Artificial Neural Network

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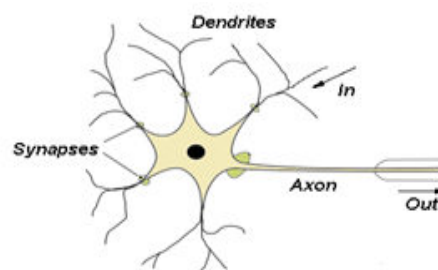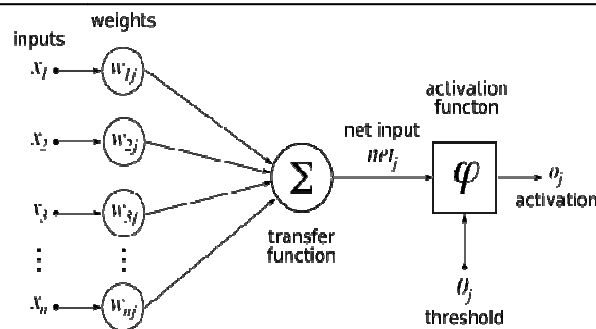Email:-nehaguptaneema@gmail.com

ABSTRACT

The long course of evolution has given the human brain many desirable characteristics not present in Von Neumann or modern parallel computers. These include massive parallelism, distributed representation and computation, learning ability, generalization ability,adaptivity, inherent contextual information processing, fault tolerance, and low energy consumption. It is hoped that devices based on biological neural networks will possess some of these desirable characteristics.On this basic we come out with the concept of artificial neural network. An artificial neural network, often just called a neural network, is a mathematical model inspired by biological neural networks. A neural network consists of an interconnected group of artificial neurons, and it processes information using a connectionist approach to computation. Neural networks have emerged in the past few years as an area of unusual opportunity for research, development and application to a variety of real world problems. Indeed, neural networks exhibit characteristics and capabilities not provided by any other technology. The article discusses the motivations behind the development of ANNs and describes the basic biological neuron. This paper presents a brief tutorial on artificial neural networks, some of the most commonly used ANN models and briefly describes several applications of it.

1. INTRODUCTION

Inspired by biological neural networks, ANNs are massively parallel computing systems consisting of an exremely large number of simple processors with many interconnections. ANN models attempt to use some "organizational" principles believed to be used in the human. One type of network sees the nodes as 'artificial neurons'. These are called artificial neural networks (ANNs). An artificial neuron is a computational model inspired in the natural neurons. Since the function of ANNs is to process information, they are used mainly in fields related with it. There are a wide variety of ANNs that are used to model real neural networks, and study behaviour and control in animals and machines, but also there are ANNs which are used for engineering purposes, such as pattern recognition, forecasting,and data compression. These basically consist of inputs (like synapses), which are multiplied by weights. Weights assigned with each arrow represent information flow. These weights are then computed by a mathematical function which determines the activation of the neuron. Another function (which may be the identity) computes the output of the artificial neuron (sometimes in dependence of a certain threshold). The neurons of this network just sum their inputs. Since the input neurons have only one input, their output will be the input they received multiplied by a weight.

Biological Neuron

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Artificial Neuron

If the weight is high,then input will be strong. By adjusting the weights of an artificial neuron we can obtain the output we want for specific inputs. But when we have an ANN of hundreds or thousands of neurons, it would be quite complicated to find by hand all the necessary weights. But we can find algorithms which can adjust the weights of the ANN in order to obtain the desired output from the network. This process of adjusting the weights is called learning or training. . The training begins with random weights, and the goal is to adjust them so that the error will be minimal.

2.CHALLENGING PROBLEMS
a)Pattern recognization:
Pattern recognition is the assignment of a label to a given input value. Well known application include Other typical applications of pattern recognition techniques are automatic recognition, classification (e.g. spam/non-spam email messages), the automatic recognition of handwritten postal codes on postal envelopes, automatic recognition of images of human faces, or handwriting image extraction from medical forms.
b)Clustering/Categorization:
Categorization is   the process in   which   ideas   and   objects   are recognized, differentiated, and understood. Categorization implies that objects are grouped into categories, usually for some specific purpose.applications of clustering include data mining,data compression and exploratory data analysis.
c)Prediction/Forecasting:
It has a significant impacton decition making in bussiness,science and engineering. Stock market prediction and weather forecasting are typical application of prediction/forecasting techniques.

3. NETWORK ARCHITECTURE
Based on the connection pattern network architecture can be grouped into two categories :
- Feed-forward networks, in which graphs have no loops.
- Recurrent (or feedback) networks, in which loops occur because of feedback connections.

Generally,**Feed-Forward Networks** are static,that is, they produce only one set of output values rather than a sequence of values from a given input. Feedforward networks are memory-less in the sense that their response to an input is independent of the previous network state.
Multilayer Perceptron Architecture: This is a full-connected, three layer, feed-forward, perceptron neural network. "Fully connected" means that the output from each input and hidden neuron is distributed to all of the neurons in the following layer. All neural networks have an input layer and an output layer, but the number of hidden layers may vary. Here is a diagram of a perceptron network with two hidden layers and four total layers:
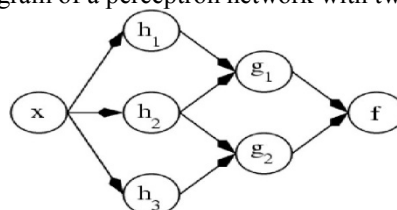
When there is more than one hidden layer, the output from one hidden layer is fed into the next hidden layer and separate weights are applied to the sum going into each layer.
 Radial Basis Function network: A radial basis function network is an artificial neural network that uses radial basis functions as activation functions. The output of the network is a linear combination of radial basis functions of the inputs and neuron parameters. Radial basis function networks are used for function approximation, time series prediction, and system control.

Issues: There are many issues in designing feed-forward networks:

- ➢ How many layers are needed for a given task,
- ➢ How many units are needed per layer,
- ➢ How will the network perform on data not included in the training set (generalization ability), and
- ➢ How large the training set should be for "good" generalization.

Although multilayer feed-forward networks using back propagation have been widely employed for classification and function approximation.

Recurrent, or feedback, networks, on the other hand, are dynamic systems. When a new input pattern is presented, the neuron outputs are computed. Because of the feedback paths, the inputs to each neuron are then modified, which leads the network to enter a new state. Different network architectures require appropriate learning algorithms.

4. OVERVIEW OF LEARNING   PROCESSES:

A learning process in the ANN context can be viewed as the problem of updating network architecture and connection weights so that a network can efficiently perform a specific task. The network usually must learn the connection weights from available training patterns. Performance is improved over time by iteratively updating the weights in the network. ANNs' ability to automatically learn from examples makes them attractive and exciting. Instead of following a set of rules specified by human experts, ANNs appear to learn underlying rules (like input-output relationships) from the given collection of representative examples. This is one of the major advantages of neural networks over traditional expert systems.

Learning paradigms:

There are three major learning paradigms, each corresponding to a particular abstract learning task.These are supervised learning, unsupervised learning and reinforcement learning.

- ➢ Supervised learning the network is provided with a correct answer (output) for every input pattern. Weights are determined to allow the network to produce answers as close as possible to the known correct answers.
- ➢ Unsupervised learning does not require a correct answer associated with each input pattern in the training data set. It explores the underlying structure in the data, or correlations between patterns in the data, and organizes patterns into categories from these correlations. Hybrid learning combines supervised and unsupervised learning. Part of the weights are usually determined through supervised learning, while the others are obtained through unsupervised learning.
- ➢ Reinforcement learning is a variant of supervised learning in which the network is provided with only a critique on the correctness of network outputs, not the correct answers themselves.

Error-Correction Rules:

In the supervised learning paradigm, the network is given a desired output for each input pattern. During the learning process, the actual output generated by the network may not be equal to the desired output. The basic principle of error-correction learning rules is to use the error signal (target output-obtained output) to modify the connection weights to gradually reduce this error.

Perceptron learning rule:

The perceptron is an algorithm for supervised classification of an input into one of several possible non-binary outputs. The learning algorithm for perceptrons is an online algorithm, in that it processes elements in the training set one at a time. In the context of artificial neural networks, a perceptron is similar to a linear neuron except that it does classification rather than regression. That is, where a perceptron adjusts its weights to separate the training examples into their respective classes, a linear neuron adjusts its weights to reduce a real-valued prediction error. The perceptron algorithm is also termed the single-layer perceptron, to distinguish it from a multilayer perceptron, which is a misnomer for a more complicated neural network. As a linear classifier, the single-layer perceptron is the simplest feedforward neural network.

Boltzmann learning

Boltzmann learning is derived from information-theoretic and thermodynamic principles.The objective of Boltzmann learning is to adjust the connection weights so that the states of visible units satisfy a particular desired probability distribution. Boltzmann learning can be viewed as a special case of error-correction learning in which error is measured not as the direct difference between desired and actual outputs, but as the difference between the correlations among the outputs of two neurons under clamped and free running operating conditions.

Hebbian Rule

The theory is often summarized as "Cells that fire together, wire together." Hebb's principle can be described as a method of determining how to alter the weights between model neurons. The weight between two neurons increases if the two neurons activate simultaneously and reduces if they activate separately. Nodes that tend to be

either both positive or both negative at the same time have strong positive weights, while those that tend to be opposite have strong negative weights.

$$Wi(new)=Wi(old)+XiY$$

For example, we have heard the word Nokia for many years, and are still hearing it. We are pretty used to hearing Nokia Mobile Phones, i.e. the word 'Nokia' has been associated with the word 'Mobile Phone' in our Mind. Every time we see a Nokia Mobile, the association between the two words 'Nokia' and 'Phone' gets strengthened in our mind. The association between 'Nokia' and 'Mobile Phone' is so strong that if someone tried to say Nokia is manufacturing Cars and Trucks, it would seem odd.

Competitive Wing Rules

Unlike Hebbian learning, competitive-learning output units compete among themselves for activation. As a result, only one output unit is active at any given time. This phenomenon is known as winner-take-all. Competitive learning has beenfound to exist in biological neural network.Competitive learning often clusters or categorizes the input data. Similar patterns are grouped by the network and represented by a single unit. This grouping is done automatically based on data correlations. The simplest competitive learning network consists of a single layer of output units.

 [Note: Only the weights of the winner unit get updated.]

The effect of this learning rule is to move the stored pattern in the winner unit (weights) a little bit closer to the input pattern. From the competitive learning rule we can see that the network will not stop learning (updating weights) unless the learning rate 0. A particular input pattern can fire different output units at different iterations during learning. This brings up the stability issue of a learning system. The system is said to be stable if no pattern in the training data changes its category after a finite number of learning iterations. One way to achieve stability is to force the learning rate to decrease gradually as the learning process proceeds .

However, this artificial freezing of learning causes another problem termed plasticity, which is the ability to adapt to new data. This is known as Grossberg's stability plasticity dilemma in competitive learning.

Eg: Vector quantization for data compression: It has been widely used in speech and image processing for efficient storage, transmission, and modeling. Its goal is to represent a set or distribution of input vectors with a relatively small number of prototype vectors (weight vectors), or a codebook. Once a codebook has been constructed and agreed upon by both the transmitter and the receiver, you need only transmit or store the index of the corresponding prototype to the input vector.

The Back propagation Algorithm

The back propagation algorithm (Rumelhart and McClelland, 1986) is used in layered feed-forward ANNs. This means that the artificial neurons are organized in layers, and send their signals "forward", and then the errors are propagated backwards. The network receives inputs by neurons in the input layer, and the output of the network is given by the neurons on an output layer. There may be one or more intermediate hidden layers. The backpropagation algorithm uses supervised learning. After finding error, we can adjust the weights using the method of gradient descendent:

(formule of back prop algo)

For practical reasons, ANNs implementing the backpropagation algorithm do not have too many layers, since the time for training the networks grows exponentially. Also, there are refinements to the backpropagation algorithm which allow a faster learning.

5. APPLICATIONS

Although successful applications can be found in certain well-constrained environments, none is flexible enough to perform well outside its domain. ANNs provide exciting alternatives, and many applications could benefit from using them. Modern digital computers outperform humans in the domain of numeric computation and related symbol manipulation.

➢ Air traffic control could be automated with the location,altitude,direction and speed of each radar blip taken as input to the network. The would be the air traffic controller's instruction in response to each blip.
➢ Animal behavior and population cycles may be suitable for analysis by neural networks. Appraisal and valuation of property, building,automobiles…etc should be ab easy task for a neural network.
➢ Echo pattern from sonar,radar and magnetic instruments could be used to predict their targets.
➢ Weather prediction may be possible.
➢ Voice recognization could be obtained by analyzing audio oscilloscope pattern.
➢ Traffic flows could be predicted so that signal timing could be optimized…..many more.

CONCLUTION

Using artificial neural networks modern digital computers outperform humans in the domain of numeric

computation and related symbol manipulation.

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