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Learning in Artificial Neural Networks

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Abstract

A lot of Materials out there either in softcopy online or hardcopy over the shelve has proven difficult to understand due to high technicality in the style of writing. The are so much of mathematical formulas and terms that are difficult for upcoming scholars in this field of artificial intelligence to grasp. This has discouraged young scholar. The need to simplify what artificial intelligence really is, is necessary to encourage more people to see its beauty and benefit. Developing countries need more of this knowledge in order to invest and develop artificial intelligence related projects to encourage fast growing rate. This article is written in the simplest of terms for people to appreciate artificial intelligence. It is free of mathematical formulas which is one of the discouraging factors in the study of artificial intelligence. It is aimed at providing the basics building foundation for scholars intending to embark on artificial intelligence projects.

Keywords: *Artificial Intelligence, Neurons*

1.0 Introduction

Today's world being termed "JET AGE" is credited to the power behind Artificial Neural Network (ANN). ANNs are Artificial Intelligence (AI) software or hardware systems designed to behave like human. The term AI was first coined at the Dartmouth conference in 1956, and since then AI has expanded because of the theories and principles developed by its dedicated researchers[1].
AI has been defined by many authors in different ways but in all, it is about machine learning. Before now, the curiosity of human led him to wonder and posed a question, "Can a machine think and behave like humans do?" This question was posed by a British mathematician, Alan Turing and this is what birthed AI. The idea behind this question posed by Alan Turing is; without any human intervention a machine should be able to take its own decision and this is about behind AI[2]. Turing didn't stop at posing a question, he invented the "Turing Test" to test whether or not a computer has intelligence; that is, if a computer is capable of thinking like a human being.
John McCarthy defined AI as "The science and engineering of making intelligent machines, especially intelligent computer programs". The term intelligent machines mean hardware systems in the form of electronic circuits or software programs developed and trained to learn, reason and make decisions that resemble the biological neural networks and their attributes.

1.2 Objectives of the Research

Learning in artificial neural networks is aimed at the following objectives;

- To explain clearly what artificial neural network is.
- To show how an artificial neural network can be made to learn.
- To throw light on the most effective process of learning in artificial neural networks.
- To show how fast an artificial neural network can learn.

2.0 Neural Networks Overview

2.1 Basic Attributes of Artificial Neural Networks

The basic attributes of Neural Networks may be divided into the architecture and functional properties (Neurodynamic)

Architecture: This defines the Networks structure. That is, the number of artificial neurons in the network and their interconnectivities. Such network consists of many interconnected neurons, or processing elements with familiar characteristics such as input, synaptic, activation, outputs and bias.

Functional Properties; (Neurodynamic) defines their properties, that is, how the neural networks learn, recall, associate, how it classifies new information and develops new classifications if necessary[3].

2.2 Biological Neurons

Artificial neurons are developed using some mathematical formulas and made to mimic biological neuron in learning and making real world decisions that are beneficial to the human race. To understand ANNs, it is necessary to have a basic knowledge of the biological neuron.

Biological neurons are nerve cells that send and receive signals from the brain. Biological neurons are of different types and as such, they vary in shape, structure, and size.[4] There are three basic parts in every neuron: a cell body, an axon, and dendrites.

- Cell Body: The cell body, also known as soma is the core section of the neuron. The basic cell functions and energy processing machinery is housed and maintained by the cell body.
- Dendrites. Dendrites are branch out from the cell body referred to as the “antennae” of the neuron. They receive and process information from other cells. When a dendrite receives signal, it causes action on the neuron either to fire or not to fire. Signals which cause a neuron to fire are termed **excitatory,** generating electrical impulse, while signals which do not have the capability to cause a neuron to fire are known as **inhibitory.**[5] The firing strength of a neuron is calculated to be the sum of all the excitatory and inhibitory signals it receives.
- Axon**:** While the dendrites receive information from other neurons, the axons send information from the cell body to other neurons. Signals from a transmitting neuron travel along the axon of a neuron to the axon terminals. An Axon’s terminal ends are connected to the dendrite of a receiving neuron by synapse[6] as seen in Figure 2.1

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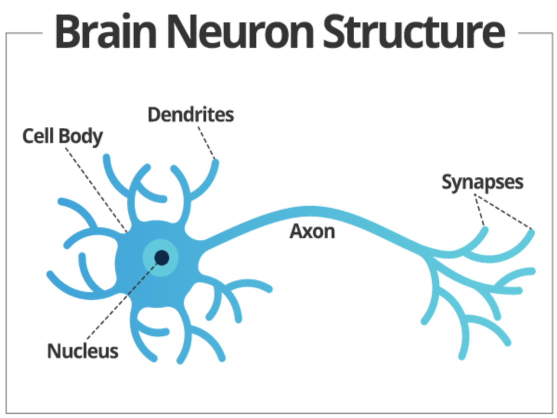

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Figure 2.1: Structure of biological neuron
Source: https://www.linkedin.com/pulse/neural-network-srasthy-chaudhary

The brain receives the stimulus from the outside world, does the processing on the input, and then generates the output. As the task gets complicated multiple neurons form a complex network, passing information among themselves.

2.3 Artificial Neural Network

ANNs are electronics circuits[7] or software models designed to look closely or resemble the biological neural networks and their attributes. Neural networks, as we know is a network of biological nerve cells, which is found in life. But the case of artificial as the name implies is the designing of electronic circuits, which has the functions and attributes of the real-life neural networks. Model network known as paradigms, in Greek known as; something that closely assimilates something else have been developed and implemented. Some of these paradigms closely resemble biological neural networks while others do not

An artificial neural network (ANN) attempts to simulate the network of neurons in the human brain. By this, computers are made to learn from example (by way of training) in order to make decisions and predictions like a human. ANN is inspired by the animal neurons also known as brain cells to aid machines with intelligence without explicit programming. Artificial neural network mimics a similar behavior. In the below (Figure 2.2) image the nodes represent human brain neurons.

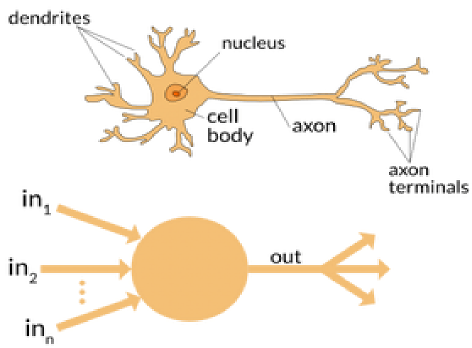

Figure 2.2 Biological Neurons[8]

The brain receives the stimulus from the outside world, does the processing on the input, and then generates the output. As the task gets complicated multiple neurons form a complex network, passing information among themselves[9]. Artificial neural network mimics a similar behavior. In Figure 2.3 the nodes represent neurons in an artificial neural network architecture.

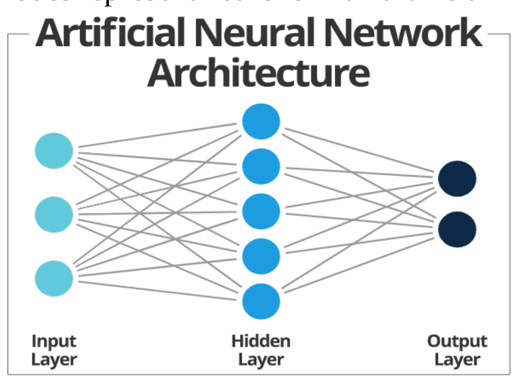

Figure 2.3 Structure of Artificial Neural Network
Source: https://www.linkedin.com/pulse/neural-network-srasthy-chaudhary

There are a lot of similarities between biological and artificial neural networks. They both;

1. Learn in parallel.
2. Learn from past experience.

2.4 How Artificial Neural Networks Learn

Learning in artificial neural network is highly important and is undergoing intense research in both biological and artificial networks. Serious attempts have been made and are still being made to design electronic circuits that closely resemble biological networks and their attributes. That is to say efforts are being made to create machines that work like the biological neurons and their interconnections.

With the ability of a machine to learn, the knowledge of a human being in a domain of activity can be imputed into a machine and then be made available to non-experts to enable them work like experts within a very short time. Now because machines are devoid of human emotion and are not susceptible to the type of stress encountered by human beings, they can be made to solve very complex problems efficiently and dependably.

2.5 **Modeling**

To develop an artificial neural network, one develops a mathematical model that best describes the biological system's functionality. Mathematics is a human invention to describe nature's phenomena. Therefore, modeling is our expression to approximate nature's creation. Now to create a model that emulates a biological system, one must first study and understand that system in every detail, so that if your mathematical model fails, you look for faults in the model and not in nature. Visual information processing is one of the most complex processes in the brain and therefore the organization of the optical pathway has influenced neural networks models. Research has been carried out, (established that visual information e.g. picture or scene analysis) is processed in stages. Simple forms such as edge orientation and contrast are analyzed in the early stages and more complex features are analyzed in later stages at theoretical pathway. Note also that between the eye and the inner part of the brain motion and color are also analyzed during picture analysis. This step-by-step picture processing has led to layered Organized models; hence, we have different layers in a neural network architecture.

2.6 **What Is Learning**

Learning according to the new lexicon Webster dictionary of the English language is to acquire knowledge of or skill in by study, instruction, practice or experience.

Now research in learning has been carried out or conducted on animals of different intelligence levels, on humans of different ages and intelligence level, on marine life and on more primitive life. Learning is not a unique process; there are different learning processes.

The neural network adapts itself to a stimulus and eventually (after making the proper parameter adjustments itself) it produces a desired respond through learning process.

2.7 **The Most Efficient Process for Learning**

As different learning methodologies suit different people, so do different learning techniques suit different neural networks.

Therefore, the most efficient process for learning depends on different people. For ANNs the paradigms developed so far consist of artificial neurons; the neurons may be connected or interconnected in different ways however and the learning process is not the same for them all. They are called learning equations.

Learning equation describes the learning from the paradigm, which in actuality is the process for self – adjusting its synaptic weights. What happens is that the neural networks engineers select the most efficient types of learning and integrate it with the most suitable artificial neural networks.

2.8 **Speed of Learning**

I want to say here that speed of learning depends on different species. How complex an electronic circuit is built determines the learning speed. An ANN that is built not as complex as a complex problem given to it will take a longer time to solve given problem or may end up not be able to solve it, while if a simpler problem is given to same machine, will solve it in no time.

3.0 Ways of Learning in Artificial Neural Network

3.1 Supervised Learning

Supervised learning in Machine learning is the commonest learning paradigm whereby labelled data is used to train a model[10].During the training of a neural network, an input stimulus is applied that results in an output response. This response is compared with a priori – desired output signal, the target response as illustrated in Figure 3.1.

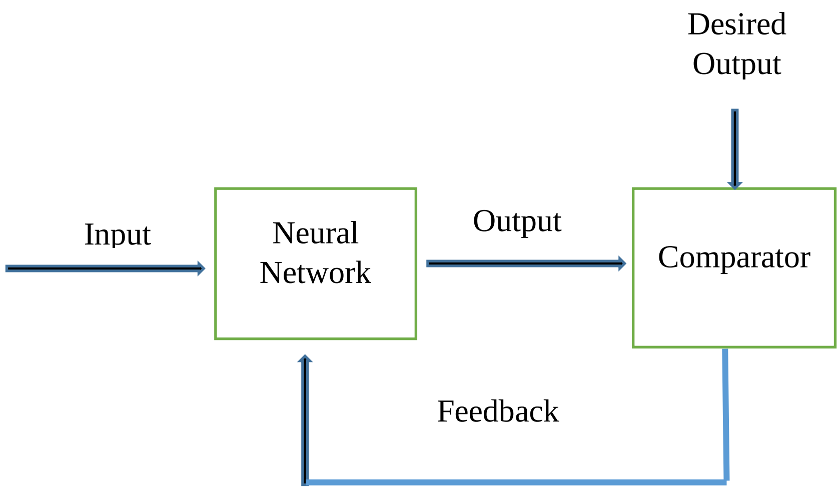

Fig 3.1 supervised Learning illustration

If the actual response differs from the target response the neural network generates an error signal, which is then used to calculate the adjustment that should be made in the network's synaptic weights so that the actual output matches the target output. In other words, the error is minimized, possibly to zero. The error minimization process requires a special circuit known as a teacher or supervisor, hence the name supervised learning. The notion of a teacher comes from biological observations. For example, when learning a language, we hear the sound of a word (from a teacher). The sound is stored in the memory banks of our brain and we try to reproduce the sound. When we hear our own sound, we mentally compared it (actual output) with the stored sound (target output) and note the significantly small then we stop.With artificial neural networks, the amount of calculation required to minimize the error depends on the algorithm used.

3.2 unsupervised Learning

Figure 3.2 is an illustration of unsupervised learning. Unlike supervised learning unsupervised learning does not require labelled data and a teacher: that is, there is no target output. During the training session, the neural net receives at its input many different excitation or input patterns, and it arbitrarily organizes the patterns into categories without any form of labelled data as input[11]. When stimulus is later applied, the neural net provides an output response indicating the class to which the stimulus belongs.

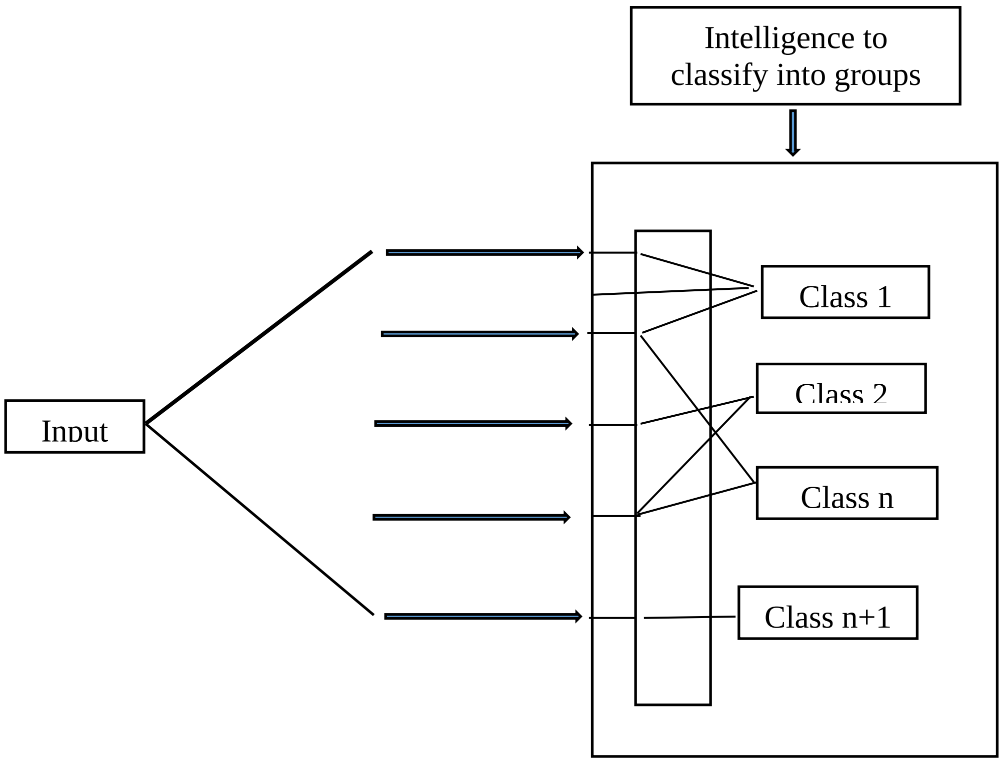

Fig 3.2 Unsupervised learning Illustration

If a class cannot be found for the input stimulus, a new class is generated. For example, show a person a set of different objects in a group, have one or more common classification, such that objectives in a group have one or more common features that distinguish them from another group. When this is done, show the same person other objects and ask him/her to place the objects in one of the groups. If it does not belong to any of the existing groups, a new group may be formed.
Even though unsupervised learning does not require a teacher, it requires guideline to determine how it will form grouping may be based on shape color, or material constituency or on some other property of the object. Hence, if no guidelines have been given as to what type of features should be used for grouping the objectives, the grouping may or may not be successful. Similarly, to classify more comprehensive patterns efficiently, neural networks, although unsupervised initially, may need some feature – selecting guidelines. In some experiments the selecting criterial are

embedded in the neural network design (i.e. they have been designed to extract certain features base on the type of input patterns).

3.3 Reinforced Learning

Reinforced learning requires one or more neuros at the output layer and a teacher that, unlike supervised learning, does not indicate how close the actual output is to the desire output but whether the actual output is the same with the target output or not. During the learning phase an input stimulus is applied and an output response is obtained (consider one output for simplicity) as illustrated in Figure 3.3. The teacher does not present the target output to the network, but presents only a 'pass/fail'. Learning here is in totally an "uncertain, potentially complex environment"[12].

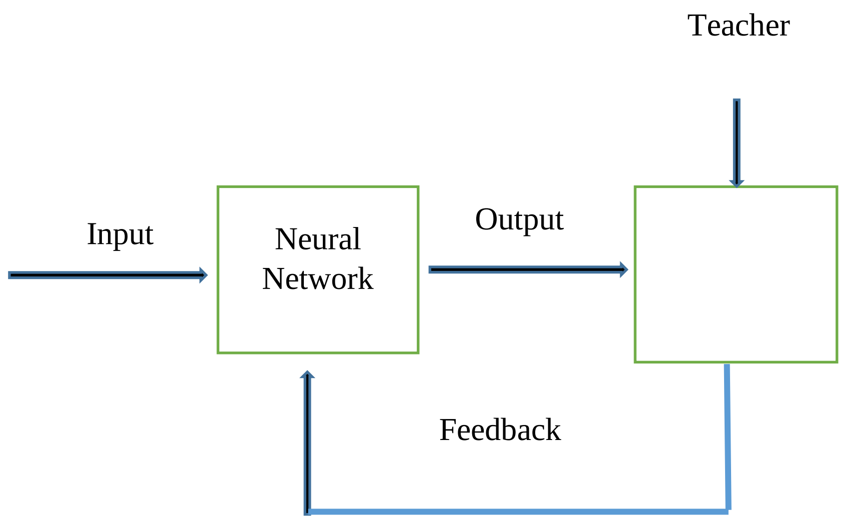

Fig 3.3 Reinforced Learning illustration

indication. Thus, the error signal generates during the training session is binary pass or fail. If the teacher's indication is bad, the network readjusts its parameters and tries again until it gets its outputs response right. During this process there is no indication if the output response is moving in the right direction or how close to the correct response it is. Hence, the process of correcting synaptic weight follows a different strategy than the supervised learning processing.

Some parameters to watch are the following the term per iteration and the number of iterations per pattern to reach the desired output during the training session, whether the neural network reaches a global or local minimum. And when in a local pattern if it can get out or if it is trapped. When reinforced learning is used as a training technique, certain boundaries should be established so that the trainee should not keep trying to get correct response.

3.4 Competitive Learning

Competitive learning is another form of supervised learning that is distinctive because of its characteristic operation and architecture. In this scheme, several neurons are at the Output layer when an input stimulus is applied each output neuron competes with the other to produce the closest output signal to the target. This Output then becomes the dominant one, and the other outputs cease producing an output signal for that stimulus. For another stimulus, output neuron becomes the dominant one and so on. Thus, each output neuron is trained to response to a different input stimulus.

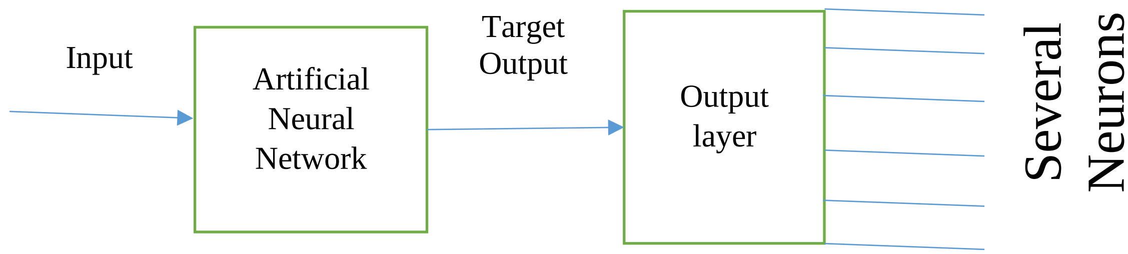

Figure 3.4 Competitive Learning Illustration

Competitive learning can also be viewed as a random specialization process. When an ANN with competitive learning is part of a greater ANN system. Then, because of connectivity issues. This random specialization may not always be desired. In this case one might try reinforced learning. Competitive learning is frequently encountered in groups of people where each number of the group was selected and trained to perform specific tasks based on the principle of the right time at the right place.

3.5 The Learning Rules

3.5.1 The Delta Rule

The delta rule is based on the idea of continuous adjustments of the value weight such that the difference of error (delta) between the desired (or target) output value and the processing element is reduced.

3.5.2 Gradient Descent Rule

The values of the weight are adjusted by an amount proportional to the first derivative (the gradient) of the error between the desired (or target) output value and the weight. The goal is to decrease (descend) the error function, avoiding local minima and reaching the actual or global minimum.

3.5.3 Hebbian Learning Rule

Donald Hebb in 1949 stated that "when an axon of cell A is near though to excite a cell B and repeatedly or persistently takes place infirming it, some growth process or metallic change takes place in one or both cell such that A's efficiency as one of the cells firing B is increased". Hebbian learning is thus derived from the work of Professor Donald Hebb. From Hebb's work, the synaptic strength (known as weight) between cell A and cell B is modified according to the degree of correlated activity between input and output. Hebbian learning, is a type of learning encountered frequently in ANNs. Anti – Hebbian learning refers to artificial networks where the synaptic contacts are inhibitory only.

4.0 Summary and Conclusion

4.1 Summary of Achievement

From the research made to gather this report, it is possible to train artificial neural networks that closely resemble biological neural network.

- That Artificial Neural Networks can be trained as an expert in a domain of activity.
- That this trained Artificial Neural Networks can be used as a knowledge base, which can be used to train up a new expert.
- That feedback features that cost little to sustain can be incorporated to realize adaptive

  self – learning systems which gradually become more knowledgeable than the original domain experts used to create them.

4.2 Suggestion for Further Improvement

Further research should be conducted into the exact nature of the circuit comprising Artificial Neural Networks.

4.3 Conclusion

In developing countries there is a scarcity of qualified personnel in many fields of modern technology. As a result, more research should be carried out to design more and better Artificial Neural Networks to increase the developing rate of such countries.

Nevertheless, after the design and training of Artificial Neural Networks, care should be taken to ensure that they are put to good use to benefit present and future generations.

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