AN INTRODUCTION TO ARTIFICIAL NEURAL NETWORK

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ABSTRACT

Artificial Neural Network (ANN) is gaining prominence in various applications like pattern recognition, weather prediction, handwriting recognition, face recognition, autopilot, robotics, etc. In electrical engineering, ANN is being extensively researched in load forecasting, processing substation alarms and predicting weather for solar radiation and wind farms. With more focus on smart grids, ANN has an important role. ANN belongs to the family of Artificial Intelligence along with Fuzzy Logic, Expert Systems, Support Vector Machines. This paper gives an introduction into ANN and the way it is used.

Keywords: - *Artificial neural network, ANN, back propagation algorithm, neuron, weights*

1. INTRODUCTION

In its simplest form, an artificial neural network (ANN) is an imitation of the human brain. A natural brain has the ability to learn new things, adapt to new and changing environment. The brain has the most amazing capability to analyze incomplete and unclear, fuzzy information, and make its own judgment out of it. For example, we can read other's handwriting though the way they write may be completely different from the way we write. A child can identify that the shape of a ball and orange are both a circle. Even a few days old baby has the ability to recognize its mother from the touch, voice and smell. We can identify a known person even from a blurry photograph.

Brain is a highly complex organ that controls the entire body. The brain of even the most primitive animal has more capability than the most advanced computer. Its function is not just controlling the physical parts of the body, but also of more complex activities like thinking, visualizing, dreaming, imagining, learning etc, activities that cannot be described in physical terms. An artificial thinking machine is still beyond the capacity of the most advanced supercomputers.

2. BRAIN NEURON

Brain is made of cells called neurons. Interconnection of such cells (neurons) makes up the neural network or the brain. There are about 1011 neurons in the human brain and about 10000 connections with each other. ANN is an imitation of the natural neural network where the artificial neurons are connected in a similar fashion as the brain network.

A biological neuron is made up of cell body, axon and dendrite. Dendrite receives electro-chemical signals from other neurons into the cell body. Cell body, called Soma contains nucleus and other chemical structures required to support the cell. Axon carries the signal from the neuron to other neurons. Connection between dendrites of two neurons, or neuron to muscle cells is called synapse [1].

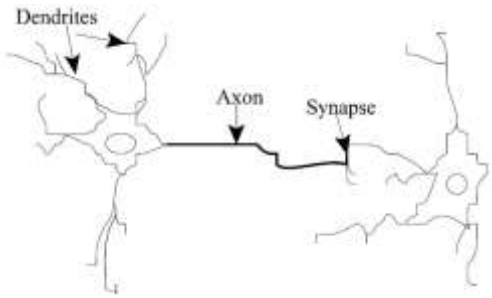

Fig 1: Brain neuron [2]

The neuron receives signals from other neurons through dendrites. When the strength of the signal exceeds a certain threshold, this neuron triggers its own signal to be passed on to the next neuron via the axon using synapses. The signal sent to other neurons through synapses trigger them, and this process continues [2]. A huge number of such neurons work simultaneously. The brain has the capacity to store large amount of data.

3. ARTIFICIAL NEURON

An artificial neural network consists of processing units called neurons. An artificial neuron tries to replicate the structure and behavior of the natural neuron. A neuron consists of inputs (dendrites), and one output (synapse via axon). The neuron has a function that determines the activation of the neuron.

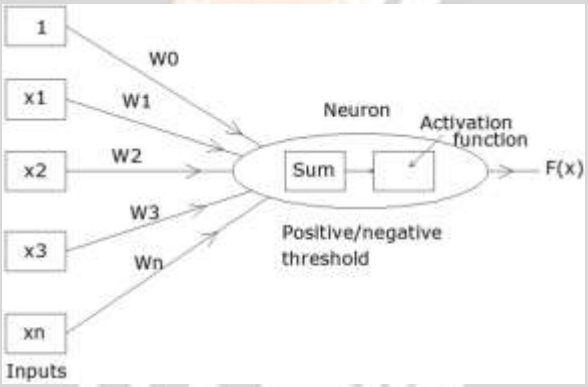

Fig 2: Model of an artificial neuron [3]

$x_1...x_n$ 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. One of the most commonly used activation function is the sigmoid function, given by

$$F(x) = \frac{1}{1+e^{-sum}}$$

where

$$sum = \sum_{i=0}^{n} x_i W_i$$

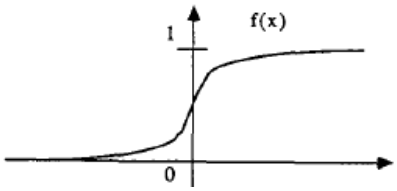

Fig 3: Sigmoid function [5]

The other functions that are used are Step function, Linear function, Ramp function, Hyperbolic tangent function. Hyperbolic tangent (tanh) function is similar in shape to sigmoid, but its limits are from -1 to +1, unlike sigmoid which is from 0 to 1.

The sum is the weighted sum of the inputs multiplied by the weights between one layer and the next. The activation function used is a sigmoid function, which is a continuous and differentiable approximation of a step function [2]. An interconnection of such individual neurons forms the neural network.

The ANN architecture comprises 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. But multiple outputs can also be present [4].

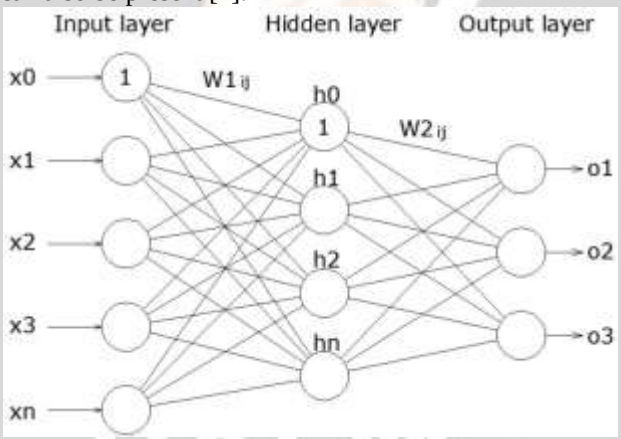

Fig 4: Neural network architecture [3]

The processing ability is stored in inter-unit connection strengths, called weights [3]. Input strength depends on the weight value. Weight value can be positive, negative or zero. Negative weight means that the signal is reduced or inhibited. Zero weight means that there is no connection between the two neurons. The weights are adjusted to obtain the required output. There are algorithms to adjust the weights of ANN to get the required output. This process of adjusting weights is called learning or training [2].

4. ANN TRAINING PROCESS

Categories of ANN are based on supervised and unsupervised learning methods. The simplest form of ANN architecture is the Perception, which consists of one neuron with two inputs and one output. The activation function used is step function or ramp function. Perceptions are used for classification of data into two separate classes. For more complex applications, multilayer perceptions (MLP) are used, which contain one input layer, one output layer, and one or more hidden layers as given in Fig 2.

Back propagation algorithm is the most commonly used method in training the neural network. Here the difference in targeted output, and the output obtained, is propagated back to the layers and the weights adjusted. A back propagation

neural network (BPNN) uses a supervised learning method and feed-forward architecture. It is one of the most frequently utilized neural network techniques for classification and prediction.

In BP algorithm, the outputs of hidden layers are propagated to the output layer where the output is calculated. This output is compared with the desired output for the given input. Based on this difference, the error is propagated back from the output layer to hidden layer, and from hidden layer to input layer. As the flow moves back, it changes the weights between the neurons. This cycle of going forward from input and output, and from output to input is called an epoch. A neural network is first given a set of known input data and asked to obtain a known output. This is called training the network. The network undergoes many such epochs till the error (difference between actual output and desired output) is within a certain tolerance). Now the network is said to be trained. This process of training sets the weights between all the neurons in all the layers. The weights so obtained from a trained network are used in calculating the response of the network to an unknown data.

5. STRENGTHS AND LIMITATIONS OF ANN

ANN is different from a normal computer program in many ways. Some of its features are: [6]
a. Adaptive learning: ANN replicates human brain in the way it learns how to do tasks while learning. A normal program cannot adapt to other types of inputs
b. Self organization: ANN can create its own organization while learning. A normal program is fixed for its task and will not do anything other than what it is intended to do
c. Parallel operation: ANN works in parallel like a human brain. This is dissimilar to a computer program which works serially.
d. Fault tolerance: One of the most interesting properties of neural networks is their ability to work even on the basis of incomplete, noisy, and fuzzy data. A normal program cannot handle incomplete, unclear data and will stop working once it encounters the smallest wrong data.
e. In comparison with human brain, ANN is quite fast, as brain processing time is slower
f. In comparison with normal program, the method in which ANN calculates output is not clear. The time taken keeps changing with different sets of inputs, though they are similar.
g. ANN can be used for data classification, pattern recognition, and in applications where data is unclear
h. ANN cannot be used when the nature of input and output is exactly known, and what needs to be done is clearly known.

6. EFERENCES

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