Artificial Neural Networks
Topic-08: Hebbian Learning

What is Neural Networks Learning Process

- The significant property of neural networks is its ability to learn from its environment to improve its performance.
- The neural networks learn about its environment through an interactive process of adjustment applied to its synaptic weight and bias level.
- Therefore the neural networks store the knowledge from its environment in terms of synaptic weight and bias level and gains knowledge about its environment after each iteration of the learning process

What is Learning in the Context of Neural Networks

- Learning is a process by which free parameters of a neural networks are adapted through a process of stimulation by the environment in which the network is embedded. The type of learning is determined by the manner in which these parameter change take place.
    - The neural network is stimulated by its environment
    - The neural networks undergoes changes in free parameters as the result of this stimulation
    - The neural network responds in a new way to the environment because of the changes that have occurred in its internal structure,
- A prescribed set of well-defined rules for solution of a learning problem is called learning algorithm

Hebbian Learning

Canadian neuropsychologist Donald O Hebb presented a theory of behaviour based as much as possible on the physiology of the nervous system in his book " The organization of behviour: in 1949.

Hebb's Rule: Hebb's Postulate on Cell Assembly Theory

Hebb reduced the type of physiological evidence in to two categories

1. Existence and properties of continuous cerebral activity
2. The nature of synaptic transmission in the central nervous system.

Hebb combined these two principles to develop a theory of how learning occurs within an organism. He proposed that repeated stimulation of specific receptors leads slowly to the formation of cell assembly, which act as a closed system after stimulation has ceased.

The most important concept to emerge from Hebb's work was his formal statement of how learning could occur. Learning is based on the modification synaptic connections between neurons.

When an axon of cell A is near enough to excite a cell b and repeatedly or persistently takes part in firing it, some growth or metabolic change take place in one or both cells such that A's efficiency as one cell firing B is increased.

This theory often summarized as cells that fire together are wired together". Hebbian learning can be described as a time dependent local, highly interactive mechanism that increases synaptic efficiency as a function of pre and post synaptic activity.

The Hebbian Learning stated in neurobiological context may be expanded and rephrased as two-part rules:

I. If two neurons on either side of a synapse are activated simultaneously(that is synchronously), then the strength of that synapse is selectively increased.

II. If two neurons on either side of a synapse are activated asynchronously, then the synapse is selectively weakened or eliminated.

Such a synapse is called Hebbian synapse.

Four key Mechanisms that characterized a Hebbian Synapse

- Time dependant Mechanism: This mechanism refers to the fact that the modifications in a Hebbian synapse depends exact time occurrence of pre-synaptic and post-synaptic signals.
- Local Mechanism: By its very nature , a synapse is the transmission site where the information bearing signals are in spatiotemporal contiguity. This locally available information is used by Hebbian synapse to produce a local modification that is input specific.
- Interaction Mechanism: The occurrence of a change on both sides of the synapse. That is a Hebbian form of learning depends on a true interaction between pre-synaptic and post synaptic signals.
- Conjunctional or correlational Mechanism: One interpretation of Hebb's postulate of learning is that the condition for a change in synaptic efficiency is the conjunction of presynaptic and postsynaptic signals. Thus according to this interpretation , the co-occurrence of presynaptic and postsynaptic signals is sufficient to produce the synaptic modification