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A Comprehensive Study on Architecture of Neural Networks and Its Prospects in Cognitive Computing

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ABSTRACT

This paper proffers an overview of neural network, coupled with early neural network architecture, learning methods, and applications. Basically, neural networks are simplified models of biological nervous systems and that's why they have drawn crucial attention of research community in the domain of artificial intelligence. Basically, such networks are highly interconnected networks possessing a huge number of processing elements known as neurons. Such networks learn by examples and exhibit the mapping capabilities, generalization, fault resilience conjointly with escalated rate of information processing. In the current paper, various types of learning methods employed in case of neural networks are discussed. Subsequently, the paper details the deep neural network (DNN), its key concepts, optimization strategies, activation functions used. Afterwards, logistic regression and conventional optimization approaches are described in the paper. Finally, various applications of neural networks in various domains are included in the paper before concluding it.

KEYWORDS

ADALINE Network, Artificial Intelligence, MADALINE Network, Neural Networks, Perceptron, Reinforcement Learning, Supervised Learning

1. AN INTRODUCTION TO NEURAL NETWORK (NN) AND HUMAN BRAIN

In this modern era of technology, Artificial Intelligence (AI) has gained significant attention of the research community due to its wide spread popularity and rampaging prospects of applications in various domains (Neural Network, n.d.; Website, n.d.). Basically, AI represents an area of computer science aimed at designing intelligent computer systems which exhibit the features that we associate with the human intelligence. Basically, AI deals with the automation of intelligent behavior. The three technologies associated with AI are: neural network, fuzzy logic and genetic algorithm and their hybrid combinations. Out of which, neural network is our topic of interest (Website, n.d.). Basically, Neural Network (NN) epitomizes simple representation of biological neuro- systems and hence receives interest from the type of rating carried out through the human brain. A NN represents a highly interconnected network of huge number of processing constituents known as neurons. A NN is ponderously parallel and so also it models parallel distributed processing. In this paper, we infuse the fundamental themes of neural networks. The biological nervous system is the chief source of inspiration in this context. Various learning algorithms exist for enabling such networks to attain knowledge. Neural networks can be viewed as an imitation of central nervous systems (Analytics Vidha, 2018). In this context, the structural constituent of human brain can be regarded as the neurons that carry out knowledge discovery, logical inference as well as pattern recognition, etc. There exists a well-known issue in this context known as stability-plasticity issue that depicts that NN devoirs

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to remain plastic to necessary information, however, it hovers stable while being provided with the extraneous information.

In this context, the human brain can be considered as the most complicated thing that needs significant attention. Normally, the human brain composes (Analytics Vidha, 2018; Gurney, 1997; Neural Network, n.d.; Website, n.d.) of 10^{10} basic components called neurons. The neuron receives electrochemical signals from various sources and sends electrical impulses to the other neurons. Every neuron is composed of 10^4 other neurons. A biological neuron comprises of a nucleus – a cell body regarded as 'Soma'. There are huge irregular shaped filaments connected to the soma, known as dendrites. Such dendrites operate as the input channels i. e. all inputs from other neurons arrive through the dendrites. Another link attached to soma is the Axon; which serves as the output channel. These are the non-linear threshold devices which produce a voltage pulse known bas action potential. The neuronal activities are quite complex and can be viewed as a summation of inputs which it receives and which turns out to be a reasonable approximation later on.

2. ARTIFICIAL NEURON: AN ABSTRACT REPRESENTATION

The human brain can be considered as a highly complex structure that can be viewed as a highly connected network of neurons (Neural Network, n.d.; Sivanandam & Deepa, 2011). Accordingly, the biological neuron can be modeled into artificial neuron. Each constituent of the model bears analogy to actual components of biological neuron. Figure 1 shows a simple model of artificial neuron on the basis of which the artificial neural network is built. In the diagram, x_1, x_2,…, x_n represent the n number of inputs supplied to the artificial neurons and w_1, w_2, …, w_n represent the weights concerned with the inputs respectively. Similar to the biological neurons, the whole input received by the artificial neuron I can be denoted as shown in following equation:

$$I = w_1 x_1 + w_2 x_2 + \ldots + w_n x_n$$

Or,

$$I = \sum_{i=1}^{n} w_i x_i .$$

Now the above sum gets passed through the non-linear filter Φ known as Activation function or squash function.

$$Y = \Phi\left(I\right) .$$

In this context, an indubitable activation function is employed called as the threshold function. Here the sum gets compared with the threshold value ɵ. If the value of I is higher than ɵ, them the output becomes 1; otherwise, this becomes 0.

$$\mathrm{Y} = \left| \left(\sum_{i=1}^{n} wixi \right) - \Theta \right.$$

Where, Φ is the Heaviside Function such that: