AN INTRODUCTION TO ARTIFICIAL NEURAL NETWORK AND THEIR APPLICATION

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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**.** ANNs are fine-grained parallel implementation of non-linear static-dynamic systems.

Keywords: - Artificial neural network, ANN, 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[1]. 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. These biologically inspired methods of computing are thought to be the next major advancement in the computing industry. Intelligence is the ability to think, to imagine, creating, memorizing, and understanding, recognizing patterns, making choices, adapting to change and learn from experience. This is the branch of computer science concerned with making computers behave like humans. Hence it is called as 'Artificial Intelligence.

2. 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.

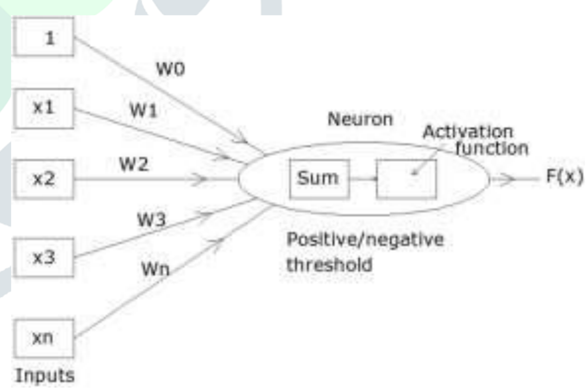

Fig 2: Model of an artificial neuron [3]

x1...xn are the inputs to the neuron. A bias is also added to the neuron along with inputs. Usually bias value is initialised to 1. W0...Wn 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 where

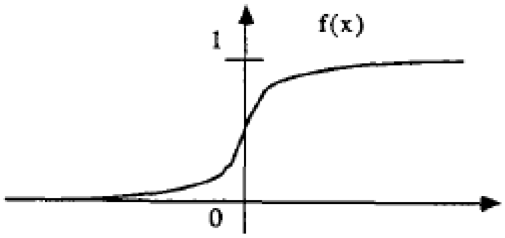

Fig 3: Sigmoid function [3]

The other functions that are used are Step function, Linear function, Ramp function, Hyperbolic tangent function. Hyperbolic tangent function is similar in shape to sigmoid, but its limits are from -1 to +1, unlike sigmoid which is from 0 to 1[6].
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 lessthan 1. But multiple outputs can also be present [4].

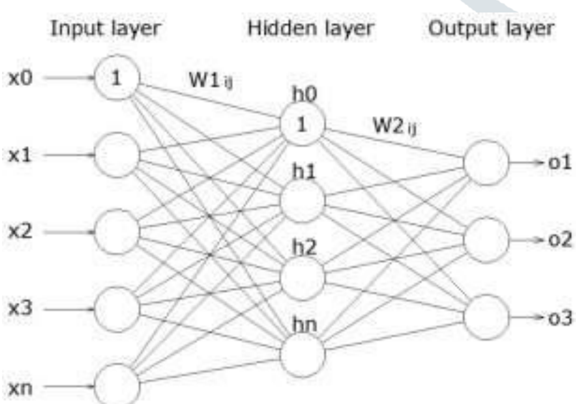

Fig 4: Neural network architecture [3]

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].

3.ANN APPLICATION

ANNs have found many applications in many of the area[5]. The generic applications of various ANN models in chronological sequence. The applications given below are few among many reported in the literature:

3.1.Alarm Processing

In emergencies, engineers are expected to
quickly evaluate various options and implement an optimal corrective action. However, the number of real-time messages (alarms) received on the VDUs is too large for the time available for their evaluation. Processing such alarms in real-time and alerting the operator to the root cause or the most important of these alarms has been identified as a valuable operational aid[7]. ANNs have been implemented for such alarm processing.three-layer Perceptron network for this purpose, with promising simulation results. The fast response of a trained ANN and its generalization abilities become very useful in this application.

3.2.Eddy current analysis

Analysis of eddy current losses requires
numerical solution of Integra-differential equations. Discretising these equations and solving them using finite-element methods is computationally very expensive[5]. Feria et al. [5] report a cellular ANN which produced a faster, computationally less
expensive and simpler method of solving these equations. They proposed a cellular NN as an alternative to finite-element methods. The cellular networks were simulated using SPICE. The cellular network calculated eddy currents and eddy current losses in a source current carrying conductor in a time-varying magnetic field. This implementation opens up a wide range of applications in structural

analysis, electromagnetic field computations, etc[6].

3.3.Harmonic source monitoring

Hartana and Richards report
identification and monitoring of harmonic sources in the systems containing non-linear loads. This approach assumes sufficient direct measurement of harmonics in the system. These authors employed multiple three-layer Perceptrons. The ANNs were trained using simulation results for varying load conditions[5]. The ANNs were used in conjunction with a state estimator to pinpoint and monitor the source of the harmonics. This approach was able to identify a harmonic source which had not been identified previously. Applications in nuclear power plants In a project initiated by US Department of Energy, researchers at the University of Tennessee have investigated the potential applications of ANNs in enhancing the safety and efficiency of nuclear power plants [1]. The areas under investigation were: diagnosis of specific abnormal conditions, detection of the change of mode of operation, signal validation, monitoring of check valves, modeling of the plant thermodynamics, monitoring of plant parameters, analysis of plant Vibrations.

4.ANN MODELS

Different type of Neural Networks (NN) has
been proposed but all of them have three things incommon: the individual neuron, the connection between them (architecture), and the learning algorithm. Each type restricts the kind of connections that are possible[3]. For example, it may specify that if one neuron is connected to another, then the second neuron cannot have another connection towards the first. The type of connection possible is generally referred to as the *architecture* or the topology of the neural network.A neural network consists of one or more layers of neurons. In large number of NN models, such as Perceptron, Linear Associator, Multi-layer feed-forward networks with Back-Propagation (BP)
learning, the Boltzmann machine and the
Grossberg model, the output from the units from one layer is only allowed to activate neurons in the next layer [5]. However in some models, such as Kohonen nets and Hopfield model the signal is allowed to activate neurons in the same layer. In models like Self- organising Feature Map (SOFM), the network connects a vector of inputs to a twodimensional grid of output neurons [7].

Figure 1. shows a general classification of ANN models.

A connection between a pair of neurons
has an associated numerical strength called
synaptic weight or adaptive coefficient [3]. The strength of interconnectivity can be represented as a weight matrix with positive (excitory), negative (inhibitory), or zero (no connection) values [2]. The weight determines the structure of the signal which
is transmitted from one neuron to another thus coding the knowledge of the network. When the cumulative excitation exceeds the cumulative inhibition by an amount called threshold (T), typically a value of 40 mV, the neuron fires sending the signals down to other neurons. [3] Only some of the networks provide instantaneous response. Other networks need time to respond and are characterized by their time-domain behaviour, which we referred to as *neural dynamics*. The time interval between inputs are applied and neurons give output is called *period of latent summation*.

Fig. 1. General classification of ANN models

A neuron is said to be ‘trainable’ if its
threshold and input weights are modifiable. Inputs are presented to the neurons. If the neurons does not give the desired output (determined by us), then it had made a mistake. Then some weights and
thresholds have to be changed to compensate for the error[2]. The rules which govern how exactly these changes are to take place is called *learning (or training) algorithm*. Learning algorithms differ from each other in a way in which the adjustment to synaptic weights of a neuron is formulated[5].The weights of the network are incrementally adjusted so as to improve a predefined *performance measure* over time. The learning process is best viewed as “search” in amulti-dimensional weight space for a solution, which gradually optimizes a pre-specified objective function. The NN becomes more knowledgeable about its environment after each iteration of the learning process. In order for the

net to learn one need to present a number of examples to the net whose attributes are known or are representatives for the unknown model [1]. The set of given examples is called the training set or training patterns.

CONCLUSION

The ANN has an ability to develop a generalized solution to the problem other than that used for training and to produce valid solutions, even when there are errors in the training data. These factors combine to make NN a power tool for modeling the problems in which functional relationships are subject to uncertainty or likely to vary with the passage of time. Another area that can be benefited from NN approach is where the time required to generate solution is critical such as real-time applications that require many solutions in quick succession. The ability of a NN to produce quick solutions irrespective of the complexity of the problem makes them valuable even when alternative techniques are available that can produce more accurate solutions.

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