19CST302 - Neural Networks & Deep Learning

Single - layer Neural Network

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Definition

A single-layer neural network represents the most simple form of neural network, in which there is only one layer of input nodes that send weighted inputs to a subsequent layer of receiving nodes, or in some cases, one receiving node. This single-layer design was part of the foundation for systems which have now become much more complex.

Overview

Single layer neural networks, also known as single-layer perceptrons, are one of the simplest forms of artificial neural networks. They consist of a single layer of neurons, each connected to the input nodes with associated weights. These networks are characterized by their linear decision boundaries and are primarily used for binary classification tasks. Despite their simplicity, single layer neural networks hold significant significance in the field of machine learning for several reasons.

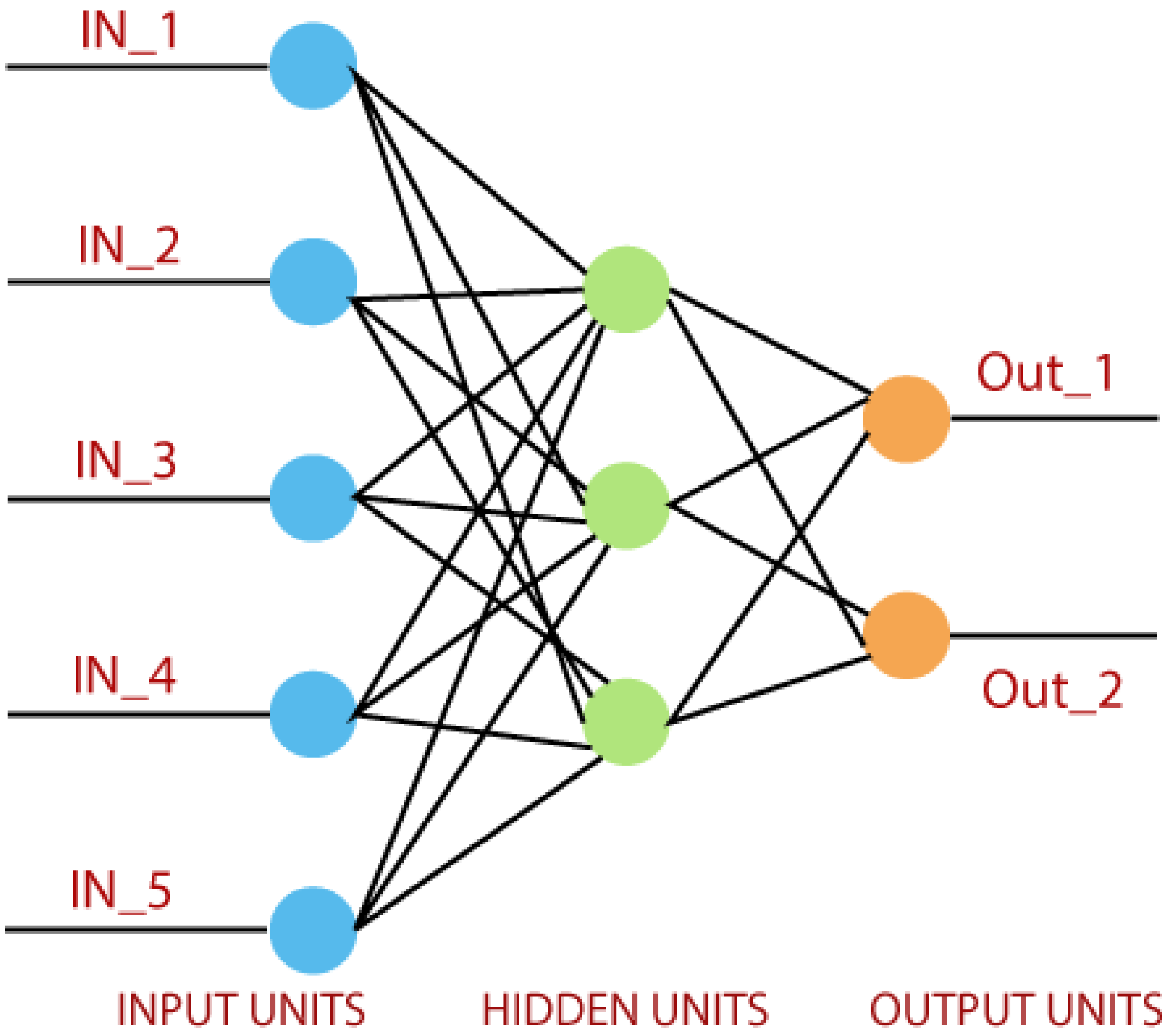
Activation Function

The activation function decides whether a neuron should be activated or not by calculating the weighted sum and further adding bias to it. The purpose of the activation function is to introduce non-linearity into the output of a neuron. We know, the neural network has neurons that work in correspondence with weight, bias, and their respective activation function. In a neural network, we would update the weights and biases of the neurons on the basis of the error at the output.

Importance Of Activation Functions

One key significance of activation functions is their ability to introduce non-linearities, allowing neural networks to approximate non-linear functions. This is crucial for solving real-world problems, as many natural phenomena and data distributions exhibit non-linear behavior. By introducing non-linear transformations, activation functions enable neural networks to model and learn these non-linear relationships, thus enhancing their capability to represent complex data.

Diagram


IN_1
IN_2
IN_3
IN_4
IN_5
Out_1
Out_2
INPUT UNITS
HIDDEN UNITS
OUTPUT UNITS

Types of Activation Functions

Sigmoid Function: The sigmoid activation function, also known as the logistic function, squashes the input values into the range of [0, 1]. It is defined as $\sigma(x)=\frac{1}{1+e^{-x}}$.

Rectified Linear Unit (ReLU): The ReLU activation function, $f(x)=\max(0,x)$, outputs the input as-is if it's positive, otherwise, it outputs zero.

Hyperbolic Tangent (Tanh): Tanh activation function, $\tanh(x) = \frac{e^{x}-e^{-x}}{e^{x}+e^{-x}}$, squashes the input values into the range of [-1, 1]. Similar to sigmoid, tanh is useful for mapping inputs to a bounded output range and is often used in hidden layers.

Working Principle

Single layer neural networks process information through a series of steps that involve receiving inputs, applying weights and biases, summing up these weighted inputs, and finally applying an activation function to produce an output. Initially, the network receives input data, which could represent features of a dataset. Each input is associated with a weight, which determines its relative importance in influencing the network's decision. Additionally, a bias term may be added to each neuron, representing its threshold for activation. The weighted inputs are then summed up, along with the bias term, to calculate the activation level of the neuron.

Activation function application for output calculation

The application of activation functions in single layer neural networks for output calculation is a crucial step in the information processing pipeline. After aggregating the weighted inputs and applying the bias term, the resulting value is passed through the activation function to introduce non-linearity and produce the output of the neuron. This process can be summarized as follows:

1. Aggregation of Weighted Inputs
2. Application of Activation Function
3. Output Calculation