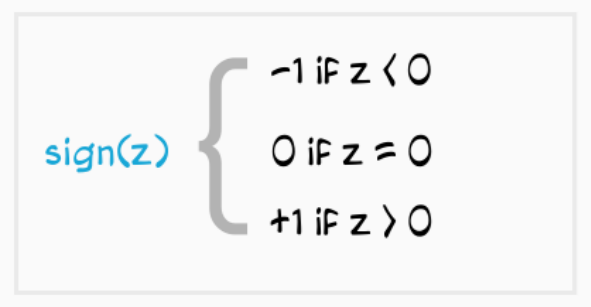
- Perceptron have one or more input and output connections. These connections have weights.
- TLU computes a weighted sum of it's inputs ($z = w_1 x_1 + w_2 x_2 + ... + w_n x_n = x^T w$), it's a matrix multiplication (really quick, thanks to GPUs ⚡). Then applies a step function to that sum and outputs the result

$$h_w(x) = step(X^T W)$$

Step function

- Step functions works as a Activation function in a neural network.
- Activation function are decision making units of neural network.
- Some common step functions used in perceptrons:
  - **heaveside step function**:
    - Most common activation function in neural network
    - Produces binary output, so also called binary step function
  - **sign step function**



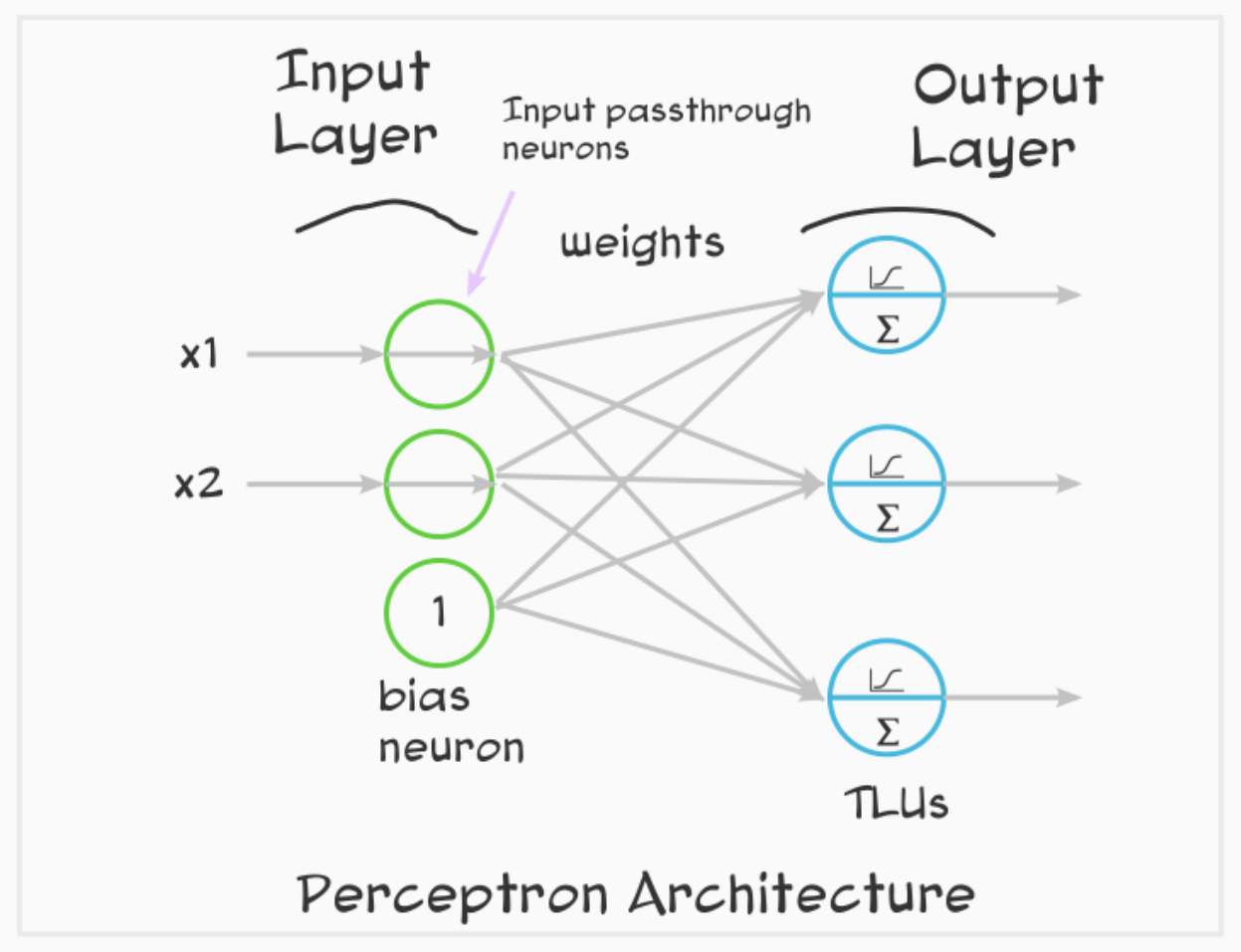


Training Perceptrons

- Training a TLU means finding the right values for x1, x2, x3...
- Perceptrons are trained using a rule which considers error made by the network while prediction.
  Reinforces connection weights which contributed to the correct prediction.

- When all the neurons in a layer is connected to all the neurons in the previous layer, it's called Fully connected layer (or Dense layer).

Another Perceptron Architecture



A perceptron architecture with 2 input neurons, 1 bias neuron and 3 output neurons

Input layer

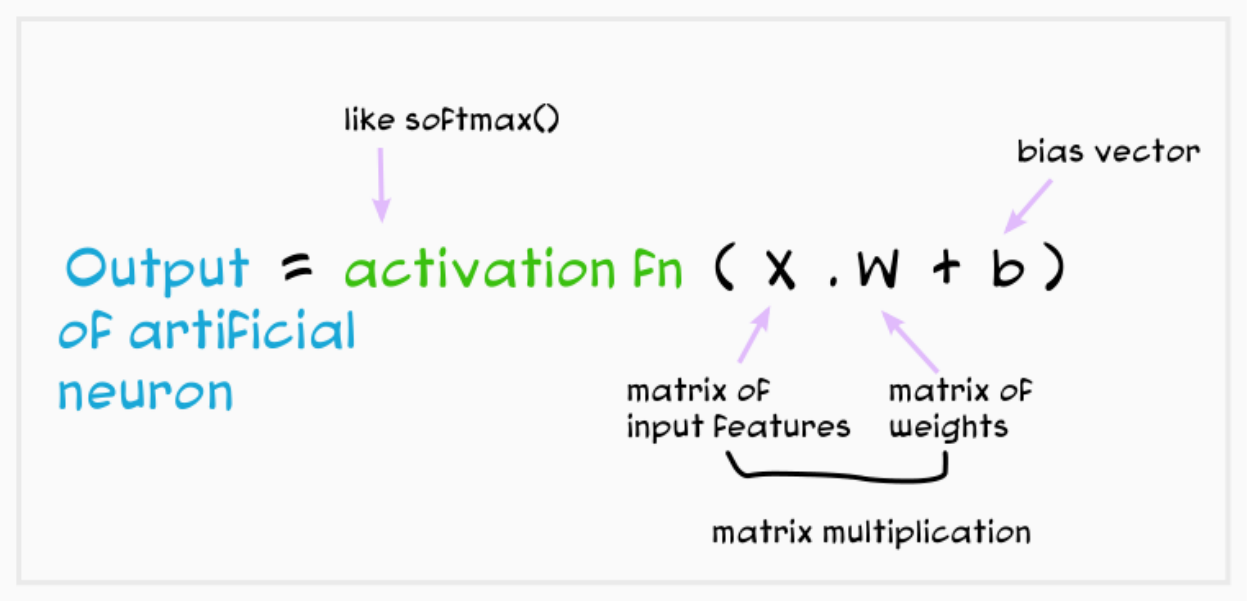
- Input of a perceptron go through a special pass-through neuron called Input neurons.
- They output whatever values they are fed.
- All input neurons form input layer.

Bias neuron

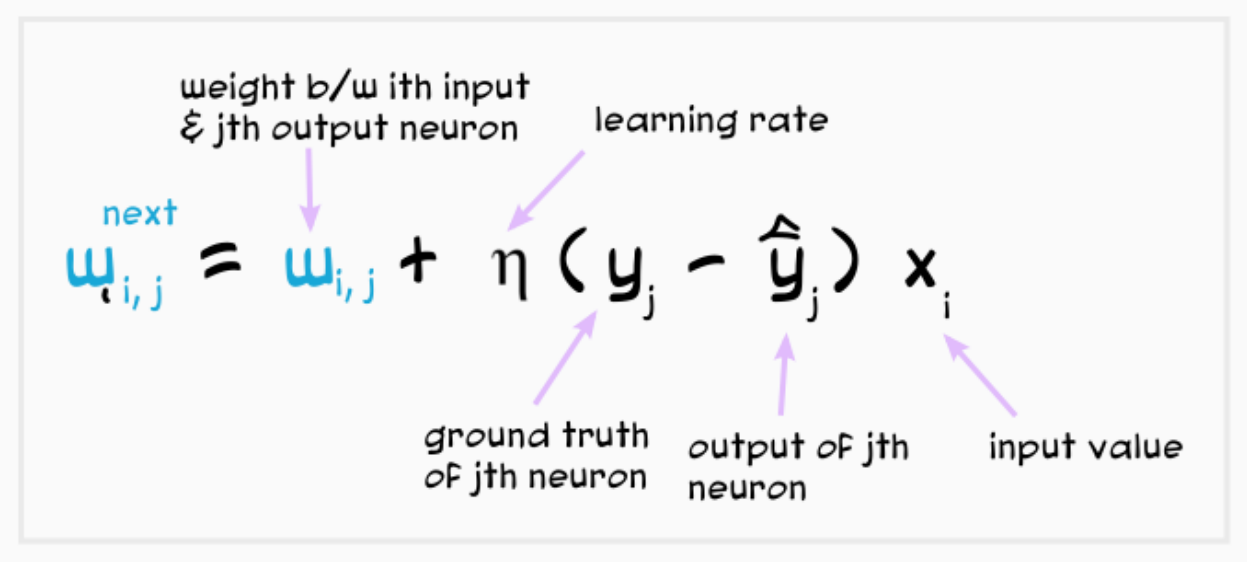
- It is a special neuron added to each layer of the neural network and it always outputs 1.

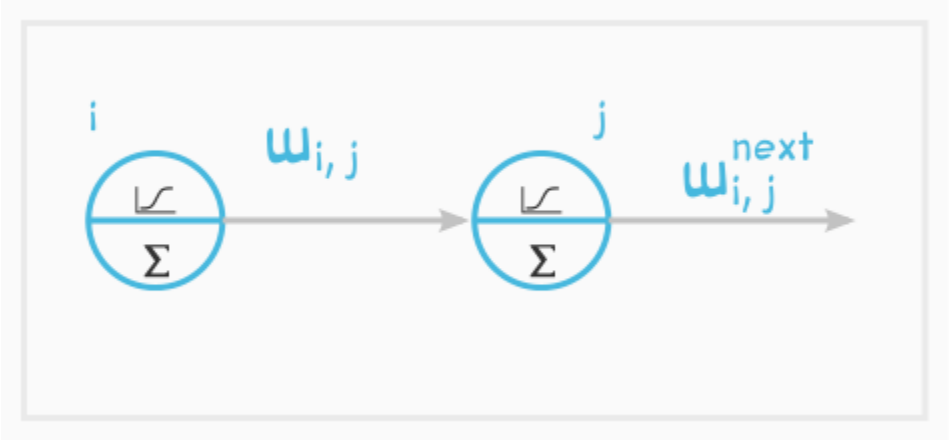
- Incoming weights increases the steepness of the activation function. This means weight decide how fast the activation function will trigger whereas bias is used to delay the triggering of the activation function.
- It can be thought as similar to the constant **c** available in linear function $y = mx + c$.

Output of an Artificial neuron



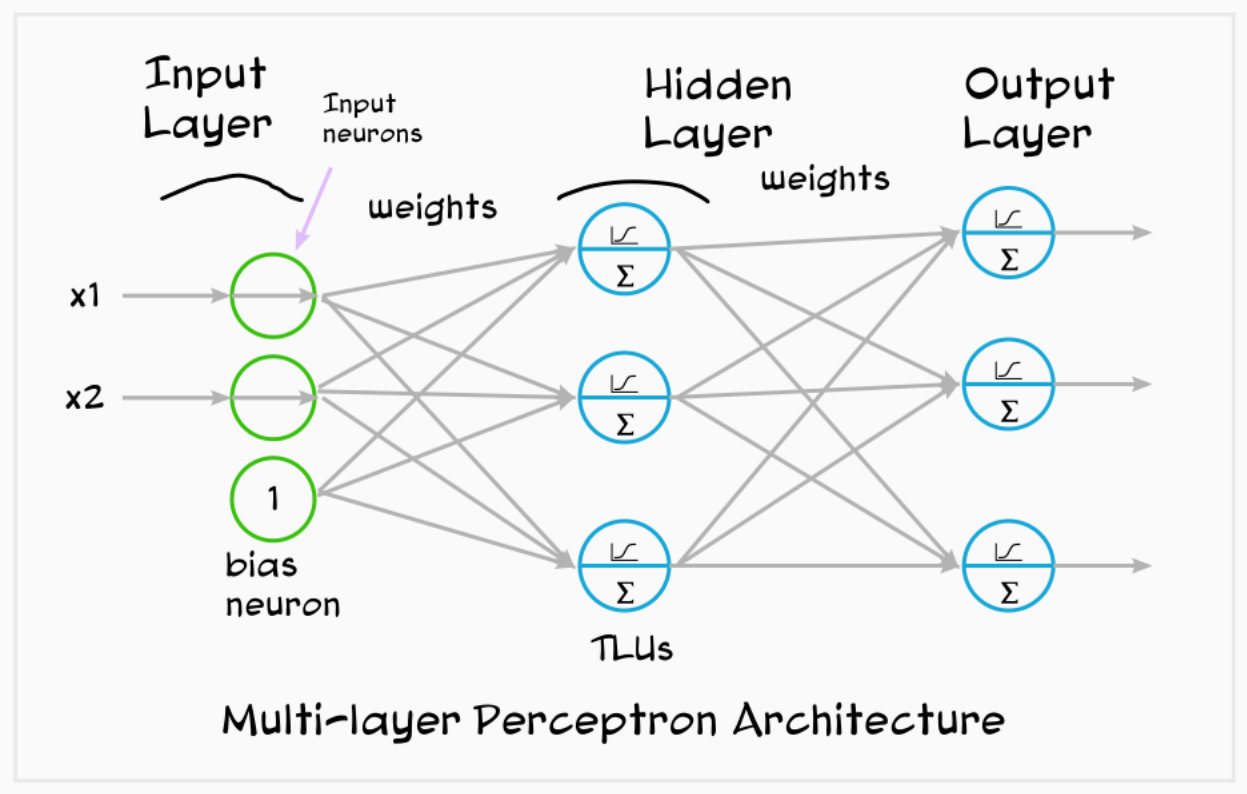
Weight update





Multi-layer Perceptron

- Addition of Hidden layer between Input and Output layer



- An MLP is composed of:
  - one input layer (passthrough)
  - one or more TLUs, hidden layers
  - one final layer of TLUs, output layer
  - Each layer except output layer has bias neuron and fully connected to next layer
- Signal flows in one direction - feed forward neural network
- When Artificial neural networks (ANNs) keeep a deep stack of hidden layers - it's called Deep Neural Network (DNN).
- For many years, researchers struggled to train MLPs.
  In 1986, Geoffry Hinton & team introduced ground-breaking Backpropagation algorithm which made training MLPs easier.