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Artificial Neural Network: A Survey

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Abstract

Artificial neural network (ANN)has emerged progressively in past few decades. This paper has highlighted the key components that have major influence on the prediction patterns generated by ANN. Literature survey emphasis the key areas which are benefited by neural networks.Its application is not restricted to a specific field now; it has gained popularity in various domains like science and engineering, food industry, energy industry, business, manufacturing and many more.

1. Introduction

An Artificial Neural Network (ANN) is the mappingof input and output signals using a model based on our understanding of how our brain reacts to the input received by our senses[1]. Similar to the densely interconnected network of biological neurons, ANN uses an artificial neuron or node network to solve learning issues. For over 50 years, simple ANNs have been used to model the approach of the brain to problem solving. It has evolved from studying basic functions like logical AND function and logical OR function for understanding the biological functionality of brain to giant distributed parallel architecture for solving real world problems like pattern recognition, face recognition, automation of smart devices and many other social, scientific and economic areas[2]. Neural networks are artificial systems that are inspired by biological neural networks. These systems learn to function without different datasets and instances without any task- specific rules[2, 3]. The idea is that the system identifies attributes from the data without being programmed with pre-sort understanding of the datasets. Neural networks are based on computational models for threshold logic. Threshold is a mixture of

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mathematics and logic algorithms. Neurons, links, weights, biases, propagation mechanisms, and a learning law are the components of a particular neural network.Evaluation of ANN application relies on various data analytical factors like performance, fault tolerance, processing speed, convergence, scalability and accuracy. In recent years, ANN is used preferably for function approximation in numerical prototypes due to its qualities of nonlinearity, self-learning, adaption and advanced input-output mapping techniques. These factors have evidently proven the efficiency and effectiveness of ANN in solving variety of problems from different spheres of life. ANN generates useful model that tends to imitate the functionality of the human brain and applied to machine learning and problem-solving.

1.1.Artificial Neural Network

In last few decades, Machine learning (ML) has been extensively used in various fields.Neural network is the subset of ML that has spawn Deep Learning [2]. Perceptron is the first neural network invented by Frank in 1958. ANN has solved various real world problems like stock exchange prediction, handwriting recognition, and image compression by using it learning and pattern recognition capabilities[4]. The key components of neural network that lead to complex modelling structure are activation function, network topology and training algorithm[3].

1.2.Activation function

The key feature of activation function is to process the input and determine whether it is to be passed through the network or not. It is a mathematical function that checks the relevance of input with respect to the model's prediction. Additionally, activation function has to be efficient in computational terms as it is enumerated over millions of neurons. Activation functions are broadly classified into three categories:

a. Binary Step Function

It is a threshold based step function that fires the neuron to pass the information if computed value is greater than or less than the threshold value. The major drawback of using binary step activation function is its inability to generate multivalued output.

b. Linear function

It is a single degree polynomial activation function that has the ability to generate multiple output but fails to maps complex data. It is of the form a = cb, where function derivative is constant and hence cannot backtrack for better predictions. Linear activation function collapses all layers of neural network into single layer that results in simple regression model.

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c. Non-Linear function

Non-linear are the most popular activation functions among the modern neural networks.They can learn and model complex data. Non-Linear functions overcomes problem of linear activation functions like backpropagation and piling up variant layers for complex neural network[5]. Sigmoid alternatively called as logistic activation function has gained popularity among nonlinear functions because output is bound in the range of 0 to 1 and tends to be differentiable[3]. It generates S shaped graph. Differential nature of sigmoid allows to perform computation across the range of input. Beside of its popularity, a variety of neural network algorithms exploit other alternatives too. Tangent hyperbolic function (tanh) is similar to sigmoid with a difference that it can model positive, neutral and negative values. Both sigmoid and tanh encounters vanishing gradient problem that slowdowns the process of reaching accurate prediction. Computational efficiency is achieved more easily in ReLu(Rectified linear unit) activation function. ReLu learns more quickly than Sigmoid and tanh activation functions. But it suffers from Dying ReLu problem, which means when the function gradient is zero then it stops learning and backpropagation. Leaky ReLu and Parametric ReLu are the two variations in ReLu to adjust the slope in negative area. The appropriateness of activation function rely on category of data it is going to operate on.

1.3.Network topology

The learning ability of any neural network depends number of hidden layers and number of neurons in each layer[6]. Topology of neural network is closely connected to complexity of the task. Set of nodes are grouped together to form different layers of network.

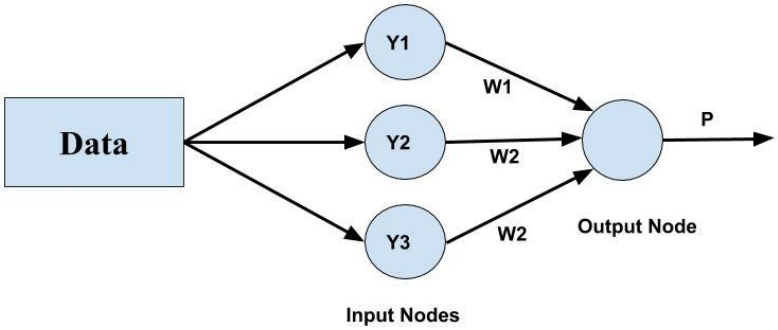

Fig.1.3.1 Single layer neural network

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Fig.1.3.1 represents the simplest network comprising of two layers where the first layer comprises of input nodes and other layer is of output node. Each input node process the individual feature of dataset and further it is connected with output nodes with some weights (w1, w2, and w3)[7]. Each Input node transforms the value of assigned attribute by applying its own activation function. Further, output node generate its final prediction by using its activation function. This single layer topology is used for basic classifications, but complex task requires mature learning which is achieved by more sophisticated networks.Fig.1.3.1 comprises of multiple hidden nodes that performs action on the signal received from input nodes before passing to the output node. Multilayer networks are mostly meshed network where each neuron in one layer is interleaved with each neuron in the next layer.The arrowheads in fig.1.3.1 show the flow of information in one direction and it is called as Feed forward network.The number of layers and number of nodes in each layer can vary and those networks that have multiple hidden layers are known as Deep Neural Networks. In order to train such networks, deep learning is used.

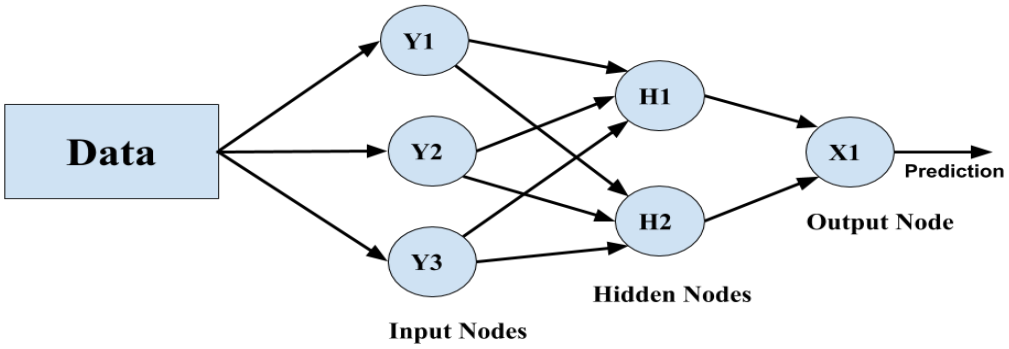

Fig.1.3.2 Multilayer neural network

Recurrent Neural Network (RNN) allow the flows in both directions with the use of loops, these are termed as feedback network. Fig.1.3.3 is the simple demonstration of feedback network where with the help of loop, information is fed back. Recurrent network is extremely complex, powerful and dynamic in nature. Loops provides delay or short term memory exhibiting the capabilities of understanding sequence of events periodically[4]. RNN is quite popular with sequential prediction problems and generative models where input data is preferred to be text or

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speech. Tabular and image datasets are not appropriate for recurrent network. Multilayer feedforward neural network also known as Multilayer Perceptron (MLP) is another ANN topology where input is accepted in the tabular form, CSV or spreadsheet. MLP is the most popular among regression and classification prediction problems.

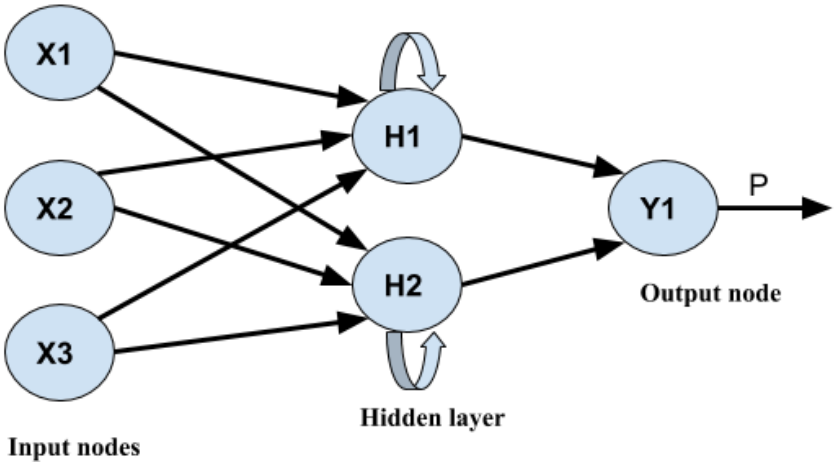

Fig.1.3.3. Recurrent network

1.3.Training algorithm

Defining the topology of neural network does not mean that it is ready to predict the outputs until it is trained with experience. Training algorithm updates the weight in network to map input data to output data. ANN trains the models using various algorithms like Levenberg-Marquardt, Gradient Descent, Resilient backpropagation, Quasi-Newton, Conjugate Gradient, and may more. Broadly training techniques can be classified into two categories that are supervised and unsupervised. As the name suggests, supervised training could be correlated with leaning under supervision. The model is trained with labeled data that states input and expected output. For example, dataset of flower images which would train the model to tell whether input image is of Rose, Lavender, or Sunflower. The dataset comprises of pre-labeled images of flower as rose, Lavender and Sunflower, and model accuracy is evaluated on the basis of how accurately it can classify the new image. Supervisedlearning has gained its popularity in majorly two areas, regression and classification problems. In contrast to supervised learning, unsupervised learning algorithms work on unlabeled data. Model is trained by analyzing the data and extracting unique features. The model structures the data using different techniques like Association, clustering, anomaly detection, and autoencoders.

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2. Related Work

Now a days, applications of ANN is not restricted to a specific a domain. ANN has proved its worth in solving real life problems of different fields like education, business, and economics. Neural network is the popular topic among researchers and various new techniques are introduced in past decades to extend its capabilities. Ning Gao has introduced a hybrid of Genetic algorithm and Back propagation (BP) neural network for GPS height conversion[8]. The hybrid approach has successfully overcome the issues of BP neural network that were slow convergence rate and falling into local minima. Huan Bao introduced approximation mapping of non-linear function using regularization function and memorizing threshold values[9]. The proposed model resolved convergence issue and avoid falling into local minima.K. Kyuma has focused on the application of neural networks in optics. Optical technologies have potential abilities in the field of image processing and information transfer[10]. Applications of neural networks is successfully extended in areas like data classification[11][12], intrusion detection[13][14], and optimization method. One of the most challenging optimization issue is classification. Different researchers have different ML techniques to resolve optimization problems [15]. ANN excellently classifies data and patterns [16]. Teresa B. Ludermir[17]proposed an approach of combining Tabu search, simulated annealing and backpropagation to optimize MLP such that network has fewer connections and better classification for all type of datasets. The methodology is experimented using four datasets: a) Thyroid dataset b) Diabetes dataset c) Fisher's dataset d) Dataset related to odor classification in artificial nose and one prediction based problem. The proposed method was successful in automatic generation of MLP topology with lesser complexity and better classification.Dhruba J Sarma has classified applications of ANN in different domains like science and engineering, food industry, energy industry, business, manufacturing, identification & control and many more [7].

3. Conclusion

Neural network mimics the functionality of human brain and has capabilities of solving various real-life problems. Activation function, network topology and training algorithm are the major elements that have impact on the accuracy of output generated by ANN. Researchers have successfully implemented ANN in solving various human issues and numerous experiments are carried out with the structure of ANN to check its efficiency to generate better predictions.

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