EXPERIMENT NO. 1

AIM: Study of Artificial Neural Network.

LABORATORY OUTCOMES:

- Students will gets familiar with basic components of neural network system..
- Students will be able understand difference between biological neural network and Artificial Neural Network
- Students will learn different interconnection and training methods of neural network.

THEORY:

History of Artificial Neural Network:

The history of ANN can be divided into the following three areas,

During 1940s to 1960s:

Some key developments of this era are as follows,

- **1943** − It has been assumed that the concept of neural network started with the work of physiologist, Warren McCulloch, and mathematician, Walter Pitts, when in 1943 they modeled a simple neural network using electrical circuits in order to describe how neurons in the brain might work.
- **1949** − Donald Hebb's book, *The Organization of Behavior*, put forth the fact that repeated activation of one neuron by another increases its strength each time they are used.
- **1956** − An associative memory network was introduced by Taylor.
- **1958** − A learning method for McCulloch and Pitts neuron model named Perceptron was invented by Rosenblatt.
- **1960** − Bernard Widrow and Marcian Hoff developed models called "ADALINE" and "MADALINE."

During 1960s to 1980s:

Some key developments of this era are as follows,

- **1961** − Rosenblatt made an unsuccessful attempt but proposed the "backpropagation" scheme for multilayer networks.
- **1964** − Taylor constructed a winner-take-all circuit with inhibitions among output units.
- **1969** − Multilayer perceptron (MLP) was invented by Minsky and Papert.
- **1971** − Kohonen developed Associative memories.
- **1976** − Stephen Grossberg and Gail Carpenter developed Adaptive resonance theory.

ANN from 1980s till Present

Some key developments of this era are as follows −

- **1982** − The major development was Hopfield's Energy approach.
- **1985** − Boltzmann machine was developed by Ackley, Hinton, and Sejnowski.
- **1986** − Rumelhart, Hinton, and Williams introduced Generalised Delta Rule.

- **1988** − Kosko developed Binary Associative Memory (BAM) and also gave the concept of Fuzzy Logic in ANN.

Biological Neuron:

Neural networks are inspired by our brains. A biological neural network describes a population of physically interconnected neurons or a group of disparate neurons whose inputs or signaling targets define a recognizable circuit. Communication between neurons often involves an electrochemical process. The interface through which they interact with surrounding neurons usually consists of several dendrites (input connections), which are connected via synapses to other neurons, and one axon (output connection). If the sum of the input signals surpasses a certain threshold, the neuron sends an action potential (AP) at the axon hillock and transmits this electrical signal along the axon. Input connections are made from the axons of other cells to the dendrites or directly to the body of the cell. Biological neuron is shown in Fig.1.

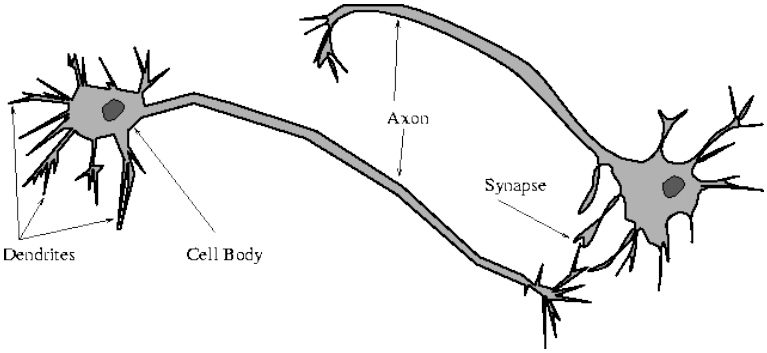

Fig. 1.1 Biological Neuron

There is only one axon per neuron. It is a single and long fiber, which transports the output signal of the cell as electrical impulses (action potential) along its length. The end of the axon may divide in many branches, which are then connected to other cells. The branches have the function to fan out the signal to many other inputs.

The brain works in both a parallel and serial way. The parallel and serial nature of the brain is readily apparent from the physical anatomy of the nervous system. That there is serial and parallel processing involved can be easily seen from the time needed to perform tasks. For example a human can recognize the picture of another person in about 100 ms. Given the processing time of 1 ms for an individual neuron this implies that a certain number of neurons, but less than 100, are involved in serial;

Artificial Neural Network (ANN):

An artificial neural network is a system based on the operation of biological neural networks, in other words, is an emulation of biological neural system. Why would be necessary the implementation of artificial neural networks? Although computing these days is truly advanced, there are certain tasks that a program made for a common microprocessor is unable to perform; even so a software implementation of a neural network can be made with their advantages and disadvantages.

Advantages of ANN:

- A neural network can perform tasks that a linear program cannot.

- When an element of the neural network fails, it can continue without any problem by their parallel nature.
- A neural network learns and does not need to be reprogrammed.
- It can be implemented in any application.
- It can be implemented without any problem.

Disadvantages of ANN:

- The neural network needs training to operate.
- The architecture of a neural network is different from the architecture of microprocessors therefore needs to be emulated.
- Requires high processing time for large neural networks.

Another aspect of the artificial neural networks is that there are different architectures, which consequently requires different types of algorithms, but despite to be an apparently complex system, a neural network is relatively simple.

Artificial neural networks (ANN) are among the newest signal-processing technologies in the engineer's toolbox. The field is highly interdisciplinary, but our approach will restrict the view to the engineering perspective. In engineering, neural networks serve two important functions: as pattern classifiers and as nonlinear adaptive filters.

An Artificial Neural Network is an adaptive, most often nonlinear system that learns to perform a function (an input/output map) from data. Adaptive means that the system parameters are changed during operation, normally called the training phase. After the training phase the Artificial Neural Network parameters are fixed and the system is deployed to solve the problem at hand (the testing phase). The Artificial Neural Network is built with a systematic step-by-step procedure to optimize a performance criterion or to follow some implicit internal constraint, which is commonly referred to as the learning rule. The input/output training data are fundamental in neural network technology, because they convey the necessary information to "discover" the optimal operating point. The nonlinear nature of the neural network processing elements (PEs) provides the system with lots of flexibility to achieve practically any desired input/output map, i.e., some Artificial Neural Networks are universal mappers. There is a style in neural computation that is worth describing.

Neural Network Topologies

In the previous section we discussed the properties of the basic processing unit in an artificial neural network. This section focuses on the pattern of connections between the units and the propagation of data. As for this pattern of connections, the main distinction we can make is between:

- Feed-forward neural networks, where the data ow from input to output units is strictly feedforward. The data processing can extend over multiple (layers of) units, but no feedback connections are present, that is, connections extending from outputs of units to inputs of units in the same layer or previous layers.
- Recurrent neural networks that do contain feedback connections. Contrary to feed-forward networks, the dynamical properties of the network are important. In some cases, the activation values of the units undergo a relaxation process such that the neural network will evolve to a stable state in which these activations do not change anymore. In other applications, the changes of the activation values of the output neurons are significant, such that the dynamical behavior constitutes the output of the neural network (Pearlmutter, 1990).

Training of Artificial neural networks:

A neural network has to be configured such that the application of a set of inputs produces (either 'direct' or via a relaxation process) the desired set of outputs. Various methods to set the strengths of the connections exist. One way is to set the weights explicitly, using a priori knowledge. Another way is to 'train' the neural network by feeding it teaching patterns and letting it change its weights according to some learning rule.

We can categories the learning situations in two distinct sorts. These are: ***Supervised learning*** or Associative learning in which the network is trained by providing it with input and matching output patterns. These input-output pairs can be provided by an external teacher, or by the system which contains the neural network (self-supervised).

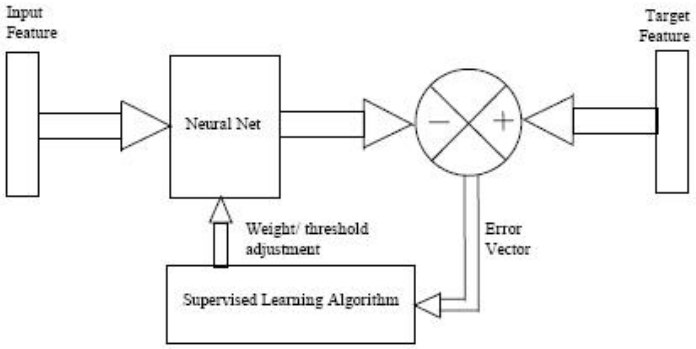

Fig. 1.2 Training of ANN

Unsupervised learning or Self-organization in which an (output) unit is trained to respond to clusters of pattern within the input. In this paradigm the system is supposed to discover statistically salient features of the input population. Unlike the supervised learning paradigm, there is no a priori set of categories into which the patterns are to be classified; rather the system must develop its own representation of the input stimuli.

Reinforcement Learning: This type of learning may be considered as an intermediate form of the above two types of learning. Here the learning machine does some action on the environment and gets a feedback response from the environment. The learning system grades its action good (rewarding) or bad (punishable) based on the environmental response and accordingly adjusts its parameters. Generally, parameter adjustment is continued until an equilibrium state occurs, following which there will be no more changes in its parameters. The self-organizing neural learning may be categorized under this type of learning.

Conclusion:

We have studied components of artificial neural network, comparison of biological neural network and artificial neural network, different neural network topologies and learning methods of neural network. ANN systems are used to design complex systems. ANN is used for implementation of real time systems due to its faster response and taking less computation time. Neural Network required training to operate the designed system.

TEXT/REFERENCE BOOKS:

- "Neural Network a Comprehensive Foundation" by Simon Haykin
- "Introduction to Soft Computing" By Dr. S. N. Shivnandam, Mrs. S. N. Deepa
- "Neural Network: A classroom Approach" by Satish Kumar

WEB ADDRESS (URLS):

- https://becominghuman.ai/artificial-neuron-networks-basics-introduction-to-neural-net.
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