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Fundamentals and applications of Artificial Neural Networks

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Abstract: The artificial neural networks is a mimic of the biological neurons and its aim is to build up needful computers related to a real-word problems and data evaluation techniques such as pattern recognition, forecasting, classification and generalization by using strong processing units called artificial neurons. In other words, the neural network revolves around the idea that certain properties of biological neurons and creating a simulated brain to solve a specific problems related to pattern recognition, data classification and forecasting. The intelligence of ANN and its ability to solve critical problems through a highly complex connectivity of neurons through its massive parallel-distributed structure. In present scenario, the ANN algorithms and architectures can be implemented in VLSI technology for real time applications. In the last few years, the applications of the ANN has increased drastically. This paper presents the fundamentals and applications of artificial neural networks.

Keywords: Artificial Neural Network (ANN), Neurons, Neural network models, Learning strategies.

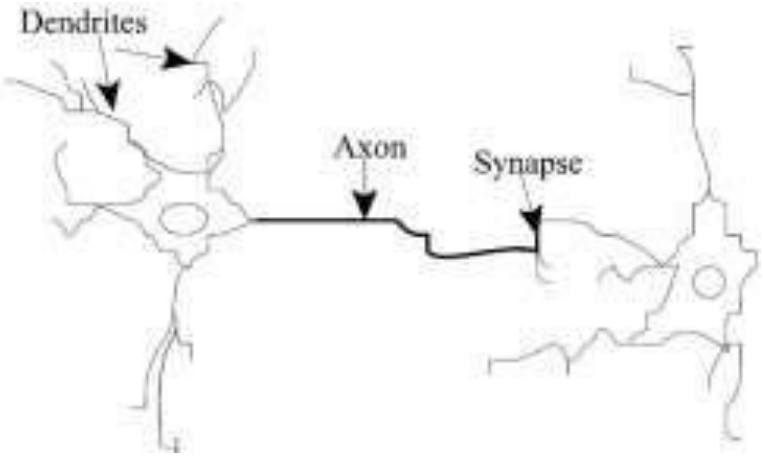
Introduction to Artificial Neural Networks

Artificial neural networks (ANN) is a simplest imitation of the human brain. The ability of a natural brain is to learn new things and adapt to environmental changes. The ability of a brain is to analyze unclear fuzzy information and make its own judgment. For example, when a snake comes on the way, immediately a signal is sent to the motor nerves of the leg to move away from the place. Also, we can read other's hand writing though their writing may be completely different from the way we write. We can also recognize a known person from a photograph.

Brain is a complex organ that control the entire body. It has some millions of functional units called neurons with trillions of connections known as synapses. It controls physical activities and also mental activities like thinking, visualizing, dreaming, learning etc.

Biological Neuron Vs Artificial Neuron

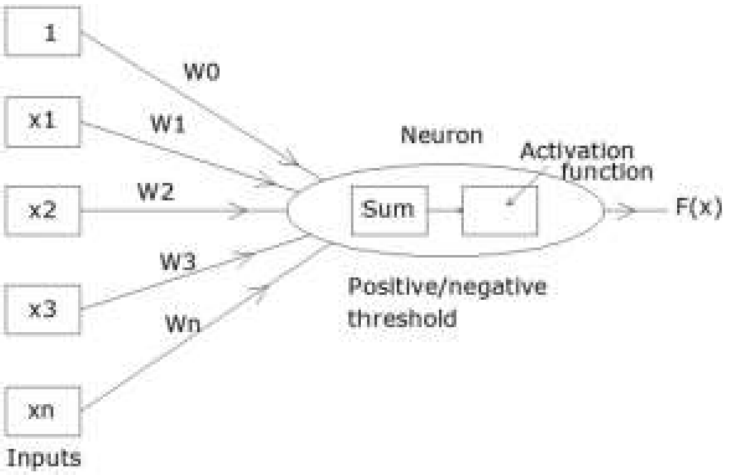
The functional units of brain are called neurons. There are about millions of neurons in the human brian. Each neuron consists of 3 parts cell body, axon and dendrites. Cell body contains nucleus and soma and other chemical structures required to support the cell. Dendrite receives electro chemical signals from other neurons in to the cell body. Axon carries the signal from one neuron to another. Connection between dendrites of two neurons or neuron to muscle cells is called synapse.



Brain Neuron

The neuron receives signals from other neurons through dendrites. The neuron sends a signal to the other neuron, when the strength of the signal exceeds a certain threshold via synapse. This process continues to the next neurons. Like this a large number of neurons work simultaneously. A large amount of the data can be stored in the brain.

The processing units of artificial neural networks are called as neurons. An artificial neuron replicate the structure and function of a natural neuron. An artificial neuron consists of inputs (dendrites) and one output (synapse via axon).



Artificial Neuron

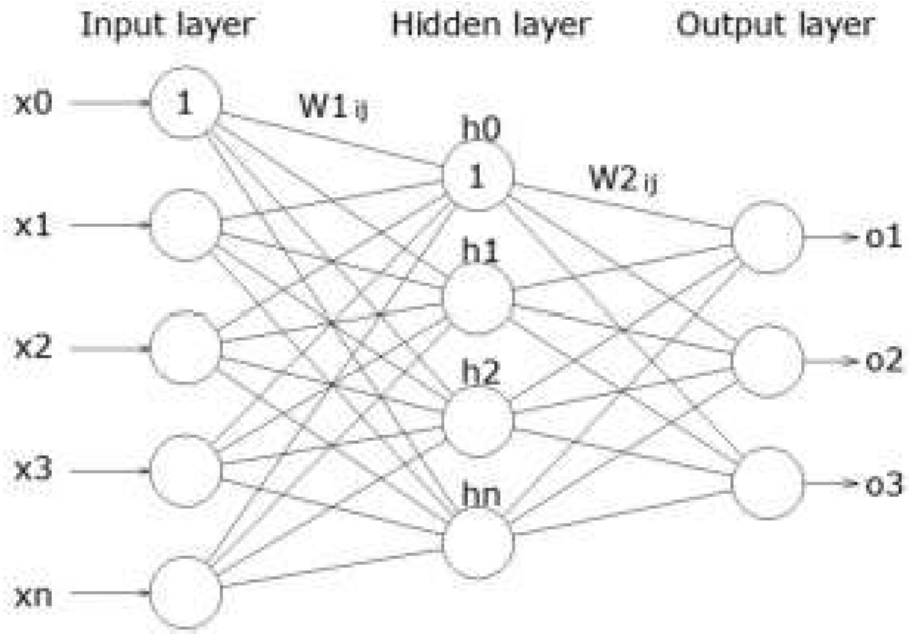
$x_1...x_n$ are the inputs to the neuron. A bias is also added to the neuron along with inputs. Usually bias value is initialised to 1. $W_0...W_n$ are the weights. A weight is the connection to the signal. Product of weight and input gives the strength of the signal. A neuron receives multiple inputs from different sources, and has a single output.

There are various functions used for activation of the neuron. The most commonly used activation function is Sigmoid activation function. The other activations functions are Step function, Linear function, Ramp function, Hyperbolic Tangent function. The sum is the weighted sum of the inputs multiplied by the weights between one layer and the next.

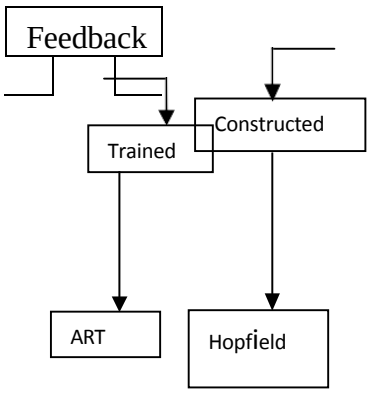
Architecture and Models of ANN

The ANN architecture consists of

a. Input layer: Receives the input values
b. Hidden layer(s): A set of neurons between input and output layers. There can be single or multiple layers
c. Output layer: Usually it has one neuron, and its output ranges between 0 and 1, that is, greater than 0 and less than 1.



Architecture of Neural Network



Classification of ANN models

A connection between a pair of neurons has an associated numerical strength called synaptic weight. If a neuron threshold and input weights are modifiable it is said to be trainable. Inputs are fed to the neurons and if the output of the neuron does not give the desired output, then it should be trained. Then training of networking consists of adjustment of weights in

such a way that the actual output is equal to the desired output. The procedure is done by using learning (or training) algorithms.
The network should be able to give desired output for any kind of input after the training. This is called testing. Every learning algorithms contains two learning rules, namely Hebbian rule (for supervised learning) and Delta rule (for un-supervised learning).
Multi-Layer Perceptron (MLP), Functional Link Network (FLN), Radial Basis Function Network (RBFN), Parallel Self-Organising Hierarchal Neural Network (PSHNN), or a feed-back network such as Hopfield network are the supervised learning in which a output target is specified.
Kohonen's SOFM and Adaptive Resonance Theory (ART) are the examples of unsupervised NN in which no output target is specified.

Applications of ANN

Some of the important applications of ANN are
Pattern Recognition / Facial Recognition / Signature Recognition: ANN's are used to recognize handwritten character, signatures and categorize them according to the person's class when developing these authentication systems. Thus, a neural network recognizes whether the signature/handwritten character is genuine or not. Convolutional Neural Networks (CNN) are used for facial recognition and image processing.
Speech Recognition: Speech recognition depends on artificial neural networks. Earlier, the statistical models like Hidden Markov Models are used for speech recognition. The deep learning and neural networks together become very important to acquire precise results.
Forecasting: The forecasting of stock market, weather, production of a commodity, crop yield etc., is known accurately by real time Multilayer Perceptron Feed forward/feed backward models. MLP consists of multiple layers of nodes, each of these are connected to the succeeding nodes.

Classification:

Medical: By using scans, neural networks are ideal in diagnosing the disease. At the moment, the researchers are being conducted on human body parts to recognize diseases from different scans, such as CAT scans, ultrasonic scans, cardiograms.

Conclusion

The computing world has a lot to gain fron neural networks. Their ability to learn by example makes them very flexible and powerful. Furthermore there is no need to devise an algorithm in order to perform a specific task; i.e. there is no need to understand the internal mechanisms of that task. They are also very well suited for real time systems because of their fast response and computational times which are due to their parallel architecture.

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