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The Use of Artificial Intelligence in Cognitive Decision Making – A Review

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***Abstract*— Many problems of the real world vary with number of parameters affecting the system and their computations become a difficult task. Artificial neural networks (ANN) can learn and be trained on a set of input and output data belonging to a particular problem. The field applications of Artificial Intelligence have increased dramatically in the past few years. ANN is built from a large number of processing elements that individually deal with pieces of a big problem. If new data of the problem are presented to the system, the ANN can use the learned data to predict outcomes without any specific programming relating to the category of events involved. A large variety of possible ANN applications now exist for non computer specialists. Therefore, with a very modest knowledge of the theory behind ANN, it is possible to tackle complicated problems in a researcher's own area of specialty with the ANN techniques. ANN learning occurs through training to a set of input and output data, where the training algorithm iteratively adjusts the connection weights. In the present paper an overview of ANN has been discussed for cognitive decision making.**

***Keywords*—Artificial neural networks, Information technology, Automation, Neural systems.**

I. Introduction

Artificial Intelligence is one of the most interesting technologies of today for various applications in different branches of engineering. It deals with methods of problem solving by using techniques of exhibiting human characteristics such as understanding language, learning, perception, and reasoning. The applications of Artificial Intelligence (AI) play a major role in reshaping traditional notions and offer an approach to computations that is different from conventional analytic methods. Artificial Intelligence techniques are an information processing technology that simulates the human brain and the nervous system. Fuzzy logic, neural networks, and expert systems are tools of AI techniques.

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Like the human brain, neural networks learn from experience, generalize from previous examples to new ones and abstract essential characteristics from inputs containing irrelevant data. Network components with names such as neurons and synaptic transmissions with weight factors are used to mimic the nervous system in a way which allows signals to travel through the network in parallel as well as serially.

Artificial Neural Network is a system closely modeled on the human brain. The field goes by many names, such as connectionism, parallel distributed processing, neuro computing, natural intelligent systems, machine learning algorithms, and artificial neural networks. It simulates within specialized hardware or sophisticated software, and the multiple layers of simple processing elements called neurons. Each neuron is linked to its neighbors with varying coefficients of connectivity that represent the strengths of these connections. Learning is accomplished by adjusting these strengths to get the output with appropriate results.

The most basic components of neural networks are modeled based on the structure of the brain. Some neural network structures are not close to the brain and some do not have a biological counterpart in the brain. However, neural networks have a strong similarity to the biological brain and therefore a great deal of the terminology is borrowed from neuroscience. Neural networks produce faster responses due to the parallel distributed processing. This paper addresses some concepts of ANN in cognitive decision making.

II. Background

Artificial neural networks (ANN) offer an approach to computation that is different from conventional analytic methods. ANN is an information processing technology that simulates the human brain and the nervous system. Like the human brain, neural networks learn from experience, generalize from previous examples to new ones and abstract essential characteristics from inputs containing irrelevant data. Network components with names such as neurons (sometime referred to as cells, units or nodes) and synaptic transmissions with weight factors are used to mimic the nervous system (analogous to synaptic connections in the nervous system) in a way which allows signals to travel through the network in parallel as well as serially. Although neural networks have some qualities in common with the human brain, this resemblance is only superficial. The ANN will never be able to duplicate the complete functions of the human brain.

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Various ANN models have been proposed over the past decades and impressive results have been obtained with some of the designs. The most popular model for many applications is the non-linear multilayered network. This method is an outgrowth of linear neural network approach that started in 1960. The original models consisted of two layers of computational neurons: input and output neurons. These models are easier to train and have found widespread commercial applications. Unfortunately, only a limited number of applications could be solved with this technique. The introduction of non-linear multi-element ANN and algorithms for calculating and correcting errors of the network's performance (e.g. the back-propagation method) made ANN very productive in the 1980. Several publications describe the development and theory of ANN from the introductory level to more advanced stages. For example, Lippman (1987) and more recently Hush and Home (1993) published updated reviews of several ANN models. Barron and Barron (1989) and Levin el al. (1990) provided a statistical interpretation of the methods and views to train ANN.

This review will concentrate on the ANN techniques and concepts useful in decision making and help researchers to identify the opportunities. This new technology is applicable for assisting decision making. In addition this paper provides guidelines and tips for the development of successful application in decision making.

A. *Basics of neural computing*

The human brain is a complex biological network of billions of highly interconnected cells called neurons. These cells receive information from as many as 10,000 other cells, and send signals to other cells based upon the incoming signal pattern. The exact mechanism by which thought arises from these neuron signals is still unknown. The human brain can be able to mimic some of its abilities, such as learning, pattern recognition, and generalization.

A neuron in the brain has four basic parts: the body, incoming channels the outgoing channel, and the connecting points between the neurons, which are called synapses and is shown in Fig.1. A neuron receives many signals from other neurons at the synapses. In the synapses, processing occurs before the signals are sent down to the incoming channels of the neuron body.

The synapses attach "weights" to the incoming signals so that each of the signals will have a different effect on the neuron. A synapse can "turn up" or "turn down" the volume of a signal so that is has a stronger or weaker effect to the receiving neuron than other signals do. A synapse can cause a signal to tend to "turn on" (excite) or "turn off" (inhibit) the neuron. A highly excited neuron sends out an output signal, an inhibited one does not.

B. *Biology of a Neuron*

All natural neurons have four basic components, which are dendrites, soma, axon, and synapses. Basically, a biological neuron receives inputs from other sources, combines them in some way, performs a generally nonlinear operation on the result, and then output the final result. The Figure 1 shows a simplified biological neuron and the relationship of its four components.

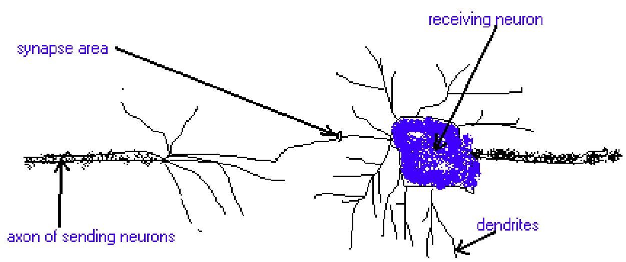

Figure 1. Biology of a Neuron

The job of the neuron body is to add up all the incoming signals and decide if the total is enough to send out a signal. Each neuron detects and sends out a signal about only one simple thing (darkness, for example). It does not send out many different signals or recognize many different things. The synapses permit the single output signal to have different effects on the neurons it goes to. For example, in one area of the brain darkness may be welcome (such as the sleep center), and in another it may be undesirable (such as an area used when driving a car).

It is the job of a group of interconnected neurons to determine more complex things such as judging the speed of an oncoming car. Such a group of interconnected neurons is called a neural network, and several biological neural networks function together to process higher levels of information. We have found and mapped many areas (networks) of the brain, which performs specific functions such as speech, vision, hearing, etc.

Learning occurs in the brain in the form of changes to the synapses. There are few theories about how this works, but the general option is that neurons "learn" as a function of the signals that they receive. The synapses change over time as signals are received, and this constitutes learning. Knowledge is "captured" in bits and pieces through the weights of the synapses that attach to incoming signals. Thus knowledge is spread out across many neural connections.

The structure of the brain is somehow suited to recognize human faces and understanding speech. In addition, the brain is having the associative type of memory. The brain naturally associates one thing with another. It can access information based on contents rather than on sequential address as in the digital computer. The associative (content-addressable) memory accounts for fast information retrieval and permits partial or approximate matching. The brain seems to be good at managing fuzzy information because of the way its knowledge is represented.

Thus, the brain-style computation points out a new direction for building an intelligent system, a direction which is fundamentally different from the symbolic approach and not suited to tasks such as high-speed arithmetic calculations. Current AI systems can do better than humans in arithmetic calculation.

III. Working of Artificial neural networks

The primary step in the design of a typical ANN is to identify the qualitative or quantitative factors that act as inputs to the network. These various inputs to the network are represented by the mathematical symbol, x(n). Each of these inputs are multiplied by a connection weight, these weights are represented by w(n). In the simplest case, these products are simply summed, fed through a transfer function to generate a result, and then output.

Even though all artificial neural networks are constructed from this basic building block the fundamentals may vary in these building blocks and there are differences. The developer must go through a period of trial and error in the design decisions before coming up with a satisfactory design. The design issues in neural networks are complex and are the major concern of system developers.

A. *Designing a neural network consists of:*

- Arranging neurons in various layers.
- Deciding the type of connections among neurons for different layers, as well as among the neurons within a layer.
- Deciding the way a neuron receives input and produces output.
- Determining the strength of connection within the network by allowing the network to learn the appropriate values of connection weights by using a training data set.

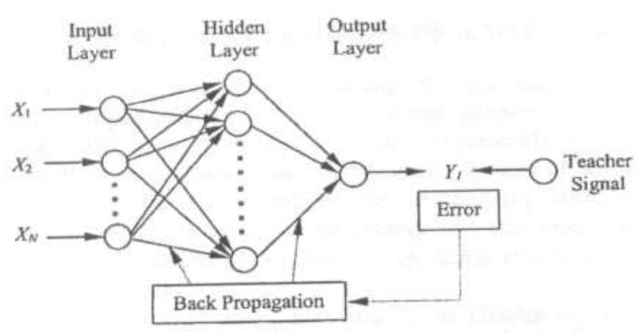

Figure 2. Layers of ANN

The process of training an ANN is an iterative process and is illustrated in Fig. 2. Biologically, neural networks are constructed in a three dimensional way from microscopic components. These neurons seem capable of nearly unrestricted interconnections. This is not true in any man-made network. Artificial neural networks are the simple clustering of the primitive artificial neurons. This clustering occurs by creating layers, which are then connected to one another. How these layers connect may also vary. Basically, all artificial neural networks have a similar structure of topology. Some of the neurons interface the real world to receive its inputs and other neurons provide the real world with the network outputs. All the rest of the neurons are hidden from view.

As the figure above shows, the neurons are grouped into layers. The input layers consist of neurons that receive input from the external environment. The output layer consists of neurons that communicate the output of the system to the user or external environment. There are usually a number of hidden layers between these two layers.

When the input layer receives the input, its neurons produce output, which becomes input to the other layers of the system. The process continues until a certain condition is satisfied or until the output layer is invoked and fires their output to the external environment. To determine the number of hidden neurons the network should have to perform its best, one is often left out to the method of trial and error. If the hidden number of neurons is increased an over fit occurs, that is the net will have problem to generalize. The training set of data will be memorized, making the network useless on new data sets. The Fig. 3 represent the basic neuron model.

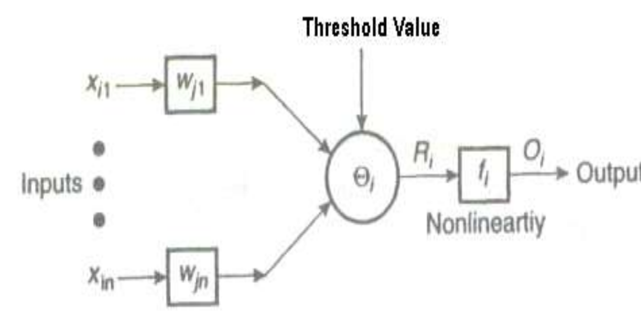

Figure 3. Basic Neuron Model

B. *Potential Applications of ANN*

I. Accidents forecasting

Accidents and their causes are highly unstructured and cannot be governed by any clear rules. The industry incurs heavy expenditure due to such unforeseen events. The first step towards the prevention of the unwanted events is to predict their occurrence. In the forecast of accidents, a feed forward back propagating neural network has been used. A case library consisting of a large number of previous cases is established to train the neural network. Once the network is out of the training phase, a new case with all the identified parameters is given to the network and the network returns a set of similar cases as an output. These similar cases maybe reviewed and modified by the user according to the case requirements. The case specific parameters such as cost of the project, duration of completion of the project, resources deployed maybe used for training the neural network in the learning phase.

II. Hydro electric dam operation

The operation of a reservoir is bounded by some constraints such as technical, environmental, and socio-economic reasons like, minimum or maximum storage volumes, and releases. The complexity in the generation of operation rules for the optimal operation of a hydro electric dam arise from number of uncertainties like future inflows to the reservoir and demands, trade-offs between a wide range of conflicting objectives, etc. Though personal judgement of a fairly experienced person serves fairly well, a neural network maybe developed to generate the operating rules of the reservoir. The constraints that influence the operation of a dam are seasonal variations in the reservoir level, inflows to the reservoir, demand from the power house, etc. These constraints are taken as the input parameters and a feed forward back propagating neural network maybe developed. The optimal operating rules for a reservoir are obtained as an output from the trained neural network.

III. Selection of the optimum bidding contractor

The successful completion of a project depends on the competence of the contractor to whom the project has been awarded. The evaluation of the tenders to select a competent contractor is a very complex process. The selection of a contractor is often guided by various factors like biased opinions, political affiliations, etc. To overcome these difficulties in decision making, an artificial neural network maybe developed. The contractor is evaluated using the bid price, technical competence and past performance records as input factors and the optimal contractor is obtained as the output.

IV. Conclusions

This paper summarizes the application of artificial neural networks. Changing the connection weights causes the network to learn the solution to a problem. The strength of connection between the neurons is stored as a weight-value for the specific connection. The system learns new knowledge by adjusting these connection weights. The learning ability of a neural network is determined by its architecture and by the algorithmic method chosen for training. The major strengths of the use of ANN lie in its ability to reflect the human thinking and decision-making process. It maybe noted that unless a researcher is deeply involved into ANN, it is not necessary to develop a neural network. Pre-trained software versions of many neural networks like MATLAB, and BRAINMAKER maybe used. Thus, the use of such pre-programmed neural networks is strongly recommended.

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