ISSN:0975-9646

Krunal N. Chandewar et al, / (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 4 (2) , 2013, 388 - 391

Neural Network

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***Abstract*— A Neural Network is a network (structure) composed of number of interconnected units (neurons). Physical or biological neurons are the basic building blocks of biological Information processing systems. The Axon, which generates the cell action potential is the main conduction mechanism of neuron.**

Each unit or neuron has a input/output (I/O) characteristic and implements a local computation. The output of any unit is determined by its I/O characteristic, its interconnection to other units and the external inputs. To achieve benefits, a neural network must have a means of interfacing with the outside world. To be useful, neural systems must be capable of storing information i.e. they must be "trainable", to develop an internal structure enabling it to correctly identify or classify new, similar patterns.

As a Neural Network (NN) is a dynamic system, its state changes overtime in response to external inputs. The connectivity of neural network determines its structure. Groups of neurons can be locally interconnected to form "clusters" that are indirectly connected to other Clusters.

Over the last 50 years, computing has been dominated by the concept of 'programmed computing' in which usually procedural algorithms are designed and subsequently implemented using the currently dominant architecture. Artificial NN approaches with other technical areas such as pattern recognition; Computer architecture; signal processing and systems; artificial intelligence; modelling and simulation; automata theory and many other fields. Neural Networks and neural computational Structures may yield superior computational paradigms for certain classes of problems like labelling problems, scheduling problems, search problems, object recognition problems etc. and these ANNs are applicable in signal processing; power systems; pattern recognition; medicine; planning, control and search; military systems; artificial intelligence etc.

Although, there are no clear rules for arbitrary applications of NN, it may be fault tolerant because of parallelism. NNs are well suited for 'trainable pattern association' and may be designed to be adaptive.

***Keywords*—** NN, AI, I/O, ANN

I. Introduction

The power and speed of modern digital computers is truly astounding. No human can ever hope to compute a million operations a second. However, there are some tasks for which even the most powerful computers cannot compete with the human brain, perhaps not even with the intelligence of an earthworm.

Neural Networks approaches this problem by trying to mimic the structure and function of our nervous system. Many researchers believe that AI (Artificial Intelligence) and neural networks are completely opposite in their approach. Conventional AI is based on the symbol system hypothesis. Loosely speaking, a symbol system consists of indivisible entities called symbols, which can form more complex entities, by simple rules. The hypothesis then states that such a system is capable of and is necessary for intelligence.

The general belief is that Neural Networks is a sub-symbolic science. Before symbols themselves are recognized, something must be done so that conventional AI can then manipulate those symbols. To make this point clear, consider symbols such as cow, grass, house etc. Once these symbols and the "simple rules" which govern them are known, conventional AI can perform miracles. But to discover that something is a cow is not trivial. It can perhaps be done using conventional AI and symbols such as - white, legs, etc. But it would be tedious and certainly, when you see a cow, you instantly recognize it to be so, without counting its legs.

But this belief - that AI and Neural Networks are completely opposite, is not valid because, even when you recognize a cow, it is because of certain properties which you observe, that you conclude that it is a cow. This happens instantly because various parts of the brain function in parallel. All the properties which you observe are "summed up". Certainly there are symbols here and rules - "summing up". The only difference is that in AI, symbols are strictly indivisible, whereas here, the symbols (properties) may occur with varying degrees or intensities.

II. DEFINITION

A structure composed of a number of interconnected units (neurons). Each unit has an input/output (I/O) characteristic and implements a local computation or function. The output of any unit is determined by its I/O characteristic, its interconnection to other units, and external inputs. Although "handcrafting" of the network is possible, the network usually develops an overall functionality through one or more forms of training. Neural Networks (NN) do not constitute one network, but a diverse family of networks. The overall function or functionality achieved is determined by the network topology, the individual neuron characteristics and the learning or training strategy or training data. To be useful, a NN must have a means of interfacing with the outside world. Typically the unit I/O characteristics are simple and the number of units is quite large.

III. a NEURA NETWORK

Neural Networks are a different paradigm for computing:

1) Von Neumann machines are based on the processing/memory abstraction of human information processing.
2) Neural networks are based on the parallel architecture of animal brains.

Neural networks are a form of multiprocessor computer system, with simple processing elements:

1) A high degree of interconnection
2) Simple scalar messages
3) Adaptive interaction between elements

A biological neuron may have as many as 10,000 different inputs, and may send its output (the presence or absence of a short-duration spike) to many other neurons. Neurons are wired up in a 3-dimensional pattern. Real brains, however, are orders of magnitude more complex than any artificial neural network so far considered. Example: A simple single unit adaptive network: The network has 2 inputs, and one output. All are binary. The output is

1 if $W_0 * I_0 + W_1 * I_1 + W_b > 0$

0 if $W_0 * I_0 + W_1 * I_1 + W_b <= 0$

We want it to learn simple OR: output a 1 if either I_0 or I_1 is 1.

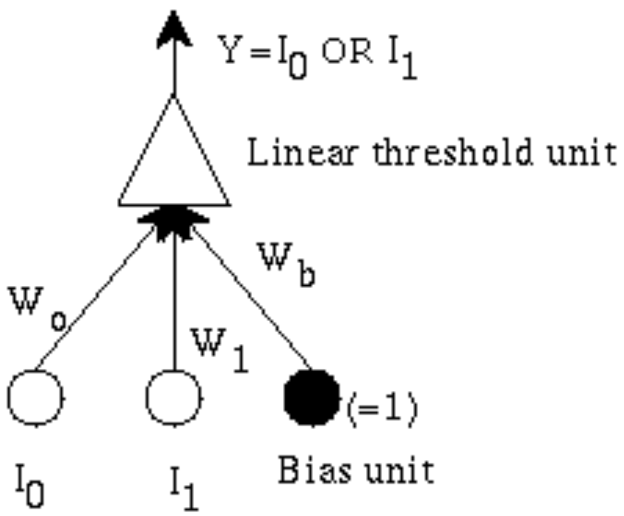

Fig. 1 Use of neural networks

IV. USE of NEURA NETWORK

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. This expert can then be used to provide projections given new situations of interest and answer. Other advantages include:

1) Adaptive learning: An ability to learn how to do tasks based on the data given for training or initial experience.
2) Self-Organization: An ANN can create its own organization or representation of the information it receives during learning time.
3) 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.
4) Fault Tolerance via Redundant Information Coding: Partial destruction of a network leads to the corresponding degradation of performance. However, some network capabilities may be retained even with major network damage.

V. ARCHITECTURE of NEURA NETWORK

1) Feed-forward networks:

Feed-forward neural network 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. Feed-forward neural network tend to be straight forward networks that associate inputs with outputs. They are extensively used in pattern recognition. This type of organization is also referred to as bottom-up or top-down.

2) Feedback networks:

Feedback networks can have signals travelling in both directions by introducing loops in the network. Feedback networks are very powerful and can get extremely complicated. 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. Feedback architectures are also referred to as interactive or recurrent, although the latter term is often used to denote feedback connections in single-layer organizations.

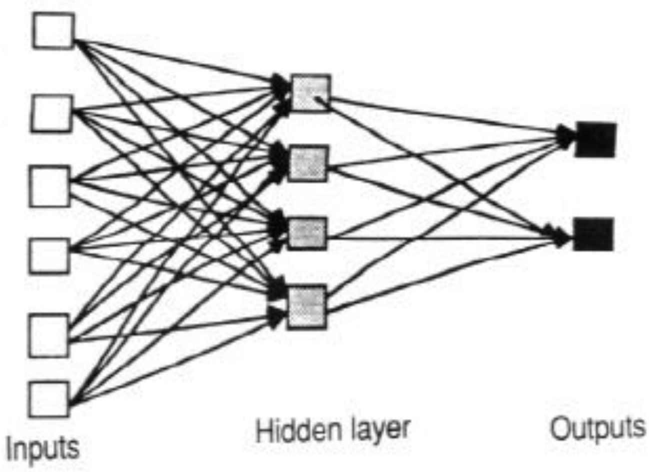

Fig. 2 Feed-forward network

VI. OVERVIEW OF NEURAL COMPUTING

1) Biological system functionality:

Biological system functionality is based on interconnections of specialized physical cells called neurons. The adaptability, context-sensitive nature, error tolerance, large memory capacity, and real-time capability of biological-information processing systems suggest an alternative architecture to emulate. The mere fact that the basic computing element of the human information-processing system is relatively slow. Yet the overall processing operation is achieved in a few hundred milliseconds suggests that the basis of biological computation is a small number of serial steps, each occurring on a massively parallel scale. Furthermore, in this inherently parallel architecture, each of the processing elements is locally connected and relatively simple.

2) Neuromorphic computing:

The term neuromorphic engineering refers to a new discipline based on the design and fabrication of artificial neural systems, such as vision systems, head-eye systems, and roving robots, whose architecture and design principles are based on those of biological nervous systems. Neuromorphic Engineering has a wide range of applications, from nonlinear adaptive control of complex systems to the design of smart sensors. Many of the fundamental principles in this field, such as the use of learning methods and the design of parallel hardware, are inspired by biological systems.

VII. Topologies of Neural Network

The principal importance of a neural network is not only the way a neuron is implemented but also how their interconnections are made. The topology of a human brain is too complicated to be used as a model because a brain is made of hundreds of billions of connections which can't be effectively described using such a low-level (and highly simplified) model. One of the easiest forms of this topology at the moment is made of three layers:

I. one input layer (the inputs of our network)
II. one hidden layer
III. one output layer (the outputs of our network)

All neurons from one layer are connected to all neurons in the next layer.

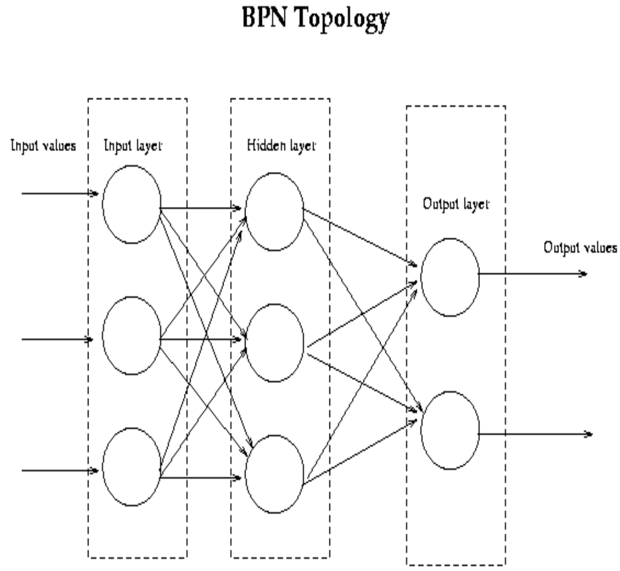

Fig. 3 BNF Topology

VIII. ADVANTAGES AND DISADVANTAGES

ANNs are a relatively new computational paradigm. Neural networks are particularly well suited for certain applications, especially trainable pattern association. The notion that artificial neural networks can solve all problems in automated reasoning, or even all mapping problems, is probably unrealistic.

Advantages:

1) Inherently massively parallel
2) May be fault tolerant because of parallelism
3) May be designed to be adaptive
4) Little need for extensive characterization of problem

Disadvantages:

1) No clear rules or design guidelines for arbitrary application

2) No general way to assess the internal operation of the network
3) Training may be difficult or impossible
4) Difficult to predict future network performance.

IX. Applications of neural networks

Neural Networks in Practice:

1) Clustering
2) Classification/Pattern recognition
3) Sales forecasting
4) Industrial process control
5) customer research
6) data validation
7) risk management
8) target marketing

Neural networks in medicine:

1) Modelling and Diagnosing the Cardiovascular System
2) Electronic noses
3) Instant Physician

Neural Networks in business:

1) Marketing
2) Credit Evaluation

X. Conclusions

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. They are also very well suited for real time systems because of their fast response and 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.
Perhaps the most exciting aspect of neural networks is the possibility that some day 'conscious' networks might be produced. There is a number of scientists arguing that consciousness is a 'mechanical' property and that 'conscious' neural networks are a realistic possibility. Finally, 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 subjects.

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