Artificial Neural Network

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ABSTRACT—*This document about Artificial Neural Network.An artificial neural network is an interconnected group of nodes, akin to the vast network of neurons in a brain. each node represents an artificial neuron and an each node has a connection from the output of one neuron to the input of another. In computer science and related fields, artificial neural networks are models inspired by animal central nervous systems (in particular the brain) that are capable of machine learning and pattern recognition. They are usually presented as systems of interconnected "neurons" that can compute values from inputs by feeding information through the network.For example, in a neural network for handwriting recognition, a set of input neurons may be activated by the pixels of an input image representing a letter or digit. The activations of these neurons are then passed on, weighted and transformed by some function determined by the network's designer, to other neurons, etc., until finally an output neuron is activated that determines which character was read. Artificial Neural network contains terms of Mechanism. It Contains terms of methods. Those are back propagation, Activation function. Using this network we can perform more and more application.*

Key Points:

- **What is an ANN?**
- **Characteristics of ANN.**
- **Architecture of ANN.**
- **Training or Learning of ANN.**
- **Back propagation.**
- **How do neural network differ from Conventional computing.**
- **Application of ANN.**

1, INTRODUCTION

Artificial neural networks (ANN) are non-linear mapping structures based on the function of the human brain. They are powerful tools for modeling, especially when the underlying data relationship is unknown. ANNs can identify and learn correlated patterns between input data set and corresponding target values. After training, ANNs can be used to predict the outcome of new process problems involving non-linear and complex data even if the data are imprecise and noisy. ANNs has great capacity in predictive modeling. An ANN is a computational structure that is inspired by observed process in natural networks of biological neurons in the brain. It consists of simple computational units called neurons, which are highly interconnected. Neural networks are typically organized in layers. Layers are made up of number of interconnected ‘nodes’ which contain an activation function.

2, BASICS OF ANNs.

Neural networks are typically organized in layers. Layers are made up of number of interconnected ‘nodes’ which contain an activation function.Patterns are presented to the network via the 'input layer', which communicates to one or more 'hidden layers' where the actual processing is done via a system of weighted 'connections'. The hidden layers then link to an 'output layer' Most ANNs contain some form of 'learning rule' which modifies the weights of the connections according to the input patterns that it is presented with. In a sense, ANNs learn by example as do their biological counterparts; a child learns to recognize dogs from examples of dogs. ANNs, like people, learn by example. An ANN is configured for a specific application, such as pattern recognition or data classification, through a learning process. Learning in biological systems involves adjustments to the synaptic connections that exist between the neurons. This is true of ANNs as well. Its computational system inspired by the

a. Structure
b. Processing Method
c. Learning Ability

of a biological brain.

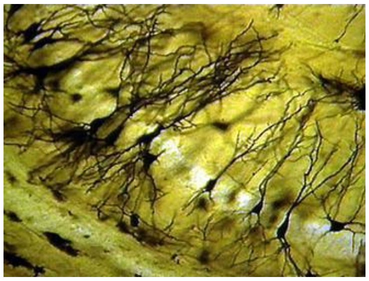

Fig 1: Biological Inspiration

3, CHARACTERISTICS OF ANNS

It has different characteristics because of its structure and learning process.

a. A large number of very simple processing neuron-like processing elements
b. A large number of weighted connections between the elements.
c. Distributed representation of knowledge over the connections
d. Knowledge is acquired by network through a learning process.
e. Adaptive learning: An ability to learn how to do tasks based on the data given for training or initial experience.

f. Self-Organization: An ANN can create its own organization or representation of the information it receives during learning time.
g. Real Time Operation: ANN computations may be carried out in parallel, and special hardware devices are being designed and manufactured which take advantage of this capability.
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h. The NNs exhibit mapping capabilities, that is, they can map input patterns to their associated output patterns.
i. The NNs possess the capability to generalize. Thus, they can predict new outcomes from past trends.
j. The NNs are robust systems and are fault tolerant. They can, therefore, recall full patterns incomplete, partial, or noisy patterns.
k. The NNs can process information in parallel, at high speed, and in a distributed manner.

4, ARCHITECTURE OF ANN.

An ANN is defined as a data processing system consisting of a large number of simple highly inter connected processing elements(artificial neurons) in an architecture inspired by the structure of the cerebral cortex of the brain. there are several types of architecture of ANNs. Neural network architecture defines its structure including number of hidden layers, number of hidden nodes and number of output nodes etc.

1. *Number of hidden layers*: The hidden layer(s) provide the network with its ability to generalize. In theory, a neural network with one hidden layer with a sufficient number of hidden neuron is capable of approximating any continuous function.
2. *Number of hidden neurons*: There is no magic formulae for selecting the optimum number of hidden neurons. However, some thumb rules are available for calculating number of hidden neurons. For a three layer network with n input and m output neurons, the hidden layer would have *sqrt(n*m)* neurons.
3. *Number of output nodes*: Neural network with multiple outputs, especially if these outputs are widely spaced, will produce inferior results as compared to a network with a single output.
4. *Activation function*: Activation functions are mathematical formulae that determine the output of a processing node. Each unit takes its net input and applies an activation function to it. Non-linear functions have been used as activation functions such as logistic tanh etc. The purpose of the transfer function is to prevent output from reaching very large value which can 'paralyze' neural networks and thereby inhibit training. .

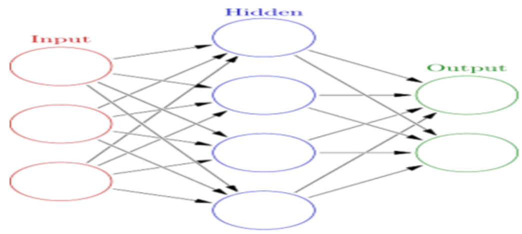

Fig:1 Artificial neural network.

It contain two types of network

1. **Feed Forward network:** Feed forward ANN allow signals to travel one way only; from input to output. There is no feedback (loops) i.e. the output of any layer does not affect that same layer. They are extensively used in pattern recognition. Its static network.

2. **Feed Back / Recurrent networks:** Feedback networks can have signals traveling in both directions by introducing loops in the network. Feedback networks are dynamic; their 'state' is changing continuously until they reach an equilibrium point. They remain at the equilibrium point until the input changes and a new equilibrium needs to be found.

5, TRAINING /LEARNING ANN

Evaluation of input going to be a output. So, ANN are constructed with layers of units, and thus are termed multilayer ANNs. A layer of units in such an ANN is composed of units that perform sillier tasks. First layer of multilayer ANN consists of input units. These units are known as independent variables in statistical literature. Last layer contains output units. All other units in the model are called hidden units and constitute hidden layer. It has two function. Those are

- The input function
- The output/activation function

Input into a node is a weighted sum of outputs from nodes connected to it. The input function is normally given by

$net_{i} = \Sigma_j w_{ij} x_{j} + \mu_i$

where net_{i}= the result of the net inputs

x_i =impacting on unit i(weighted by the weights w_{ij})

w_{ij}=weights connecting neuron j to neuron i.

x_j=output from unit j.

μ_i=threshold for neuron i.

Each unit takes its net input and applies an activation function to it. For example, output of j^{th} unit, also called activation value of the unit, is

$g(\Sigma w_{ij} x_i)$ where $g(.)$= activation function

x_i=output of i^{th} unit connected to unit j.

A number of non linear functions have been used in the literature as activation functions. The threshold function is useful in situations where the inputs and outputs are binary encoded. However the most common choice is sigmoid functions, such as

$g(netinput)=[1+e^{-netinput}]^{-1}$

or

g(netinput)=tanh(netinput)

The activation function exhibits a great variety, and has the biggest impact on behavior and performance of the ANN. The main task of the activation function is to map the outlying values of the obtained neural input back to a bounded interval such as[0,1] or [-1,1]. The sigmoid function has some advantages, due to its differentiability within the context finding a steepest descent gradient for the back propagation method and moreover a wide domain of values into the interval[0,1].

There are three types of learning methods. Those are

a. Supervised learning

Every input pattern that is used to train the network is associated with an output pattern, which is the target or the desired pattern. A teacher is assumed to be present during the learning process, when a comparison is made between the network's computed output and the correct expectedout put, to determine the error. The error can then be used to change networks parameters, which result in an improvement in performance.

b. Unsupervised learning

In this learning method, the target output is not presented to the network. It is as if there is no teacher to present the desired patterns and hence, the system learns of its own by discovering and adapting to structural features in the input patterns.

c. Reinforcement learning

In this method, a teacher though available, does not present the expected but only indicates if the computed output is correct or incorrect. The information provided helps the network in its learning process. A reward is given for a correct answer computed and a penalty for a wrong answer. But, reinforced learning is not one the popular forms of learning

6, BACK PROPAGATION

Backpropagation, an abbreviation for "backward propagation of errors", is a common method of training artificial neural networks. From a desired output, the network learns from many inputs, similar to the way a child learns to identify a dog from examples of dogs. Back propagation, which uses the data to adjust the network's weights and threshold so as to minimize the error in its predictions on the training set. we denote by w_{ij} the weight of the connection from unit $u_i$to unit u_j. It's then convenient to represent the patterns of connectivity in the network by a weight matrix w whose elements are the weights $w_{ij.}$ The pattern of connectivity charcteristizes the architecture of the network. A unit in the output layer determines its activity by following a two step procedure.

- First , it computes the total weighted input xj, using the formula:

$X_j=\Sigma_i y_i w_{ij}$

Where y_i= activity level of the j^{th}unit

w_{ij}=weight of the connection between the $i^{th}$and j^{th} unit

- unit calculates the activity y_j using some function of the weighted input

  Typically we use the sigmoid function:

$y_j=[1+e^{-x}{}_j]^{-1}$

- computes the error E, which is defined by the expression:

$E=1/2\ \Sigma(y_i-d_i)^2$

Where y_i=activity level of the i^{th} unit in the top layer

$d_{i=}$desired output of the j^{th} unit

7, HOW DO NEURAL NETWORK DIFFER FROM CONVENTIONAL COMPUTING

To better understand artificial neural computing it is important to know first how a conventional 'serial' computer and it's software process information. A serial computer has a central processor that can address an array of memory locations where data and instructions are stored. Computations are made by the processor reading an instruction as well as any data the instruction requires from memory addresses, the instruction is then executed and the results are saved in a specified memory location as required. In a serial system (and a standard parallel one as well) the computational steps are deterministic, sequential and logical, and the state of a given variable can be tracked from one operation to another.

In comparison, ANNs are not sequential or necessarily deterministic. There are no complex central processors, rather there are many simple ones which generally do nothing more than take the weighted sum of their inputs from other processors. ANNs do not execute programed instructions; they respond in parallel (either simulated or actual) to the pattern of inputs presented to it. There are also no separate memory addresses for storing data. Instead, information is contained in the overall activation 'state' of the network. 'Knowledge' is thus represented by the network itself, which is quite literally more than the sum of its individual components.

Depending on the nature of the application and the strength of the internal data patterns you can generally expect a network to train quite well. This applies to problems where the relationships may be quite dynamic or non-linear. ANNs provide an analytical alternative to conventional techniques which are often limited by strict

8, APPLICATIONS OF ANN

Given this description of neural networks and how they work, what real world applications are they suited for? Neural networks have broad applicability to real world business problems. In fact, they have already been successfully applied in many industries.Since neural networks are best at identifying patterns or trends in data, they are well suited for prediction or forecasting needs including:

- sales Forecasting
- Industrial Process control
- Customer research
- Data Validation
- Risk management
- Control system and Monitoring
- Mobile computing
- Fingerprint Recognition
- Clustering/categorization
- Content addressable memory
- Pattern Recognition

Two successful applications are:

- Zip code Recognition
- Ne Talk(Text to voice translation)

9, CONCLUSTION

The computing world has a lot to gain from 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 responseand computational times which are due to their parallel architecture.Neural networks also contribute to other areas of research such as neurology and psychology. They are regularly used to model parts of living organisms and to investigate the internal mechanisms of the brain.Finally, I would like to state that even though neural networks have a huge potential we will only get the best of them when they are integrated with computing, AI, fuzzy logic and related subjectsA common criticism of neural networks, particularly in robotics, is that they require a large diversity of training for real-world operation. This is not surprising, since any learning machine needs sufficient representative examples in order to capture the underlying structure that allows it to generalize to new cases.

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