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BASICS OF ARTIFICIAL NEURAL NETWORK

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ABSTRACT

An Artificial Neural Network (ANN) is a typical model in machine learning that is inspired by the structure and function of the human brain. Its purpose is to imitate the functioning of human brain to solve complex problems. It is made up of three layers: input layer, hidden layer and output layer. ANN model output is dependent on some parameters that are, input, weights, summation function and activation function. ANN uses a training algorithm that is back propagation algorithm to learn the datasets. The main concept behind ANNs is to imitate the processing of information and learning from it the way human brain does. ANN is applied in image recognition, speech recognition and medical diagnosis. This paper gives the overview of Artificial Neural Network, Its architecture types, working, algorithms used and its pros & cons. It also explains how actually ANN works with the help of an example.

Keyword: Artificial Neural Network, activation function, back propagation algorithm, image recognition.

INTRODUCTION

The machine learning's algorithm, artificial neural network has evolved since its beginning to develop intelligent system that can imitate human-like processes. Artificial Neural Network is a computational model that works same as the functioning of human nervous system. That is, just like neurons in our nervous system are able to learn from past data, in the same way the ANN is able to learn from the data and provides output in the form of predictions and classifications. In 1943, it was assumed that the concept of neural network started with the work of Warren McCulloch and Walter Pitts when they modeled a simple neural network using electrical circuits in order to describe how neurons in brain might work. ANN is trained

using a training set where the model takes ‘n’ number of inputs to predict the most accurate output. There are several different architectures for ANN, most commonly used are: Feed-Forward Neural Network, Recurrent Neural Network and Convolutional Neural network.

LITERATURE SURVEY

A. Artificial Neural Network

Artificial Neural Network is a machine learning algorithm that is based on the neural structure of the brain whose goal is of having machines that can imitate the brain. It is a field of artificial intelligence where it attempts to imitate the human brain so that computers will understand things and make decision in a human-like manner. ANN is designed by programming computers to behave simply like interconnected brain cells.

In 1943, the foundation of ANN was traced by the work of Warren McCulloch and Walter Pitts. In their paper “A Logical Calculus of ideas Immanent in Neurons Activity”, they introduced a mathematical model of a simplified neuron known as McCulloch-Pitts neuron. This model provided basics for understanding neural networks.

The functioning of ANN is similar to the way neurons works in our nervous system. Artificial Neural Network primarily consists of three layers:

- Input layer – it accepts inputs in several different formats provided by the programmer.
- Hidden layer – it is present in between input and output layer. It performs all the calculations to find hidden features and patterns.
- Output layer – in this we get the desired outcome.

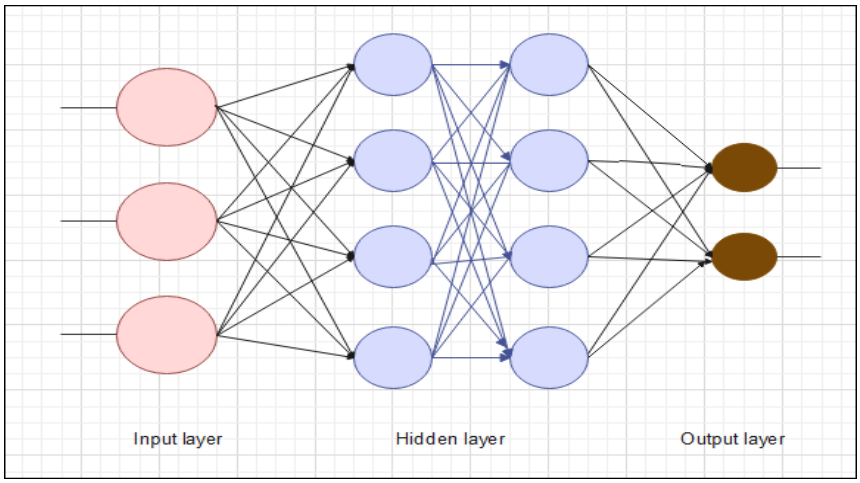

Figure 1: Structure of Artificial Neural Network

B. Review of Researchers

Initial research of neural networking began in the late 1800s with scientific attempt to achieve the activity of the human brain. In 1943, McCulloch and Pitts created a model of the neuron which laid the groundwork for neural network research.

In 1951, Marvin Minsky published the book "Perceptrons" which criticized the limitations of Perceptrons and it is also said that he made the first Artificial Neural Network while working in Princeton.

Researchers such as Rumelhart, Hinton and Williams demonstrated the ability of training multi-layer Perceptrons by Backpropagation algorithm. Backpropagation is a type of gradient descent algorithm used with ANN for reduction and curve-fitting.

In 1989, Yann LeCun's work on Convolutional Neural Network demonstrated the superior performance of image recognition tasks which is an application of artificial neural network that lead to their widespread adoption in the following decades.

Research in hardware acceleration that includes the use of Graphics Processing Units (GPU) and specialized chips becomes integral. Moreover, there is growing interest in neuromorphic computing which aims to design hardware architectures inspired by the principles of neural networks.

In 1987, the IEEE international conference was begun for ANN scientists.

METHODOLOGY

A. Working of ANN

Artificial Neural Network is a weighted directed graph, where the nodes are formed by the artificial neurons and the connection between the neuron outputs and neuron

inputs is represented by the directed edges with weights. The ANN receives the input signal from the external world in the form of patterns and image in the form of a vector. Then mathematically, these inputs are notated by x(n) for every 'n' number of inputs.

Each of the input has a weight associated with it, which is multiplied by input. In ANN these weights represent the strength of the interconnected neurons inside the artificial neural network. These weights are the details used by the ANNs to solve a certain problem.

If the sum of inputs associated with its weight equates to zero, a bias is added to make the output non-zero. Bias has the weight and the input which is always equal to 1. A certain threshold value is benchmarked to keep the response in limit of the desired value. And then the sum of weighted inputs is passed through the activation function.

The activation function obtains the result after the summation function has calculated the sum. Based on the output received, the activation function gives the appropriate result from the node and then obtains the final output.

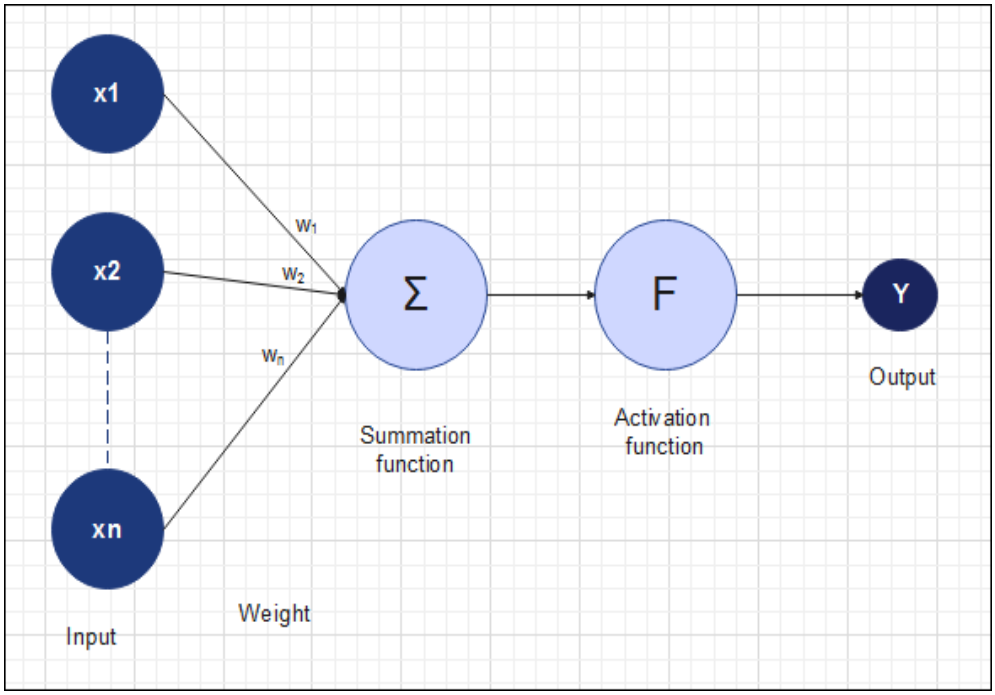

Figure 2: Working diagram of Artificial Neural Network

B. Training of Artificial Neural Network

We can train the neural network by feeding it by teaching patterns and letting it change its weight according to some learning rule. An ANN is designed and implemented in a way that the set of input data results into a desired output. The weights can be trained by feeding learning patterns into the solution, and by letting the net change the weights according to some learning rule.

Learning based solutions can be categorized as:

- Supervised Learning

  Supervised learning in which the network is trained by providing it with input and matching output patterns. And these input-output pairs can be provided by an external system that contains the neural network.

- Unsupervised Learning

  In this the output is trained to respond to a cluster of patterns within the input. Unsupervised learning uses a machine learning algorithm to analyze and cluster unlabeled datasets. Compared to the supervised learning method, there are no prior set of categories into which the patterns are to be classified.

- Reinforcement Learning

  This learning is considered as an intermediate form of the above two types of learning, which trains the model to return an optimum solution for a problem by taking a sequence of decisions by itself. The learning component grades its action based on the environmental response and adjusts its parameter according to it. The parameter adjustment process is continued until an equilibrium state surface where no further adjustments are necessary.

C. Algorithms Used In ANN

The neural network learns by adjusting its weights and bias repeatedly to yield the desired output. The training is performed using a defined set of rules that is learning algorithm. Here are some training algorithms which are used in training ANN:

- Gradient Descent Algorithm

  This is the simplest training algorithm used in case of a supervised training model. In case if the actual output is different from the target output, then this algorithm changes the weights of the network in such a manner to minimize the mistake. It aims to minimize the difference between predicted and actual values by iteratively adjusting the weights and biases of the network.

It is also a widely used optimization algorithm in Deep Learning that is used to minimize the cost function of a neural network model during its training.

- Backpropagation Algorithm

  It is a method for supervised learning used by neural network to update parameters to make the networks prediction more accurate. "Backward propagation of errors" is a crucial algorithm in training ANNs. It enables the network to learn from its mistake and adjust its parameters to minimize errors.

  Backpropagation involves computing the gradient of the loss with respect to each weight and bias in the network that is achieved through the application of the chain rule of calculus.

  Backpropagation is a foundational component of training ANN, providing a mechanism for the network to iteratively learn and improve its performance over time.

- Forward Propagation Algorithm

  It is a fundamental algorithm in ANNs that facilitates the computation of predicted outputs based on given input data. In short, forward propagation is the mechanism by which input data is processed through the layers of an ANN to produce predictions. This algorithm is an essential step both during training phase and when making predictions with a trained network.

  During training, forward propagation is followed by backward propagation, where the error between the predicted and actual outputs is calculated which is then used to update the weights and biases in the network, allowing it to learn and improve its performance.

APPLICATIONS OF ARTIFICIAL NEURAL NETWORK

There are many applications of Artificial Neural Network which are:

1. Facial Recognition

   Facial Recognition Systems are serving as robust system for close observations. Recognition Systems matches the human face and compares it with the digital images. They are used in offices for selective entries. Convolutional Neural Networks are used for facial recognition and image processing.

2. Social Media

ANNs are used here to study the behaviours of social media users. Multilayer Perceptron ANN is used to mine data from social media applications. This takes user's favourite instagram pages, bookmarked choices as inputs for training the MLP model.

3. Speech Recognition

In this, ANNs are used to transcribe spoken words into text. These technologies are used in virtual assistants like Siri, Alexa, and customer service chatbots that requires the ability to understand and respond to human speech.

4. Recommender Systems

In recommender systems, ANNs are used to analyze user behaviour and make recommendations about products, contents and services users are interested in. this technology is used by e-commerce websites and other online platforms to improve the user experience.

5. Fraud Detection

In this, ANNs are used to analyze financial transactions and identity patterns that indicate a fraud activity. This technology is being used by banks and other financial institutions to improve their security measures and prevent financial losses.

ADVANTAGES OF ARTIFICIAL NEURAL NETWORK

1. Adaptability and Learning

   ANNs can adapt and learn from data which allows them to improve their performance over time and is valuable in dynamic and changing environment.

2. Non-Liner Relationships

   ANNs are capable of learning non-linear relationships between inputs and outputs, making them useful for the applications like image and speech recognition.

3. Fault Tolerance

   ANN is fault tolerable which means that they can function correctly even if some of the neurons in the network are damaged or destroyed.

4. Parallel Processing

   ANN has the ability to perform many calculations simultaneously, which allows them to process large amounts of data quickly and efficiently.

5. Handling incomplete data

   ANN can generalize patterns from training data to make predictions on unseen data.

6. Feature Learning

   ANN can learn relevant features from data during training that eliminates the need for manual feature engineering, making them useful for tasks where extracting meaningful features is challenging.

CONCLUSION

In this paper we have discussed about the Artificial Neural Network, working and its training phases. There are various advantages of ANN like they can handle large amount of and process them fast and in an efficient way. ANN can capture many kinds of relationships which allow users to quickly and easily model phenomena which otherwise may have been very difficult to explain. Today neural network discussions are occurring everywhere. With the development of science and technology, artificial neural networks will inevitably become more mature, and their applications in various chemical processes will also become more common.

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