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BASICS OF ARTIFICIAL NEURAL NETWORKS FUTURE SCOPES AND APPLICATIONS

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ABSTRACT

Artificial neural network is a computer program inspired from the human brain that acts just like the human brain processes information. ANN's gather data or information similarly to that the brain does, that is by detecting patterns and learning through experience not by programming. An ANN is configured for specific purposes, such as pattern recognition or data classification, through a learning process.with the knowledge of the biological system involves adjustments to the synaptic connections that are present between neurons. This holds true for ANN as well. This paper gives an overview of the Artificial Neural Network and it also explains it's application and advantages.

INTRODUCTION

The study of the human brain has been an ongoing field of study for thousands of years. With the coming of the age of technology it was only natural that we try and harness this thinking process. In 1843 Warren McCulloch a neurophysiologist and Warren Pitts a young mathematician wrote a paper on how the neurons might work. They modelled the neural network with electrical circuits. Neural Networks have the ability to derive meaning from complicated and imprecise data at times that can be used to find meaning in data that human brain or other computer techniques fail to notice. This could be detecting trends, extracting data, observing trends. A trained neural network can be considered as an "expert" in the category of information it has been given to process. Other advantages of a neural network are :

1. Adaptive Learning – An ability to learn how to complete tasks based on the initial experience or training.
2. Self-Organization – An ANN can make it's own representation of the data it gets during the learning state.
3. Real Time Operation – ANN operations can be carried out in parallel and special hardware devices are being designed and manufactured which take advantage of this capability.
4. Fault Tolerance – Partial destruction of a network leads to degradation of performance. But just like with the human brain, some capabilities may still be retained even with major network damage.

The problem solving approach of an ANN is different from that of conventional computers. Conventional computers use an algorithmic approach that means that the computer follows a given set of instruction that it follows in order to solve a problem. Unless the program knows what steps to follow to solve the problem it won't be able to. This in turn restricts the capabilities of a conventional computer to problems that we already know how to solve. But what if computers could solve problems, we don't know how to solve? That is exactly what a neural network does. They process information in a similar way to the brain. The network is consisting of highly interconnected processing elements (similar to neurons in a brain) that are working in parallel to solve a problem To do specific tasks neural networks cannot be programmed to do specific tasks rather neural networks learn by example, these examples need to be selected very carefully otherwise time might be wasted or in a worse

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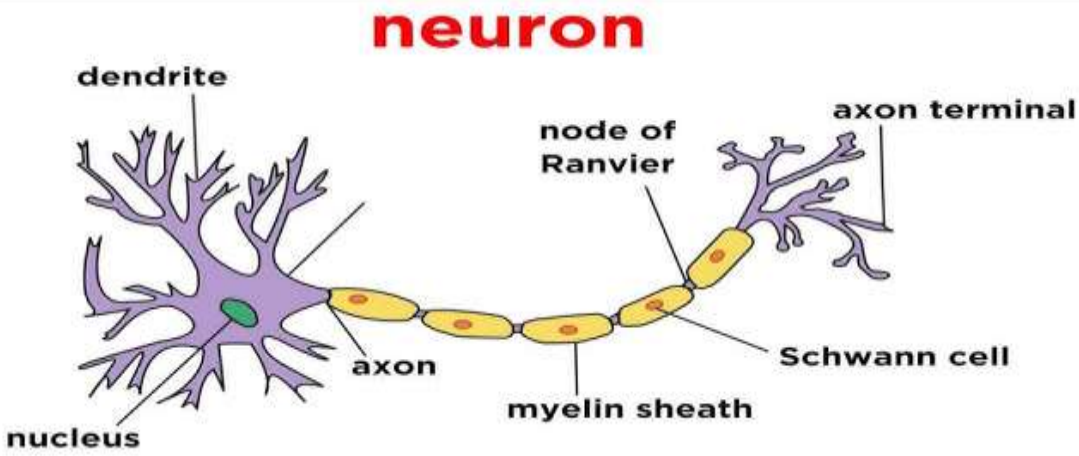
situation the network might not function correctly. The disadvantage is because the network finds how to solve the problem by itself, the operation can then be very unpredictable. Whereas, conventional computers use a cognitive approach, to solve a given problem; the steps to solve the problem must be known and stated in small unambiguous instructions .Neural networks and conventional computers are not in competition with each other rather they complement each other. Some tasks are more suited for conventional algorithmic computers like arithmetic operations and tasks that are better suited for the neural networks. Also a large number of tasks that are more suited to a combination of the two approaches in order to perform maximum efficiency.



What is an Artificial Neural Network?

Neural Networks are a set of algorithms that are inspired by how the human brain functions. When you open your eyes what you see and what you feel is processed by the neurons in your brain, that then recognises what is around you. That's how similar the Neural Networks work. They take a big set of data, process the data and output what it is.

Neural Networks are sometimes called as ANN's (Artificial Neural Network) because unlike neurons in our brain they are artificial. They mimic nature and also the functioning of a neural network. ANN's consist of a big number of elements that are highly interconnected that are working in unison to solve problems.

The advancements in biological research promises an understanding of how the natural thinking mechanism works. Research explains that the brain processes information as patterns. some of these patterns are complicated and allow us the ability to recognise faces, understand facial expressions, deduce emotions and so much more. Using ANN's and the knowledge of the working of a human brain we can design machines that can work just like a human brain does and work on complex problems that are difficult. for the human brain to solve.

Traditionally the neural network used to be referred as network or circuit of a biological neuron, but the modern term refers to mostly as ANN. ANN is a mathematical model that is inspired by how the biological nervous system, such as brain information system. ANN is made up of interconnected artificial neurons that are programmed to work just like neurons in our brain so that they process the problems in unison just like a brain. An ANN is used in speech recognition, image analysis, adaptive control etc. These applications are done through a process that is similar to how a human brain learns things.

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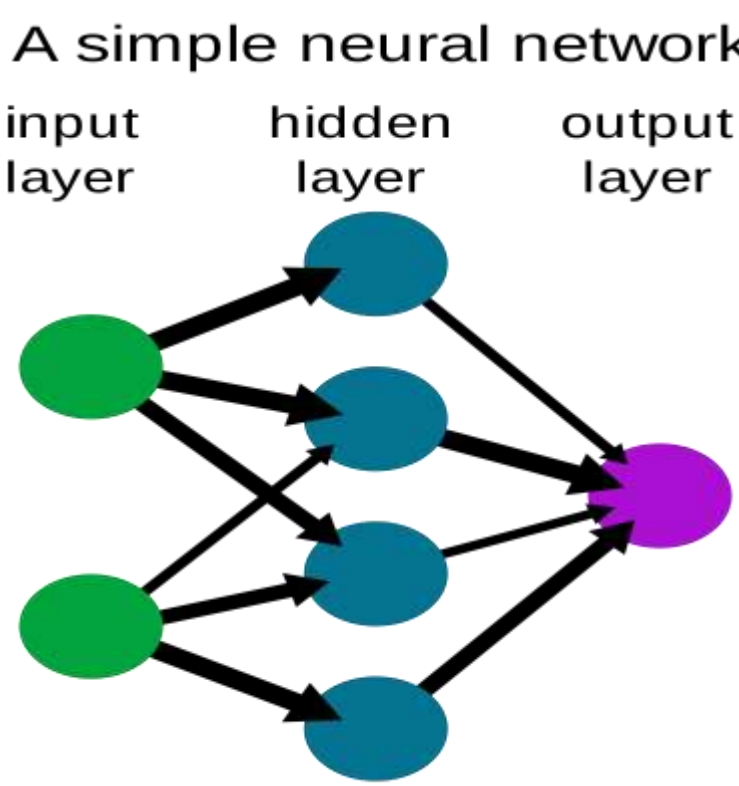

Working of ANN

The use of neural networks revolves arounds the ways in which these individual neurons can be clustered together. This clustering also occurs in the human mind, which in turn processes information and then it can be processed in an interactive, dynamic and self organized way. Biologically the neurons are capable of nearly endless interconnections.The neural network is a three dimensional network made up of microscopic components This is not true and not possible for any man made network. The current technology using integrated circuits are two dimensional with a limited number of layers for interconnections. This in turn restricts the type and scope of artificial neural networks that can be implemented in silicon.

Currently neural networks are just simple clusters of primitive artificial neurons. This clustering is achieved by creating layers which are then connected to each other.

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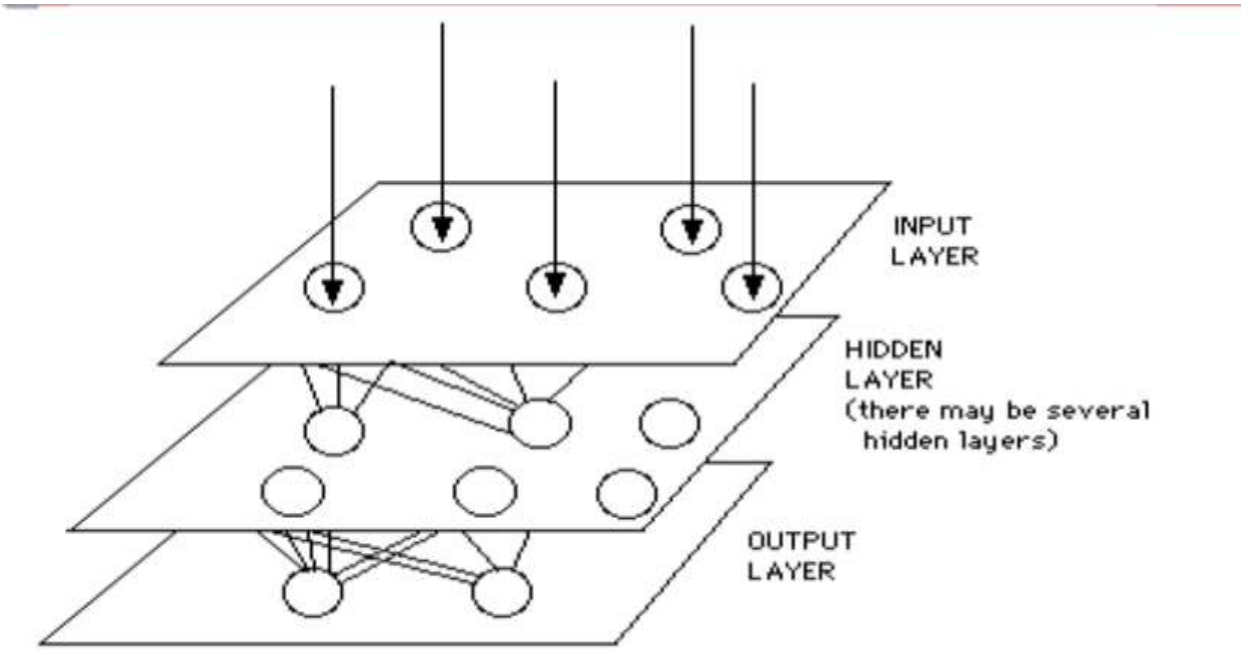

All artificial neural networks have a similar structure or topology as shown in the Figure.In this structure the neurons interact with the real world to get inputs. While other neurons provide the real world with the outputs processed by the network.The output is the particular character that the network has scanned or the image it thinks is being viewed. The rest of the Neurons are hidden from the view. A neural network is a little more than just a bunch of neurons. Early researchers tried to connect neurons in a random order which did not work and had no success. Now it is known that even a snail has a brain that is structured. The easiest way to design a structure is to create layers of elements. Grouping of these neurons into layers, connection between these layers, the summation and transfer function that comprises a functional neural network.

Although there are networks that consist of just one layer or sometimes even one element, most applications require at least three normal types of layers. These are input, hidden and output. The neurons in the input layer receive data from the input files in real-time application. The output layer sends the information directly to the outside world to other devices such as a control system. Between these layers lies many hidden layers, this is because we can't see their output even if they're part of the model, these internal layers contain many types of neurons in interconnected structures. The input and output of these hidden neurons simply go to other neurons.

In most of the neurons there is a hidden neuron which usually receives inputs from the input layer. Once the neuron completes its function it passes the output to all the neurons in the layer below itself providing a feedforward path to the output.

These lines of communication from neuron to another is an important aspect of neural networks. They hold the system together. These connections provide variable strength to an input. There are two types of these connections. One causes the summing mechanism of the next neuron to add while the other causes it to subtract..To put it into human terms one will excite while the other inhibits.

In some networks there's a need for a neuron to inhibit the other neuron in the same layer. This is called lateral inhibition. This is mostly commonly found in the output layer. For example in text recognition if the probability of a character being a "P" is .95 and the probability of the character being an "F" is .85, the network wants to choose the highest probability and inhibit all the others.This concept is known as competition.

Another type of connection is feedback.This is where the output of one layer is routed back to the previous layer.

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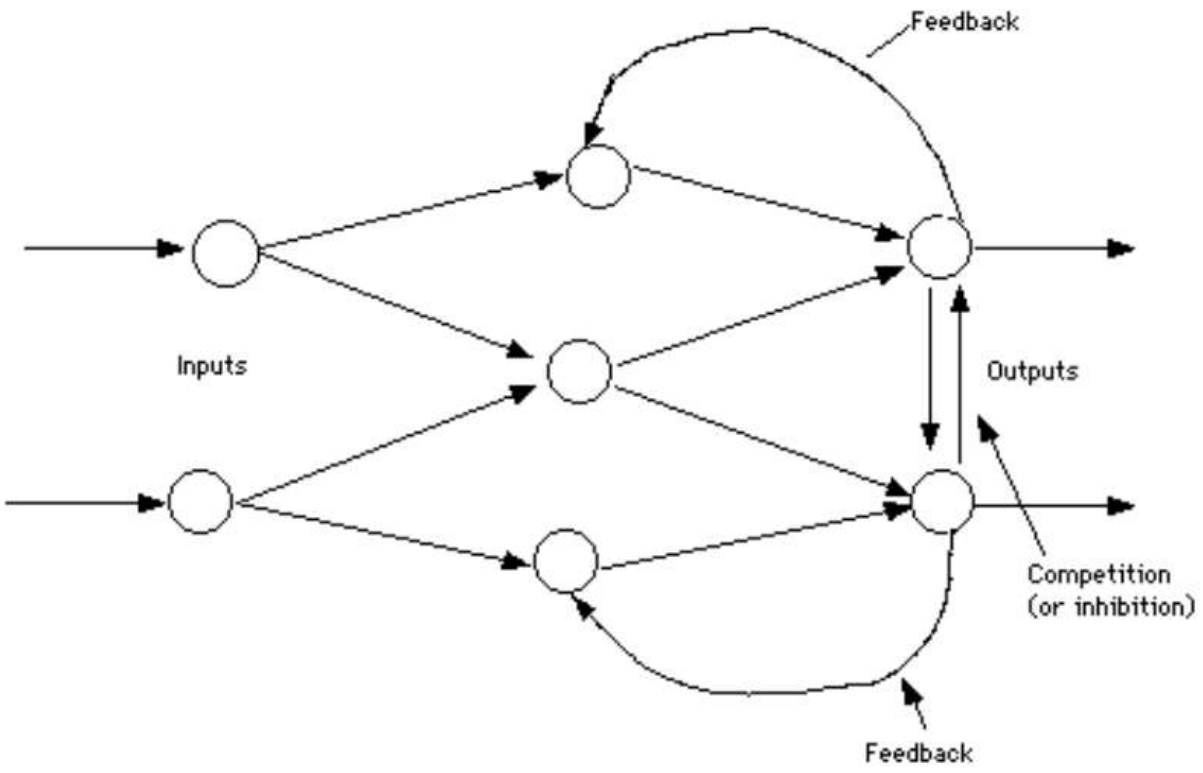

Figure 2:- Simple Network with Feedback and Competition.

The way that the neurons are connected to each other impact significantly on the operation of the network. In a large , more professional software development package the user is allowed to add, delete, and control these connections at will. By tweaking parameters these connections can be made to either be excited or inhibited.

TRAINING AN ARTIFICIAL NEURAL NETWORK

After a network has been structured for a particular application, that network can then be trained. To start this process the initial weight are taken at random. Then, the training or learning can begin. There are two approaches to training a network - Supervised and Unsupervised, Supervised training is where It is defined by its use of labeled datasets to train algorithms to classify data or predict outcomes accurately. As input data is fed into the model, it adjusts its weights through a reinforcement learning process, which ensures that the model has been fitted appropriately. Unsupervised training on the other hand is where the network has to make sense of the given inputs/ data by itself without any outside help. Vastly most networks use supervised learning whereas unsupervised learning is used to perform some initial characterization on the inputs. However, in the full blown sense of being truly self learning, it is still just a shining promise that is not fully understood.

1. **SupervisedLearning**

   In supervised learning the network is given both, the inputs and the outputs. The network processes the inputs and then

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compares the results with the desired outputs, Errors then propagate back to the system and weights are adjusted which in turn control the system. This process occurs over and over again this is because weights are continually tweaked. The set of data which enables training a network is known as "training set". During the training of a network the same set of data is processed multiple times over and over again so as to refine the connections weights. The current commercial tools provide tools that are helpful in monitoring how close the network is to predicting or calculating the correct answer. These tools allow the training processes to go on for days stopping only, if and when the system reaches the desired statistical point, or accuracy. However, some networks never learn, this can happen because of multiple reasons , input data may not contain specific information needed for the desired output, Networks may not converge if there is not enough data that can enable complete learning. In an ideal condition there's enough data so that to enable complete learning. There should be enough data that a part of it can be held back as a test after the learning process of the system completes.Networks with multiple layers are capable of memorizing data. To monitor the network to determine whether the system is simply memorizing its data in some non significant way, therefore supervised training needs to hold back a set of data so that the system can be tested after it has undergone its training.

If a network simply can't solve the problem, then a review of the inputs and outputs must be conducted, the number of layers, connection between the layers, the summation, transfers, and training functions and also even the initial weights themselves. There's a lot of rules that are used in implementing the adaptive feedback required to adjust weights during training. The most common of these is known as back-propagation. The various learning techniques are explored in greater depth later in this report.

Training is not just a technique it involves conscious analysis so as to ensure that the network is not over trained. Initially, an artificial neural network configures itself according to the general statistical trend of the given data. Later on it continues to "learn" about other aspects of the given data which may not be correct from a general viewpoint. When the learning phase is completed and no further learning is needed, the weights can be frozen if desired. Some systems are then turned into hardware so that it can be quick.

2. **Unsupervised Learning or Adaptive Learning.**
   In unsupervised training the network is provided with inputs but not the outputs for the given inputs.The system must decide itself what features it will use to group the input data. This is also known as adaptation or self-organization. Currently,unsupervised learning is not very well understood. This adaptation would enable robots and machines to learn on their own as they encounter new situations and environments. Human life is filled with situations where training sets are impossible to exist. Be it mountain climbing, wars there's so many situations where a complete new environment and unknown situations one might face, therefore there continues to be research into and hope for this field.

Real World Applications of ANN

There are endless possibilities with the Artificial Neural Networks some of them are :

1. Speech Recognition holds a very prominent role in interaction between humans.and although limited we're progressing towards a future where communicating with a machine will be very lifelike,
2. Character Recognition is very much possible with a trained ANN.
3. Classification, which includes pattern and sequence recognition, sequential decision making.
4. Human Face Recognition biometric ability of a machine to identify a face with a well trained neural network is very much possible.
5. Self Driving Vehicles may seem like a far off future but it is possible and is being implemented in electric cars throughout the world and is a forefront for the future,

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Challenges of Neural Network

Some of the challenges we face with Neural Networks are :

1. Training - With the neural networks, particularly in robotics applications, excessive training is necessary for real world operations. We can overcome this by randomly shuffling training examples. Using a numerical optimization algorithm, small steps in place of large steps. Another way can be by grouping examples in mini-batches. This in turn improves efficiencies and convergence capabilities is an ongoing research area.
2. Theoretical issues - Problems remain to be unsolved, even with the most sophisticated neural network.
3. Inauthenticity - The theoretical challenges we address above arise because neural networks don't function exactly like a human brain does they operate like a brain. The specifics of how a brain completely functions is still unknown. ANN's don't replicate the human brain but merely use them as an inspiration. Statistical association is possible because of this, which is the basis of artificial neural networks.
4. Hardware Issues - The focus on neural networks is due to the huge increase in computation power since 1991, which in turn has enabled the increase in greater multi-layering and deep learning and use of multiple parallel GPU's (Graphical Processing Unit) has reduced the time required significantly. Despite this, the hardware needed specifically for AI is being innovated and designed but there's a lot of time before we reach there.
5. Hybrids - To overcome some of the challenges of neural networks, there's a proposal to combine neural networks with symbolic AI. Humans possess an unequivocal form that uses symbols and rules. So far, the difficulties of developing symbolic AI have been unresolvable — but that status may soon change.

The Future of Neural Networks

Some likely developments in neural network technologies are :

1. **Fuzzy Logic Integration -** This recognizes that are more than just true or false values - it takes into account concepts that are relative, like somewhat, sometimes and usually. Fuzzy logic will be an essential feature in future neural network applications.
2. **Pulsed Neural Network -** Recent neurobiological experiment data has clarified that brains communicate and connect through pulsing and use the timing of pulses to transmit information and perform computations. This has accelerated research including theoretical analysis, model development, neurobiological modelling and hardware deployment, This all is to make computing come closer to the way our brains function.
3. **Specialized Hardware -** There's a development explosion to create hardware that will increase the speed of computation and also lower the cost of neural networks in turn. Established companies and startups are racing to develop improved chips and graphic processing units, but the real news is the fast development of neural network processing units (NNPUs) and other hardware which is specific to AI is collectively referred to as *neurosynaptic architectures.*
4. **Improvement in existing technologies -** New software and hardware along with the current neural network technologies and the increased computing power of neurosynaptic architectures, is just a start of what neural networks can do and the endless possibilities that lie ahead of us.
5. **Robotics -** There's countless predictions that say we'll have robots that will be like us, feel like us, talk like us. However, futurist Yonck says that we still have a very long way to go before robots replace us.

CONCLUSION

In this paper we have discussed the basics and and working of an ANN. Also training phases of an ANN. Depending upon the nature of the application and the strength of internal data patterns a ANN has a big advantage over conventional networks. Over the conventional techniques ANN provides an analytical alternative. Conventional systems on the other hand are limited by assumptions of normality, linearity and variable independence. This allows users with the power of ANN to quickly and easily model phenomenons that are relatively difficult or impossible to explain otherwise. Neural Networks are progressing at a very fast pace, it holds the key to our future, with the development of better hardware and new knowledge of the brain we can truly progress towards

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an automated future where everything that could be controlled without us having to do anything.

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