Chapter 4
Artificial Neural Networks and Learning Techniques

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ABSTRACT

The recent craze for artificial neural networks has spread its roots towards the development of neuroscience, pattern recognition, machine learning and artificial intelligence. The theoretical neuroscience is basically converging towards the basic concept that the brain acts as a complex and decentralized computer which can perform rigorous calculations in a different approach compared to the conventional digital computers. The motivation behind the study of neural networks is due to their similarity in the structure of the human central nervous system. The elementary processing component of an Artificial Neural Network (ANN) is called as 'Neuron'. A large number of neurons interconnected with each other mimic the biological neural network and form an ANN. Learning is an inevitable process that can be used to train an ANN. We can only transfer knowledge to the neural network by the learning procedure. This chapter presents the detailed concepts of artificial neural networks in addition to some significant aspects on the present research work.

1. INTRODUCTION

The primary research objective of Artificial Neural Networks is the implementation of massively parallel networks through modeling and simulation which could able to perform complex computations with a high efficiency equivalent to that of a human brain. The resurgence of interest in the study of neural networks is partially due to the failure of computing mathematically 'hard problems' like machine learning, robotics and speech recognition.

These are basically parallel networks and solving them would require large amount of computational power. In recent years, with the help of neural networks involving suitable hardware, we will be able to resolve these problems in real-time scenario. However, significant study of research works in the corresponding field proves that neural networks are able to address the problems quite efficiently.

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Artificial Neural Networks (abbreviated as ANN), are the computation tools established on the basis of biological neuron systems. They are generally modeled on the interconnection of the neurons which are present in the nervous system of the human brain as well as other organisms like mammals. They act as information processing paradigms, inspired by biological nervous systems.

A human brain can be visualized as the biological neural network, a network of neurons which are responsible for transmission of different patterns of electrical signals within the brain. An ANN may consist of hundreds or thousands of processor units, whereas a human brain may contain billions of neurons which are used for different information processing within the human body, for example, reaction to heat, light, etc. Biological Neural Networks (BNN) is basically natural occurrence equivalence of ANN. Both BNN and ANN contain "neuron" as their fundamental unit. However, ANN possesses many characteristics which are quite different to BNN. ANN is nonlinear processing system that is quite suitable for variety range of tasks like pattern recognition, clustering, data compression and data mining. The most important characteristic of ANN is its "learning" capability. In biological systems, learning is adopted by adjusting the synaptic connections that exist between the neurons in the human brain. The same is true for ANN as well.

In this chapter, we will start with the conceptual overview of the properties and different characteristics of ANN with certain examples. Finally, we will deal with the techniques for visualizing a network of neurons with recent areas of ongoing research.

1.1 Background

The main inspiration of ANN came from the human nervous system where the "neurons" are considered as the fundamental unit. Likewise, in simple ANN, the artificial nodes are referred to as "neurons" or "processing elements" which resembles the typical biological nervous system. The background concept of "neural network" belongs to those systems which possess the capability of "learning" and involve sets of adaptive weights. These adaptive weights are physically connections which are used during training and adaptation of the ANN. Neural network models mainly evolve from cognitive science and theoretical neuroscience. The models of artificial intelligence and pattern recognition mainly evolve from "neural network".

However, in the era of modern technology, the ANNs are more likely to possess a practical approach based on signal processing and statistical analysis instead of an earlier perspective of biology. A more universal approach of such systems will lead to real life problem solving and in more general, will result in machine learning and artificial intelligence.

1.2 History

McCulloch and Pitts (1943) are considered as the inventors of model of "neural network" based on mathematics and algorithms. The model, popularly known as threshold logic, paved the way to the application of ANN to artificial intelligence. Later studies were continued by the renowned psychologist Hebb (1948), who originated the concept of learning with the help of neural plasticity, popularly known as Hebbian Learning. Hebbian Learning is typically an unsupervised learning methodology and in due course of time, this model was applied to computation models with Turing's B-type machines. Farley and Clark (1954) were the first to simulate the Hebbian network with the help of calculators. Rochester et. al. (1956) created other computational machines of neural network. Successively, Rosenblatt (1958)