Study of Artificial Neural Networks and Neural Implants

Yashika Birdi[1] , Tanjyot Aurora[2], Parul Arora[3]

[1] Lecturer computer science Department
SGGI ,Rakhra, patiala

[2] Lecturer computer science Department
SGGI ,Rakhra, patiala

[3] Student (M.tech)computer science Department
UCOE, patiala

[1]yashika.birdi@gmail.com
[2]tanjyot.aurora@gmail.com
[3]arora.parul33@gmail.com

Abstract—.**Throughout the years, the computational changes have brought growth to new technologies. Such is the case of artificial neural networks, that over the years, have given various solutions to the industry. An Artificial neural network was motivated by models of the biological brain .It can create its own organization or representation of information it receives during learning time.**
It is a adaptive model that is constructed by first trying to conclude the essential features of neurones and their interconnections. We then typically program a computer to simulate these features. It consists of many very simple processors units. The major areas of applications of artificial neural networks include medicine, business and forecasting .other application areas include Robotics, Neural implants, image processing ,data mining etc. one such area is Neural implants also known as brain implants have been used to cure incurable diseases and also in controlling thoughts and recording and playing back our dreams and much more.

Keywords- interneuronal, presynaptic terminals, Purkinje cells

*****

I. Introduction

An Artificial Neural Network (ANN) is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain, process information. It is a system based on the operation of biological neural networks.
Biological neural networks are made up of real biological neurons that are connected or functionally related in the peripheral nervous system or central nervous system . It consists of an interconnected group of artificial neurons, and it processes information using a connectionist approach to computation.
An Artificial neural network is a processing device, either an algorithm, or actual hardware, whose design was motivated by the design and functioning of human brains and components.

II. HISTORY

ANN was motivated by models of biological neural networks much of the motivation came from the desire to produce artificial systems capable of "intelligent", computations similar to those that the human brain routinely performs. And thereby possibly to enhance our understanding of the human brain. The history of neural networking probably started in the late 1800s with scientific attempts to study the workings of the human brain. In 1890, William James published the first work about brain activity patterns. The first artificial neuron was produced in 1943 by neurophysiologist Warren McCulloch and the logician Walter Pits[1]. But the technology available at that time did not allow them to do too much. In 1958 The Computer and the Brain was published which proposed many radical changes to the way in which researchers had been modeling the brain.

III. NEED OF USING ARTIFICIAL NEURAL NETWORK

Neural networks, with their remarkable ability to process 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. Other advantages include:-

1. A neural network can perform tasks that a linear program cannot.
2. When an element of the neural network fails, it can continue without any problem by their parallel nature.
3. A neural network learns and does not need to be reprogrammed.
4. It can be implemented in any application.
5. It can be implemented without any problem.
6. An ANN can create its own organisation or representation of the information it receives during learning time.[2]

IV. THE BIOLOGICAL MODEL EVOLUTION

The basic model of the neuron is based upon the functionality of a biological neuron. Neurons are the basic signalling units of the nervous system and each neuron is a discrete cell whose several processes arise from its cell body.Fig.1 shows the structure of a neuron.

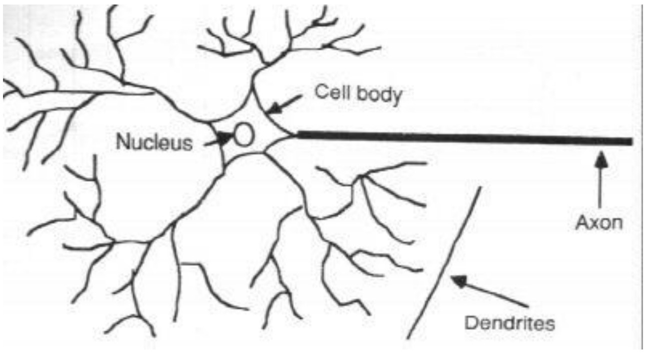

Fig. 1 The Structure of a Neuron

The neuron has four main regions to its structure. The cell body, or soma, has two offshoots from it, the dendrites, and the axon, which end in presynaptic terminals. The cell body is the heart of the cell, containing the nucleus and maintaining protein synthesis. A neuron may have many dendrites, which branch out in a treelike structure, and receive signals from other neurons. A neuron usually only has one axon which grows out from a part of the cell body called the axon hillock. The axon conducts electric signals generated at the axon hillock down its length. These electric signals are called action potentials. The other end of the axon may split into several branches, which end in a presynaptic terminal. Action potentials are the electric signals that neurons use to convey information to the brain. All these signals are identical. Therefore, the brain determines what type of information is being received based on the path that the signal took.

The brain analyzes the patterns of signals being sent and from that information it can interpret the type of information being received. Myelin is the fatty tissue that surrounds and insulates the axon. Often short axons do not need this insulation. There are uninsulated parts of the axon. These areas are called Nodes of Ranvier. At these nodes, the signal traveling down the axon is regenerated. This ensures that the signal traveling down the axon travels fast and remains constant (i.e. very short propagation delay and no weakening of the signal).

The synapse is the area of contact between two neurons. The neurons do not actually physically touch. They are separated by the synaptic cleft, and electric signals are sent through chemical 13 interaction. The neuron sending the signal is called the presynaptic cell and the neuron receiving the signal is called the postsynaptic cell. The signals are generated by the membrane potential, which is based on the differences in concentration of sodium and potassium ions inside and outside the cell membrane.

Neurons can be classified by their number of processes (or appendages), or by their function. If they are classified by the number of processes, they fall into three categories. Unipolar neurons have a single process (dendrites and axon are located on the same stem), and are most common in invertebrates. In bipolar neurons, the dendrite and axon are the neuron's two separate processes. Bipolar neurons have a subclass called pseudo-bipolar neurons, which are used to send sensory information to the spinal cord. Finally, multipolar neurons are most common in mammals. Examples of these neurons are spinal motor neurons, pyramidal cells and Purkinje cells (in the cerebellum)[3].

If classified by function, neurons again fall into three separate categories. The first group is sensory, or afferent, neurons, which provide information for perception and motor coordination. The second group provides information (or instructions) to muscles and glands and is therefore called motor neurons. The last group, interneuronal, contains all other neurons and has two subclasses. One group called relay or projection interneurons have long axons and connect different parts of the brain. The other group called local interneurons are only used in local circuits.

We construct these neural networks by first trying to conclude the essential features of neurones and their interconnections. We then typically program a computer to simulate these features. The fig. 2 shows the neuron model used to construct the neural network.

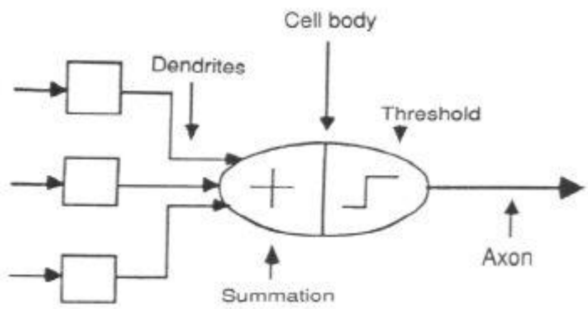

Fig. 2 The Neuron model

V. THE ANN ARCHITECTURE

An Artificial Neural Network consists of many very simple processors units, each possibly having a small amount of local memory. The units are connected by unidirectional communication connections, which carry numeric (as opposed to symbolic) data. The units operate only on their local data and on the inputs they receive via the connections.

Each unit performs a relatively simple job i.e it receives input from neighbours or external sources and use this to compute an output signal which is propagated to other units.

Within neural systems it is useful to distinguish three types of units: input units which receive data from outside the neural network, output units which send data out of the neural network, and hidden units whose input and output signals remain within the neural network[4]. During operation, units can be updated either synchronously or asynchronously. With synchronous updating, all units update their activation simultaneously; with asynchronous updating, each unit has a probability of updating its activation at a time t, and usually only one unit will be able to do this at a time.

Each layer consists of one or more nodes, represented in the fig-3 by the small circles. The lines between the nodes indicate the flow of information from one node to the next. In this particular type of neural network, the information flows only from the input to the output (that is, from left-to-right).

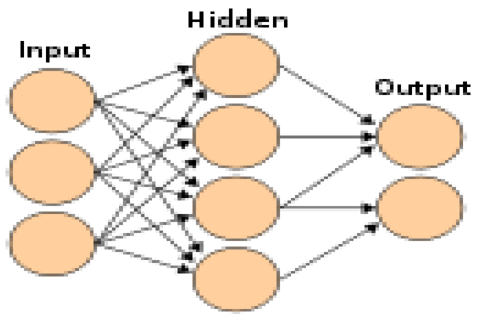

Fig. 3 A Simple Neural Architecture

VI. ARTIFICIAL NEURAL NETWORK TYPES

The artificial neural networks are basically of two types

A. *Feed-forward neural networks*

In this dataflow from input to output units is strictly feedforward. i.e they 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. The data processing can extend over multiple layers of units, but no feedback connections are present, that is, connections extending from outputs of units to inputs of units in the same layer or previous layers.
Feed-forward ANNs tend to be straight forward networks that associate inputs with outputs. They are extensively used in pattern recognition. Examples of feed-forward neural networks are the Perceptron and Adaline.

B. *Recurrent neural networks*

These consist of the feedback connections. These 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 so ,the activation values of the units undergo a relaxation process such that the neural network will evolve to a stable state in which these activations do not change anymore that state is known as the equilibrium point .
The Feedback networks 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 organisations.

VII. ARTIFICIAL NEURAL NETWORKS LEARNING PARADIGMS

Learning is an inherent characteristic of the human beings. By virtue of this, people, while executing similar tasks, acquire the ability to improve their performance. Such principle of learning that can be adhered to machines to improve their performance is usually referred to as 'machine learning'. Machine learning can be broadly classified into three categories:
i) Supervised learning,
ii) Unsupervised learning
iii) Reinforcement learning.

A. *SUPERVISED LEARNING*

Supervised learning is a technique where the input and expected output of the system are provided, and the ANN is used to model the relationship between the two.
In this a trainer submits the input /output exemplary patterns and the learner has to adjust the parameters of the system autonomously, so that it can yield the correct output pattern when excited with one of the given input patterns.

B. *UNSUPERVISED LEARNING*

The learning system adapts its parameters by some algorithms to generate the desired output patterns from a given input pattern. In absence of trainers, the desired output for a given input instance is not known, and consequently the learner has to adapt its parameters autonomously. Such type of learning is termed 'unsupervised learning'.

C. *REINFORCEMENT LEARNING*

In reinforcement learning, the learner does not explicitly know the input-output instances, but it receives some form of feedback from its environment. The feedback signals help the learner to decide whether its action on the environment is rewarding or punishable. The learner thus adapts its parameters based on the states (rewarding / punishable) of its actions.

VIII. APPLICATIONS OF ARTIFICIAL NEURAL NETWORKS

The utility of artificial neural network models lies in the fact that they can be used to infer a function from observations and also to use it.. The major areas of applications of artificial neural networks include medicine, business and forecasting .other application areas include Robotics, Neural implants, image processing ,data mining etc.

The artificial neural networks are being devised for another application area known as the neural implants which are being worked upon and will become a reality in a decade.
The neural implants will help in restoring the damaged areas in the brain and will also help to control computers, television , mobile phones and many more.

IX. NEURAL IMPLANT –AN APPLICATION OF ANN

Neural implants , often referred to as Brain implants, are technological devices that connect directly to a biological individual brain which is usually placed on the surface of the brain, or attached to the brain's cortex.[5]

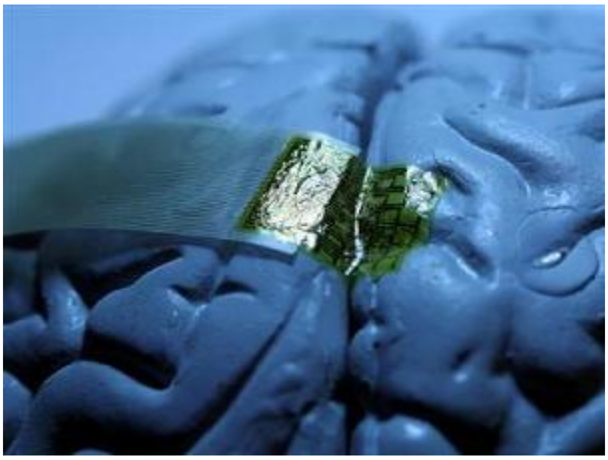

Fig. 4 Brain implant

The fig.4 shows how the technological devices are implanted in the brain. According to a recent research the Neural-implantation devices known as the neurosimulators such as deep brain stimulation and Vagus nerve stimulation are being increasingly implanted in the brain of individuals suffering from Parkinson's disease and clinical depression respectively are proving themselves valuable for people with diseases which were previously regarded as incurable. This device takes advantage of electrodes to bring deep stimulation to certain brain areas. These devices also bring stimulation on a set schedule. These devices are implanted in the human skull where they track electrical activity using electrodes implanted deep in the brain. In case they identify the sign of a seizure, they will bring short and mild electrical stimulation in order to restrain it.

X. NEURAL IMPLANTS IN CONTROLLING MACHINES WITH OUR THOUGHTS

Researchers are developing neural implants that can think independently as the human brain does. These "brain computers" are programmed with complex algorithms that can interpret thoughts. But the algorithms used in current brain-machine interfaces are incapable of adapting to change. They are order-takers, but not adaptive problem-solvers.
The status quo of brain-machine interfaces that are out there have static and fixed decoding algorithms, which assume a person thinks one way for all time.
Neural implants would allow people to control heavy machinery or robots with nothing but their thoughts remotely—perhaps everywhere around the world. However, giving control to "thinking" computer will cause a difficulty in realizing the real in charge. Up till now, brain-machine interfaces have always been designed as a one-way conversation between the brain and a computer. The brain gives the instructions and the computer merely follows commands but now the neural implant will help the computer to put forward its views too.

This technology will help in mental work like creating company reports and term papers .These would become easy. It will be better than having a photographic memory, but of course with a neural implant you could theoretically have one of them too. Your implant could easily store an image of everything you've ever looked at, especially the way micro data storing technology is developing.

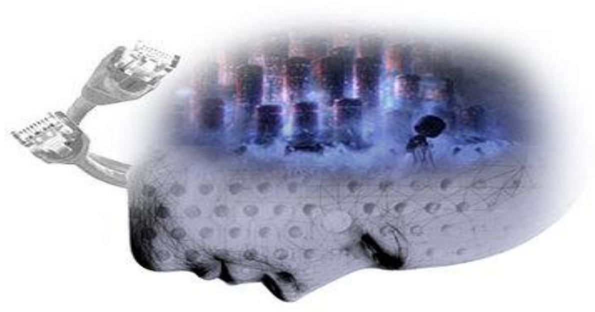

Fig. 5 Brain implant to control thoughts

According to Intel, its customers would soon have the possibility to have a computer chip implanted into their brains so they would operate computers**,** mobile phones**,** TV and more, using their thoughts, without any physical interaction[6]. Neuroscientists will ask them to think about moving a cursor on a computer screen, and if the chips record their thoughts correctly, the cursor will move by itself**.**
Currently the company's new invention is being developed at its lab located in Pittsburg, USA. The chip will be able to feel brain activity with the help of a special technology based on Functional Magnetic Resonance Imaging (FMRI)**.** Scientists at Intel have not yet developed such a chip but according to one of the company's researchers **Dean Pomerleau** they are close.
Theoretically, different people thinking of the same word or image would have the same activity in their brains, but since no one really knows exactly how the brain works, this is not certain. Fig.6 shows that according to operant conditioning studies of Fetz and colleagues showed that monkeys could learn to control the deflection of a biofeedback meter arm with neural activity[8] .Also Hopkins University found a mathematical relationship between the electrical responses of single motor-cortex neurons in rhesus macaque monkeys and the direction that monkeys moved their arms (based on a cosine function).

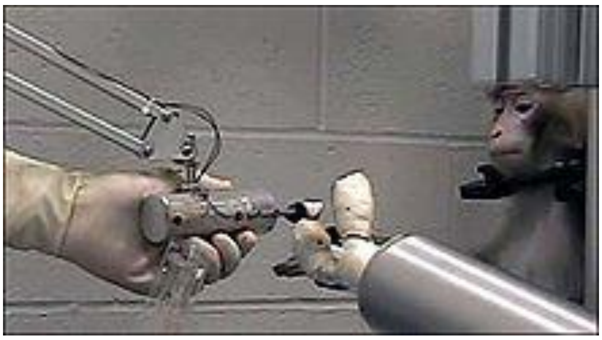

Fig. 6 Monkey controlling robotic arm

With the help of FMRI, Pomerleau together with his colleagues scanned the brains of volunteers in order to see whether brain patters match when people are thinking about the same things. It is worth mentioning that in theory different people that think of a similar word of picture have similar brain activity. However, such theory cannot be proved since no one yet knows how exactly our brain works.

The research team says that up till now the results look rather promising. According to the lead researcher, in a decade or so people will be more inclined towards the company's new invention implanted into their brains. [7]

XI. NEURAL IMPLANTS IN RECORDING AND PLAYING BACK OUR DREAMS

A sophisticated brain-machine interface might one day give us the chance to record -- and then revisit, rewind and presumably overanalyse -- our nocturnal imaginings.

In late 2010, French computer-whiz-turned-CalTech-trained-neuroscientist Moran Cerf and colleagues published research in which epilepsy patients with surgically implanted electrodes in their brains were able to use their minds to brighten a faded-out image of Marilyn Monroe or Michael Jackson on a video screen, by thinking about a particular image and firing the neurons associated with it. The advances in sensor technology eventually will make it possible to monitor such higher-level brain activity from the outside. Think of all the things we could do if we had access to a person's brain and basically visualize their thoughts. Among the applications is a dream catcher. We would like to read people's dreams. If we had to the ability to actually convert the brain impulses that cause dreams into video images, we can imagine some potentially huge benefits. For one thing, we might be able to determine at last what the real function--or functions--of dreams are in the human mind. If it turns out that dreams really do have a role in mental health, being able to watch your dreams with a therapist--as opposed to trying to recall them later--would provide much more detailed information, and possibly invaluable personal insights. We will also be able to determine whether the gift of dream precognition really exists, since we could record an Edgar Cayce-like sleeping prophet's brain impulses, translate them into detailed visual data, and quantitatively measure how many of those visions actually come to pass. .If it turns out that dreams really yield creative inspiration, as some have long believed, artists and writers would be able to replicate their unconscious breakthroughs more accurately than ever

XII. NEURAL IMPLANTS IN MEDICINE

A. PARALYSES

University of Florida researchers are developing devices that can interpret signals in the brain and stimulate neurons to perform correctly.

it will be possible for a tiny computer to fix diseases or even allow a paralysed person to control a prosthetic device with his thoughts. it uses a prosthetic device that detects neural signals corresponding to plan and intentions.

B.RESTORING MEMORY

The memory is stored in the brain's hippocampus. When the hippocampus stops working you only lose the ability to store new memories, but that the old memories are still there.Berger and his research team have developed a mathematical model of the hippocampus.This model has been programmed onto a silicon chip, which will act much as other brain implants by being attached to the human brain this will help in restoring the memory.

XIII.CONCLUSION

Humans and other animals process information with neural networks. These are formed from trillions of neurons (nerve cells) exchanging brief electrical pulses called action potentials. Computer algorithms that mimic these biological structures are formally called artificial neural networks.

This artificial neural network is basically a computational or mathematical model. Neural implants(Application of ANN) use devices which help the computer to communicate with humans and have its own say.

Since the speed and resolution, the bandwidth ,with which we can scan the brain are also accelerating exponentially we will end up building machines that will learn as our brain learns and that will be a formidable combination such that the next generation of technology would be designed by machines themselves.

REFERENCES

[1] McCulloch, W.S. & Pitts, W.H. (1943). A Logical Calculus of the Ideas Immanent in Nervous Activity, Bulletin of Mathematical Biophysics, 5:115-137

[2] Ben Kröse & Patrick van der Smagt(1996) ,An introduction to Neural Networks

[3]Konar ,amit. Artificial intelligence and softcomputing : behavioral and cognitive modeling of the human brain / Amit Konar.

[4] The scientific and engineers guide to data signal processing ,STEPHEN W.SMITH PH.D chapter-26

[5] Hertz, J., Palmer, R.G., Krogh. A.S . (1990) Introduction to the theory of neural computation, Perseus Books. ISBN 0-201-51560-1

[6] Intel Wants a Chip Implant in Your Brain by LIN EDWARDS (PHYSORG.COM) (November 23, 2009)

[7]Intel: Chips in brains will control computers by 2020 By Sharon Gaudin November 19, 2009

[8] Schmidt, EM; McIntosh, JS; Durelli, L; Bak, MJ (1978). "Fine control of operantly conditioned firing patterns of cortical neurons.". *Experimental neurology* **61** (2): 349–69. doi:10.1016/0014-4886(78)90252-2. PMID 101388