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A Review Paper on Artificial Neural Network in Cognitive Science

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Abstract:

Artificial neural networks are fundamental means for providing an attempt at modelling the information processing capabilities of artificial nervous system which plays an important role in the field of cognitive science. This paper focuses the features of artificial neural networks studied by reviewing the existing research works, these features were then assessed and evaluated and comparative analysis. The study and literature survey metrics such as functional capabilities of neurons, learning capabilities, style of computation, processing elements, processing speed, connections, strength, information storage, information transmission, communication media selection, signal transduction and fault tolerance were used as basis for comparison. A major finding in this paper showed that artificial neural networks served as the platform for neuron computing technology in the field of cognitive science.

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Keywords — **Artificial Neural Network (ANN), Adaptive Learning, Pattern Recognition, Cognitive**

I. INTRODUCTION

Neural Computing is an information processing paradigm, inspired by biological system, composed of a large number of highly interconnected processing elements (neurons) working in unison to solve specific problems.

Artificial Neural Networks (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. An Artificial Neural Network (ANN) is a mathematical model that tries to simulate the structure and functionalities of biological neural networks.

Artificial Neural Networks are relatively crude electronic models based on the neural structure of the brain. The brain basically learns from experience. Human problem solving is basically a pattern processing problem and not a data processing problem. In any pattern recognition task humans perceive patterns in the input data and manipulate the pattern directly. This paper attempts at developing computing models based on artificial neural networks (ANN) to deal with various pattern recognition situations in real life.[1]

II. NEED FOR ARTIFICIAL NUERAL NETWORK

However, humans can effortlessly solve complex perceptual problems at such a high speed and extent as to the world's fastest computer. Why is there such a remarkable difference in their performance?

The biological neural system architecture is completely different from the von Neumann architecture. This difference significantly affects the type of functions each computational model can best perform. Numerous efforts to develop "intelligent" programs based on von Neumann's centralized architecture eve not resulted in general-purpose intelligent programs.[2]

The long course of evolution has given the human brain many desirable characteristics not present in Von Neumann or modern parallel computers. These include a variety of challenging computational problems. Such as,

- Massive, Parallel,
- Distributed,
- Representation and Computation,
- Learning capacity,
- Generalization ability,
- Contextual information processing techniques,
- Fault tolerance and reliability.

III. ORIGIN AND RESEARCH HISTORY

The history is relevant because for nearly two decades the future of Neural network remained uncertain. McCulloch and Pitts (1943) are generally recognized as the designers of the first neural network.They combined many simple processing units together that could lead to an overall increase in computational power.[2]

Hebb (1949) developed the first learning rule that is if two neurons are active at the same time then the strength between them should be increased. In the 1950 and 60's, many researchers (Block, Minsky, Papert, and Rosenblatt worked on perceptron . The neural network model could be proved to converge to the correct weights that will solve the problem.

The weight adjustment (learning algorithm) used in the perceptron was found more powerful than the learning rules used by Hebb. The perceptron caused great excitement. It was thought to produce programs that could think.[3]

Minsky & Papert (1969) showed that perceptron could not learn those functions which are not linearly separable. The neural networks research declined throughout the 1970 and until mid 80's because the perceptron could not learn certain important functions. Neural network regained importance in 1985-86.

By lot of strong efforts neural networks modelled a simple neural network with electrical circuits. Neural networks, with their remarkable ability to derive meaning from complicated or imprecise data, can be used to extract patterns and detect trends that are too complex to be noticed by either humans or other computer techniques. A trained neural network can be thought of as an "expert" in the category of information it has been given to analyse. They include,

1. Adaptive learning by experiences: An ability to learn how to do tasks based on the data given for training or initial experience.

2. Self-Organization and Action: An ANN can create its own organization or representation of the information it receives during learning time.

3. Real Time Operation with correct response: ANN computations may be carried out in parallel, and special hardware devices are being designed and manufactured which take advantage of this capability.

4. Threshold and Fault Tolerance: Partial destruction of a network leads to the corresponding degradation of performance. However, some network capabilities may be retained even with major network damage.

IV. ARCHITECTURE

A. Comparative Analysis

1.Biological Neuron

Biological neural networks are made up of real biological neurons that are connected or functionally related in the peripheral nervous system or the central nervous system. In the field of neuroscience, they are often identified as groups of neurons that perform a specific physiological function in laboratory analysis.

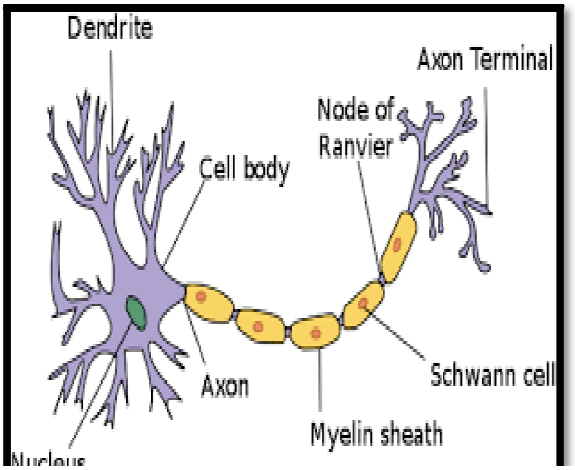


Fig 1 :A Biological Neuron

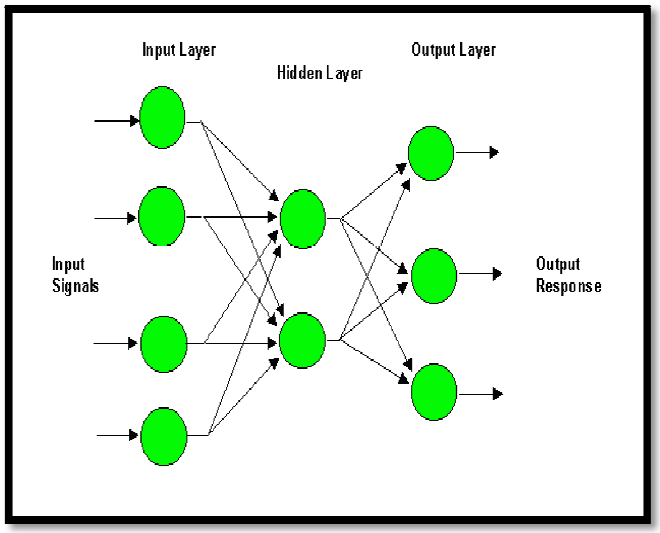


Fig 2: Artificial Neural Network

Apart from the electrical signaling, there are other forms of signaling that arise from neurotransmitter diffusion, which have an effect on electrical signaling. As such, neural networks are extremely complex.

Artificial intelligence and cognitive modeling try to simulate some properties of biological neural networks. While similar in their techniques, the former has the aim of solving particular tasks, while the latter aims to build mathematical models of biological neural systems.[7]

2. Artificial Neuron

In the artificial intelligence field, artificial neural networks have been applied successfully to speech recognition, image analysis and adaptive control, in order to construct software agents or autonomous robots. Most of the currently employed artificial neural networks for artificial intelligence are based on statistical estimations, Classification optimization and control theory.[2]

IV. MATHEMATICAL MODEL

The study of neural network models contributes indirectly to the study of the way in which brains work. The neurons which make up a brain have a number of known physiological properties; the brain operating as a whole has other known properties. [4]

By investigating the overall behaviour of assemblies of cells which have some, but not all, of the properties of neurons and comparing this behaviour with that of a brain it should be possible to decide the role and the relative importance of the properties that neuron.[5]

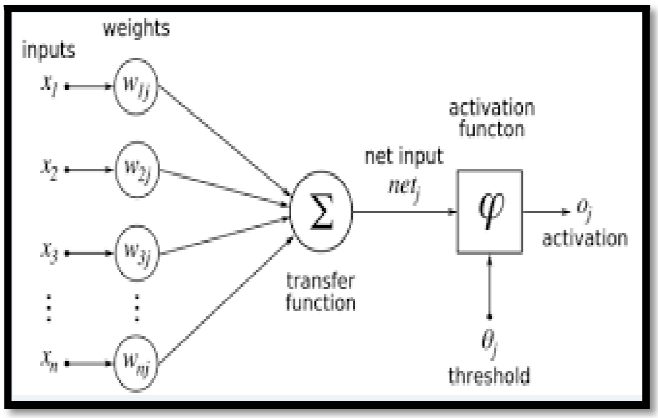
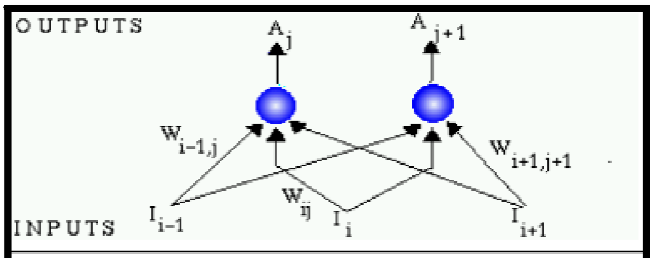


Fig 3: Mathematical Model of ANN

Artificial Neural Networks works on x inputs named as $x_1,x_2,x_3 \ldots x_n$ their weight function wij, Calculate the net function netj, based on that activation(**θ**) of the input and apply the required response will be lead to produce the desired output. However ANNs are able to learn by techniques such are called learning algorithms.

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1) set all the synaptic weight matrixW to
   small random value.
2) calculate the output vector A for an
   input vector I
3) calculate error of output vector A for
   the desire output vectorT for input
   vector I
       error = eta(T - A)
4) update the synaptic weight according to
   the error of input vector I
       W(t + 1) = W(t) + error, t = epoch.
5) repeat step 2 to 5 with all the input
   vectors, until the error is acceptable,
   stop.
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Fig 4: Learning Algorithm

V. IMPLEMENTATION

A SIMPLE EXAMPLE: PROBLEM DEFINITION

Calculate a Square root(or as close to as possible) of a given input number using Multilayer perceptron.

From the learning algorithm error computation can be calculated.[10]

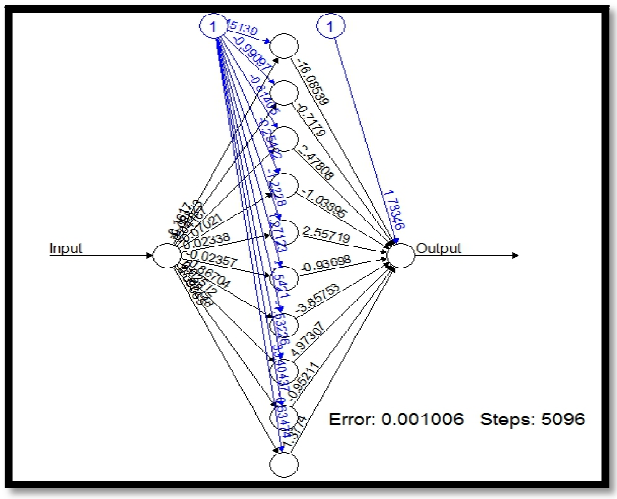

Fig 5: Error Computation

The Artificial Neural Network result into following results.

Input Expected Output Neural Net Output

Input	Expected Output	Neural Net Output
1	1	0.9623402772
4	2	2.0083461217
9	3	2.9958221776
16	4	4.0009548085
25	5	5.0028838579
36	6	5.9975810435
49	7	6.9968278722
64	8	8.0070028670
81	9	9.0019220736
100	10	9.9222007864

Fig 6: Square root computed by ANN

VI. APPLICATIONS

A. General Application

Since neural networks are best at identifying patterns or trends in data, they are well suited for prediction or forecasting needs including:

- Industrial process control
- Sales forecasting
- Customer research
- Data validation
- Risk management

- Target marketing.

B. **Neural networks in medicine**
Artificial Neural Networks (ANN) are currently a 'hot' research area in medicine and it is believed that they will receive extensive application to biomedical systems in the next few years. At the moment, the research is mostly on modeling parts of the human body and recognizing diseases from various scans (e.g. cardiograms, ultrasonic scans, etc.).

C. Neural Networks in business
Business is a diverted field with several general areas of specialization such as accounting or financial analysis. Almost any neural network application would fit into one business area.

D. Data Mining
Data mining is a fast-growing area. Data mining is a part of a process called KDD knowledge discovery in databases. This process consists basically of steps that are performed before carrying out data mining such as data selection, data cleaning, pre-processing of data, and data transformation.

E. Graphics:
ANNs play an important role in graphics fields also. Graphics designers are trying to synthesis or merging actual or real images with computer generated images for enhancing visualization of the output image.

F. Robotics
Robotics is one field within ANN. The term "artificial intelligence" is defined as systems that combine sophisticated hardware and software with elaborate databases and knowledge-based processing models to demonstrate characteristics of effective human decision making.

G. Games:
Modern computer games usually employ 3D animated graphics and recently also 3D sound effects to give the impression of reality.[12]

VII. FUTURE OF ANN

Artificial neural Network may be able to perform in future these following aspects,

1. Robots using ANN that can see, feel, and predict the world around them.
2. Common usage of self-driving cars
3. ANNs can be able to use for Composition of music.
4. Handwritten documents to be automatically transformed into formatted word processing documents.
5. Self-diagnosis of medical problems using neural networks.

CONCLUSION

ANNs are computer algorithms that have the ability to learn by training experience. Because of this feature, they are often well suited for modelling complex and non-linear Processes. They are well advanced and able to compute and behave as human being.

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