Connection between the Neural Networks and the concepts of Quantum Mechanics: Studying Neural Networks along with Quantum Mechanics

Subhodeep Moitra
Department of Computer Application
Techno College Hooghly
subhodeep2000@gmail.com

Deblina Banerjee
Department of Computer Application
Techno College Hooghly
banerjeedeblina0@gmail.com

Abstract

The main objective of this liturature is to study the inner working of Neural Networks(NN) or a Deep Learning NN (DLNN) with respect to the concepts of Quantum Mechanics. The main objective of this study is to establish a working link between the NN and the Quantum Mechanics.

Keywords: Neural Network, Deep learning, Quantum Mechanics, Physics

Quantum State <——-> Neuron Activation

A quantum state denoted by $|\Psi\rangle$, represents the system's state in a superposition of possible outcomes. Mathematically it can be expressed as:

$$|\Psi\rangle = \sum_i c_i |i\rangle$$

$|i\rangle$ re basis states and c_i are the complex coefficients representing the probability amplitudes. On the other hand a neuron's activation a_j, is the result of a weighted sum followed by a non-linear activation function:

$$a_j = \sigma\left(\sum_i w_{ij} x_i + b_j\right)$$

Where, w_{ij} is the weight connecting input i to neuron j,

w_i is the input value,

b_j is the bias term and

σ is the activation function.

In both the systems the state (quantum or neuron activation) is unobservable directly in its raw form but influences the system's evolution.

Super position <——-> Layer output

In super position a quantum particle exists in all possible states until measured. For example, in two states system (qubit):

$$|\Psi\rangle = \alpha|0\rangle + \beta|1\rangle$$

Where, α and β are complex amplitudes satisfying the condition,

$$|\alpha|^2 + |\beta|^2 = 1$$

Also in a neural network, a layer processes many neurons simultanously and their outputs collectively represents a high dimensional “super position” of information. For a layer with n neurons, the output can be represented as

$$a = \sigma(W_x + b)$$

Where, a is the vector of the activation,

W is the weight matrix,

x is the input vector and,

b is the bias vector.

The layer outputs like the quantum superposition encode multiple possibilities before collapsing into the next layer’s input or the final output.