International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 10 Issue: 02 | Feb 2023 www.irjet.net p-ISSN: 2395-0072

Artificial Neural Network: A brief study

Mayuri Thorat[1], Shraddha V. Pandit[2], Supriya Balote[3]

[1]Student, Dept. of Artificial Intelligence and Machine Learning, PES's Modern College Of Engineering, Pune, Maharashtra, India
[2]Associate Professor, Dept. of Artificial Intelligence and Data Science, PES's Modern College Of Engineering, Pune, Maharashtra, India
[3]Assistant Professor, Dept. of Artificial Intelligence and Machine Learning, PES's Modern College Of Engineering, Pune, Maharashtra, India

---

Abstract - *An Artificial Neural Network (ANN) is a data processing paradigm inspired by the way biological nervous systems, such as the brain, process data. The unique structure of the information processing system is a crucial component of this paradigm. It is made up of a huge number of highly interconnected processing elements (neurons) that work together to solve issues. ANNs, like humans, learn by example, and a huge dataset results in more accuracy. Through a learning process, an ANN is trained for a specific application, such as pattern recognition or data classification. This is also true of ANNs. This paper provides an overview of Artificial Neural Networks (ANN), their working, and training. It also describes the application and benefits of ANN.*

Key Words: **ANN (Artificial Neural Network), Neurons**

1. INTRODUCTION

A person who knows how to solve a problem could give the computer instructions on how to solve that specific problem, so we first should know the answer to that problem or we should know how to overcome the problem that is in front of us. The computer follows a set of instructions to solve a problem, but without the specific steps that the computer needs to follow or know, the computer cannot assault the problem. This limits the ability of conventional computers to solve problems to those that he already knows how to understand and solve. However, what about those issues? Whose response we are unsure of, hence networks were used instead of our conventional strategy in that situation.

In essence, neural networks process information like that of the human brain, and these networks learn from examples. They will learn from their experiences and from the examples they are given; you cannot program them to carry out a certain task. ANN is primarily motivated by neurons, which are nothing more than your brain cells and how the human brain functions [4]. A vast network of processing components makes up our brains. The drawback is that the network solves the problem on its own.

A network of 10 billion neurons can be found in a typical brain. Axon: Output, Synaptic: Link, Cell body: Processor, Dendrites: Input (as shown in fig 1). Here is a diagram of a neuron, which essentially shows how a biological neuron receives input from other sources, combines that input and then performs a general operation. This is similar to how the human brain learns from experience and examples. Dendrites tries will receive signals from the other neurons, transfers them to the cell body, and the cell body will perform some function; this function may be summation or multiplication. After performing the set of inputs by exam, it is transferred to the next. We aim to build a network to do that as well. A network of 10 billion neurons can be found in a typical brain. Axon: Output, Synaptic: Link, Cell body: Processor, Dendrites: Input (as shown in fig 1). Here is a diagram of a neuron, which essentially shows how a biological neuron [4] receives input from other sources, combines that input and then performs a general operation. This is similar to how the human brain learns from experience and examples. Dendrites tries will receive signals from the other neurons, transfers them to the cell body, and the cell body will perform some function; this function may be summation or multiplication. After performing the set of inputs by exam, it is transferred to the next. We aim to build a network to do that as well. We are interested in developing artificial neural networks (ANNs) for two primary reasons:

Technical viewpoint**:** Some issues, like character recognition or predicting a system's future states, call for highly parallel and adaptive processing.

Biological viewpoint: ANNs can be used to recreate and model human (or animal) brain components, providing insight into natural information processing. ANN is a problem-solving technique that involves creating software that functions similarly to our brains.

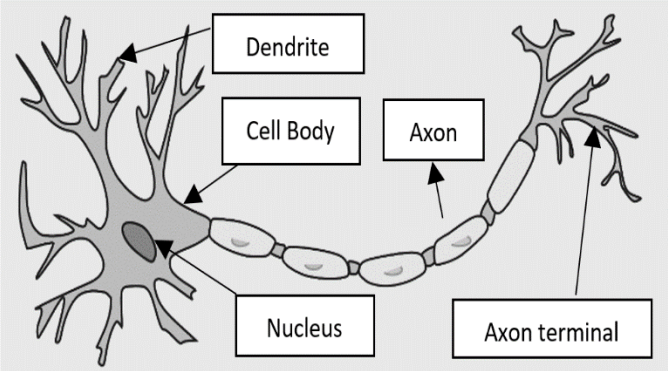

Fig 1:- A Simple Neuron Diagram.

1.1 What is ANN?

In essence, artificial neural networks are a class of computing systems developed to analyze and process data like that of the human brain. Artificial neural networks can be tailored for a particular application and possess self-learning features that enable them to produce improved results as new data becomes available. The ability to translate websites into several languages, use virtual assistants to do online grocery orders, and identify patterns and classify data are all made possible by neural networks. Artificial neural networks (ANNs) are computational networks that are biologically inspired As shown in Fig. 3. Artificial neural networks are a technology based on brain and nervous system research. These networks mimic biological neural networks, although they use a subset of the principles found in biological brain systems. ANN models, in particular, imitate the electrical activity of the brain and nervous system. Processing elements communicate with one another. An artificial neural network is made up of three or more interconnected layers. The first layer is made up of input neurons. Those neurons send data to the deeper layers, which deliver the final output data to the last output layer. The inner layers are all hidden and built by units that change the information received from layer to layer adaptively through a sequence of transformations. Each layer serves as both an input and output layer, allowing the ANN to comprehend more complicated things. These inner layers are referred to collectively as the neural layer. To arrive at solutions, ANN uses data samples rather than whole data sets, which saves both time and money. ANNs are simple mathematical models used to improve existing data analysis technology. A basic neural network is composed of three main components: An input layer, a hidden layer [5], and an output layer are components of an artificial neural network.

Input Layer: Also known as Input Nodes, this layer contains the inputs/information from the outside world that the model uses to learn and draw conclusions. Input nodes send data to the following layer, the Hidden layer.

Hidden Layer: A hidden layer is a group of neurons that do all computations on the input data [5]. There can be any number of hidden layers in a neural network. The most basic network has a single hidden layer

Output layer: The output layer contains the model's output/conclusions produced from all calculations. The output layer could have one or more nodes.

Advantages

- Adapt to new circumstances
- Powerful, it can simulate intricate functions
- Easy to use, learn by doing, and requires relatively little domain-specific knowledge from the user

Disadvantages

- Forgets
- Not exact
- Large complexity of the network structure

The model may generalize and forecast unseen data after learning from the initial inputs and their associations, as well as from unforeseen relationships inferred from unobserved data.

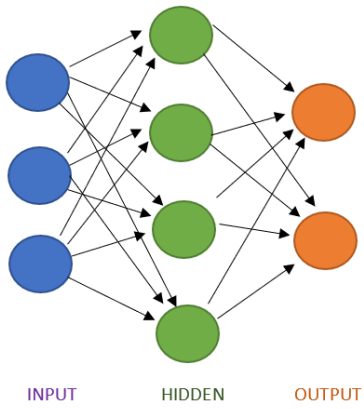

Fig 2:- A Simple ANN Diagram.

2. ADVANTAGES

1. A linear program cannot carry out tasks that a neural network can. Due to its parallel properties, the neural network can continue functioning even when one of its components falters.

2. After training, the system can generate output without requiring complete inputs.

3. Since Neural Networks are made to make robots function like people, they have several advantages over human replacements and a wide range of applications. agriculture, mining, engineering, and other fields.

4. ANN does not place any limitations on the input variables, in contrast to many other prediction algorithms. Learning, rather than programming, is used to construct the system.

5. ANNs can learn and model non-linear and complicated interactions, which is crucial because many of the relationships between inputs and outputs in real-life situations are non-linear and complex.

6. One of the many advantages of neural networks is their ability to multitask. The design of new, sophisticated programs allows them to multitask

7. And produce multiple effects. A task that could take humans longer hours to complete can be completed swiftly by a machine if it is properly programmed.

8. Any application can use it to execute it.

9. The complete software backup is accessible online if the hardware is damaged or fails.

10. Neural networks make decisions and don't need to be reprogrammed [4].

3. APPLICATIONS

With countless applications being implemented every day, various real- time applications of Artificial Neural Networks are as follows.

1. Handwriting Recognition: Handwritten characters are transformed into digital characters that a computer can read using neural networks.

2. Stock Exchange prediction: The stock exchange is

3. Travelling Issues of sales professionals: It deals with determining the best route between cities in a specific region.

4. Image compression: The goal of neural network data compression is to replicate the original image by storing, encrypting, and compressing it once again. we can use picture compression neural networks to reduce the amount of our data.

5. Function approximation: including time series prediction and modelling.

6. Classification: including patterns and sequence recognition, novelty detection and sequential decision-making.

7. Data processing: including filtering, clustering blinds source separation and compression. (data mining, e-mail Spam finding)

8. Monitoring of the environment: ANNs can be used to forecast natural occurrences including weather, air quality, and earthquakes.

9. Marketing: ANNs can be used in consumer segmentation and tailored advertising to forecast customer behavior and optimize marketing strategies.

10. Cybersecurity : It can be utilized for tasks like virus detection, intrusion detection, and network traffic analysis in the field of cybersecurity.

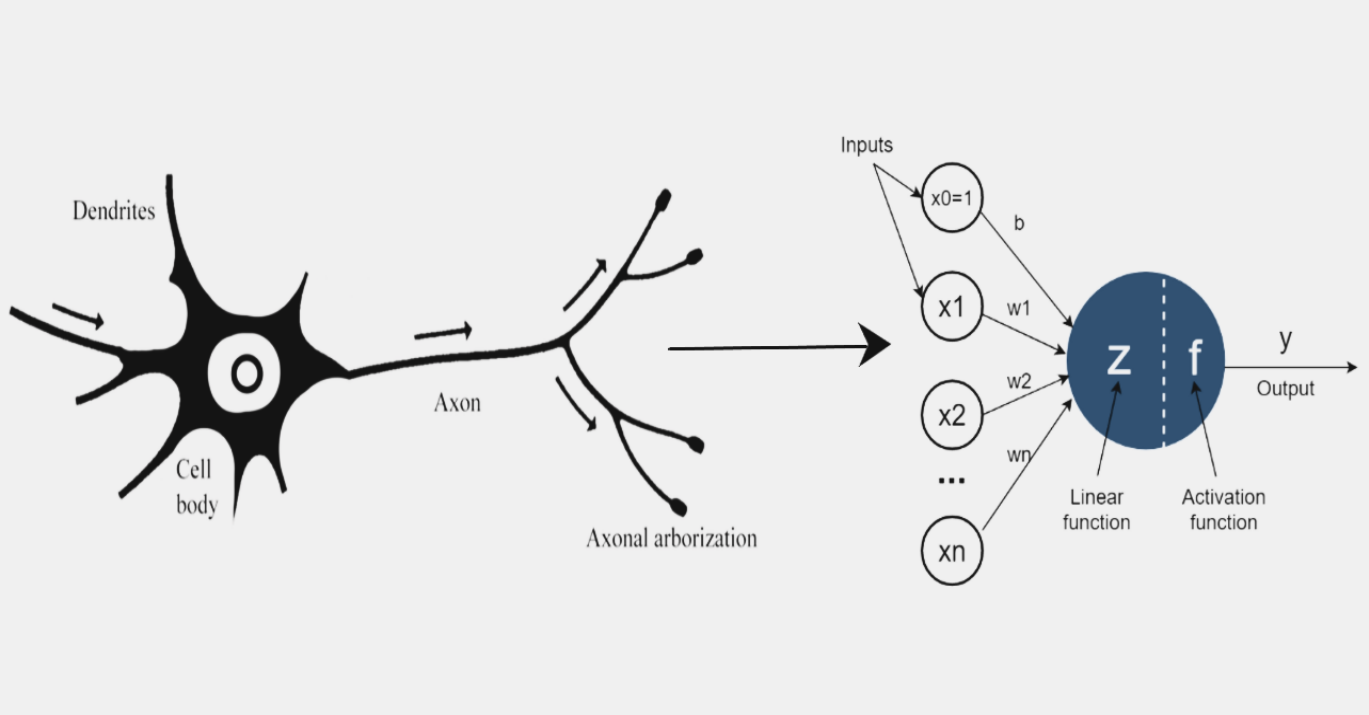

Fig 3:- A simple neuron and ANN comparison diagram

4. WORKING OF AN ANN

Artificial neural networks are built in the same way as the human brain is, with neuron nodes connected in a web-like pattern. The human brain is made up of billions of neurons. Each neuron is made up of a cell body that transports information to and from the brain. The primary principle behind such networks is inspired by how the human neural system processes data and information to learn and develop knowledge. The fundamental component of this concept is the development of new structures for the information processing system. The system is composed of a huge number of highly interconnected processing components known as neurons that collaborate to solve problems and communicate information via synapses (electromagnetic connections).

The neurons are tightly linked and grouped into layers. The data is received by the input layer, and the ultimate result is generated by the output layer. Typically, one or more secret layers are placed between the two. The number of hidden layers is determined by the application under consideration. The output of the input layer becomes the input of the hidden layer, while the output of the hidden layer becomes the input of the output layer. This configuration makes anticipating or knowing the precise flow of data challenges. In real-time applications, the layer of input neurons receives data either through input files or directly from electrical sensors. The output layer sends data to the outside world, a secondary computer operation, or other devices such as a mechanical control system. Many hidden levels can exist between these two layers. Many neurons are found in these internal layers in diverse interrelated systems. Each of these hidden neurons' inputs and outputs simply goes to other neurons. All artificial neural networks have a similar structure or topology as shown in Figure 4. In most networks, each neuron in a hidden layer gets signals from all neurons in the layer above it, which is often an input layer. After completing its role, a neuron sends its output to all neurons in the layer below it, creating a feedforward path to the output. These routes of communication between neurons are critical components of neural networks. They are the connections that supply varying levels of strength to an input. These links are classified into two sorts. One causes the following neuron's summing mechanism to add, while the other causes it to remove. In human words, one excites while the other inhibits.

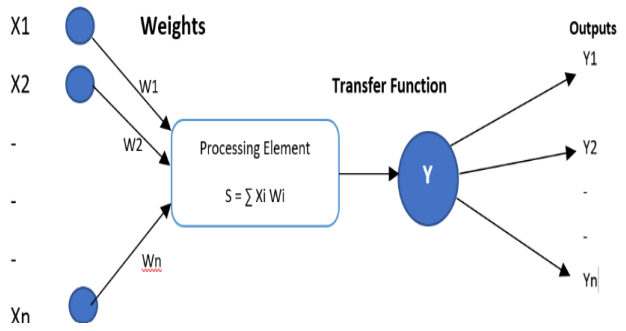

Fig 4:- An ANN's Diagram with activation function (Y).

As shown in the figure, we have various inputs (X1, X2, ... Xn) and corresponding weights [5] (W1, W2, ... Wn). We calculate the weighted sum of some of these inputs and then pass them through an activation function [5], which is nothing more than a threshold value.

Threshold Value: The threshold value decides whether a neuron fires or not. Above the threshold value, the neuron fires; otherwise, it does not fire. Artificial neural networks are made up of a large number of artificial neurons, each with its activation function [1] and a processing element. Perceptron has two modes: training mode and using mode.

Training mode: The neuron can be programmed to fire or not fire in response to specific input patterns.

Using mode: When a taught input pattern is detected at the input, the related output is set to the current output.

We must first train our perceptron, and only then can we use it. We give more weight to more significant factors and less weight to less important factors. Weight W1 is assigned to input X1, similarly, X2 is assigned to W2, and Xn is assigned to Wn [3].

Example: X1, X2 and X3 are the inputs. Weights = W1, W2, W3 and Threshold = P

Calculation: O = X1 x W1 + X2 x W2 + X3 x W3

If P (Threshold Value) is greater than O, the neuron is activated. Each layer will attempt to obtain a more abstract version of the input.

5. TRAINING AN ANN

When a network has been structured for a specific application, it is ready to be trained. The initial weights are picked at random to begin this process. The training, or learning, process then begins. Training methods are classified into three types: supervised, unsupervised, and Reinforcement Training. Both the inputs and the outputs are provided in supervised training. Unsupervised training provides the network with inputs but not the expected outputs. The system must then pick which features will be used to group the supplied data. Supervised learning, Reinforcement learning, and Unsupervised learning are the three types of ANN training. There are some drawbacks to adopting supervised learning. These constraints can be bypassed by employing the unsupervised learning technique.

A. Supervised Training [5].

The first type of training technique is supervised training. Where we are given both inputs and outputs. Backpropagation is the most often used algorithm for the supervised training of multi-layer perceptron's. To reduce the error, we propagate backwards and update the weights after the weighted sum of inputs and travel through the activation function. The output is often referred to as the stop condition. If our actual outcome matches the desired output, we can stop executing the algorithm (we have reached our goal state). If there is a disparity between the target and actual output, it is due to an error factor. If the factor is discovered using the formula [3],

$$E\ total = \sum \left[\!\left[1/2(\text{target} - O/P(\text{actual output}))^2 \right.\right.$$

We employ backpropagation [5] to reduce this error by modifying weights (By increasing and decreasing values of weights). This is a trial-and-error strategy for achieving a zero-error factor. It is the fastest learning mechanism with high accuracy. Many different tasks, including as classification, regression, and sequence prediction, can be accomplished by supervised learning. For instance, in image classification, an image serves as the input, and the label identifying the object or category in the image serves as the output. Regression produces continuous values, such as the price of a house depending on its characteristics. In sequence prediction, the network learns to foretell the following element in a chain, such as the word that will come next in a sentence. For training, supervised learning needs a lot of labelled data, which can be expensive and time-consuming to acquire. Nonetheless, it has been effective in a variety of applications, including computer vision, natural language processing, and speech recognition.

B. Unsupervised Training.

Unsupervised training is the second type of training. The network is given inputs but not the desired outputs during unsupervised training. The system must then pick which features will be used to group the input data. It is an independent learning process which requires no help from a supervisor and contains an unlabeled dataset. It is used to uncover hidden patterns. Autoencoders are one popular unsupervised learning method used in ANN training. Using neural networks, autoencoders can be trained to encode input data into a lower-dimensional representation and then decode it to restore the original space. In order to reduce the

difference between the input and the reconstructed output, the network is trained. Data compression, feature extraction, and dimensionality reduction are all tasks that can be accomplished with autoencoders. Clustering is a typical unsupervised learning method used in ANN training. Based on a similarity metric, clustering algorithms combine similar data points. In unsupervised learning, the network learns to map input data points to the corresponding cluster labels using the output of clustering algorithms. Tasks including anomaly detection, categorization, and recommendation systems can be accomplished using this method. In ANN training, generative adversarial networks (GANs) are another well-liked unsupervised learning method. A generator network and a discriminator network make up GANs. The discriminator learns to discriminate between actual and created data, while the generator learns to produce new data samples that mimic the input data. The networks are trained iteratively with the generator trying to trick the discriminator and the discriminator trying to classify the data accurately. Before ANNs are fine-tuned with supervised learning, they can be pretrained using unsupervised learning. By giving the network useful properties and lowering the amount of labelled data needed for training, pretraining can enhance network performance.

C. Reinforcement Training.

The third type is reinforcement training, It is also called as Markov decision process. It learns from feedback and past experiences. It is a long-term iterative process. The more feedback, the more accuracy. It is and combination of supervised and unsupervised training. Actor-critic training is a popular technique for ANNs with RL. The performer and the reviewer make up each of the two segments of the network in this strategy. The critic learns to estimate the value function, which is the predicted cumulative reward from a particular state, and the actor learns the policy. In order to update the policy, the value function offers feedback on the effectiveness of the activities made. The actor-critic technique is an iterative process where the critic changes the value function based on the observed rewards and the actor adjusts the policy based on feedback from the critic. Gradient descent is frequently used for the updates, and the gradients are calculated with consideration for the network's parameters

6. CONCLUSIONS

In this paper, we discussed how artificial neural networks (ANNs) work, and also an ANN's training stages. ANN has several benefits over the traditional method and applications of ANNs. We may soon witness additional developments in the use of neural networks, given how quickly businesses are adopting AI and machine learning at the moment. Users everywhere will have access to a wide range of customized options thanks to AI and machine learning. Neural networks, for instance, can enable the enhanced tailored experience that all mobile and web applications strive to provide you with depending on your search history. Neurology and psychology are also two fields of study that benefit from the study of neural networks. They are frequently employed to examine the inner workings of the brain and model certain aspects of living organizations. The transfer functions, size of the training sample, network topology, and weights adjusting technique are only a few examples of the many variables that determine how well ANNs perform.

REFERENCES

[1] Lippmann, R.P., 1987. An introduction to computing with neural nets. IEEE Accost. Speech Signal Process. Mag., April: 4-22.

[2]Nam Pham, Hao Yu, Bogdan M. Wilamowski, "Neural Network Trainer through Computer Networks", 2010 24th IEEE International Conference on Advanced Information Networking and Applications.

[3] K Ishthaq Ahamed, Dr. Shaheda Akthar, "Survey on Artificial Neural Network Learning Technique Algorithms", International Journal of Imaging and Robotics, [Formerly known as the "International Research Journal of Engineering and Technology (IRJET) Volume: 03 Issue: 02 | Feb-2016

[4] Roza Dastres, Mohsen Soori, "Artificial Neural Network Systems", International Journal of Imaging and Robotics, [Formerly known as the "International Journal of Imaging" (ISSN 0974-0627)] Volume 21; Issue No. 2; Year 2021; Int. J. Imag. Robot.

[5] Dr S.Maheswari, "Neural network based individual classification system", International Research Journal of Engineering and Technology (IRJET) Volume: 03 Issue: 02 | Feb-2016.

[6]Happiness Ugochi Dike, Yimin Zhou, Kranthi Kumar Deveerasetty, Qingtian Wu, "Unsupervised Learning Based On Artificial Neural Network: A Review", 2018 IEEE International Conference on Cyborg and Bionic Systems (CBS).

[7]Miguel Antonio Sovierzoski; Fernanda Isabel Marques Argoud; Fernando Mendes de Azevedo, "Evaluation of ANN Classifiers During Supervised Training with ROC Analysis and Cross Validation", 2008 International Conference on BioMedical Engineering and Informatics.