ARTIFICIAL NEURAL NETWORKS AND APPLICATIONS:A REVIEW

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Abstract : Artificial neural network (ANN) is an information processing system whose function is inspired by the way biological nervous system such as human brain works. It is a collection of a large number of highly interconnected functional units (analogous to neurons present in human brain) working in synch with each other to solve specific problems. ANN can be trained to learn by examples and can perform a wide variety of tasks like pattern recognition, feature extraction and selection from large and complex data sets that are otherwise not feasible with conventional mathematical computing techniques. Because of their learning capability and flexible architecture ANN has attracted researchers across the globe to develop specific applications for solving a wide variety of real world problems ranging from simple to complex. The objective of this paper is to study various aspects of neural network and review some of its applications that have been developed to solve specific real world problems. For this study secondary data has been collected from reputed journals for the period from 2008 to 2014, standard books and websites.

IndexTerms **- artificial neural network, human brain, neurons, learn, pattern, feature, application.**

I.INTRODUCTION

Today's age is the age of automation. Soft computing which differs from traditional computing in the way that it can solve such real world problems which cannot be stated with accuracy and precision has brought revolutions in the field of automation. Soft computing is a combination of various computing techniques.One of it's important computing paradigm is artificial neural networks.Artificial neural network(ANN) a computing model that can simulate the function of biological neural network present in human brain. The remarkable property of ANN's is their capability to learn from examples .Their extensive computational capability has made them replace experts in particular fields. Today they are used in wide areas of applications like:

- Detection of frauds related to credit cards
- Face recognition
- Charcter recognition.
- Diagnosis of diseases
- Road traffic accidents prediction
- Students performance prediction
- Network security
- Prediction of targets by sonar, radar and magnetic instruments
- Controlling the traffic of aircrafts.
- Photos and handwriting recognition
- Speech recognition
- Development of strategies for games, business and wars
- Weather forecasting
- Market segmentation
- Stock market for prediction of exchange
- Criminal sentencing
- Composition of music

The area of applications of ANN's is not limited.They can replace experts in any field. In our paper we will review some of these applications.

II.BIOLOGICAL NEURAL NETWORK

As ANN's are inspired by the functioning of human brains first it is necessary to understand how a biological neural network present in human brains functions. [1] The human brain consists of billions of highly interconnected neurons ,which is a special type of cell that provides us the capability to learn ,retrieve information from past experiences and give appropriate response to particular stimulus.

The biological neuron as shown in figure 1[2] consists of three main parts [1]:

1. Cell body or soma
2. Dendrites
3. Axon

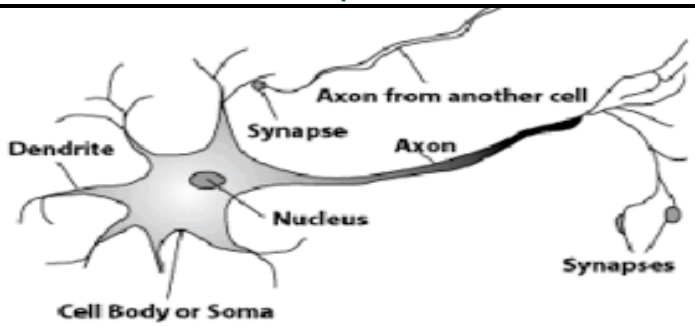

fig.1.biological neuron
Source: https://www.researchgate.net/figure/282895074_fig1_Fig-1-A- simplified-model-of-biological-neuron

The cell body contains the nucleus which processes the input signals received from fine hair like structures called dendrites which are nerve fibers connected to the cell body. An axon is a single fibre like structure emerging from the cell body and it carries the information from the neuron. The end of axon splits into fine strands and each strand splits into bulb like structures called synapse. Synapse is like a junction or gate between two neurons. The information from one neuron is transferred to other neurons through synapse.

III. MODEL OF A SIMPLE ARTIFICIAL NEURON

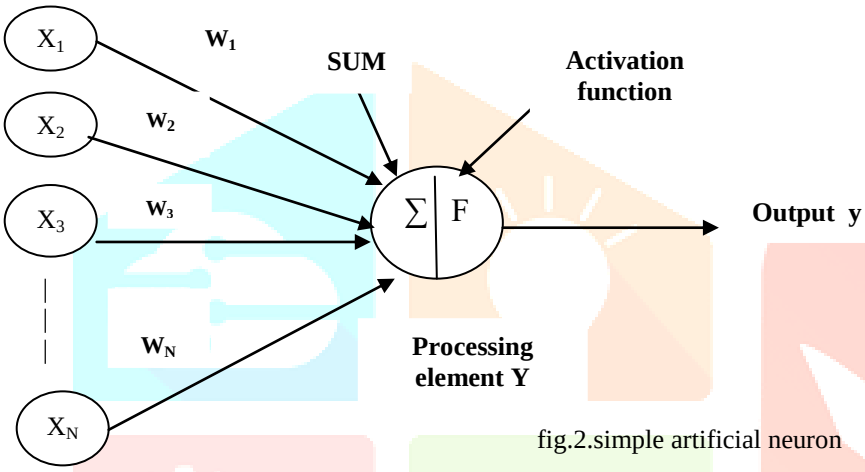

fig.2.simple artificial neuron

Figure 2 depicts a simple model of artificial neuron where x_1,x_2,x_3……..x_n are input neuron which receive the input signals and w_1,w_2,w_3…….....w_n are the corresponding weights that represent the strength of connection link from input neuron to the output neuron Y. Neuron Y calculates the net input y_{in} as sum of all the weighted inputs as sHown in equation1.

$$y_{in} = x_1 w_1 + x_2 w_2 + x_3 w_3 + \ldots\ldots x_n w_n \quad \ldots\ldots\ldots\ldots(1)$$

The activation function f is applied over the net input to calculate the output y as shown in equation2.

$$y = f(y_{in}) \quad \ldots\ldots\ldots\ldots..(2)$$

IV. NEURAL NETWORK ARCHITECTURE

In an ANN processing elements (neurons) are highly interconnected to other processing elements (neurons) to form layers. There are two basic types of neural network.

1. Single layer neural network
2. Multilayer neural network

4.1. A single layer neural network is made up of only two layers: input and output as shown in figure 3. The input layer neurons receive the input signals and pass it on to the output layer for processing.

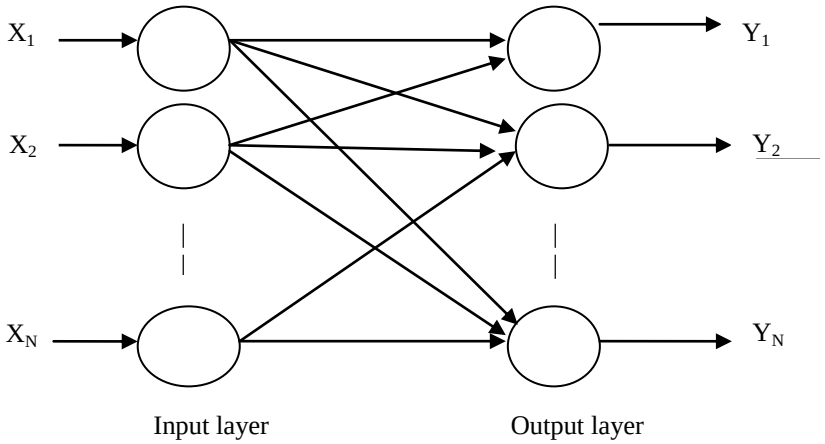

fig.3.single layer neural network

4.2. A multi layer neural network has one or more layers present between the input and output layer which are called hidden layers.

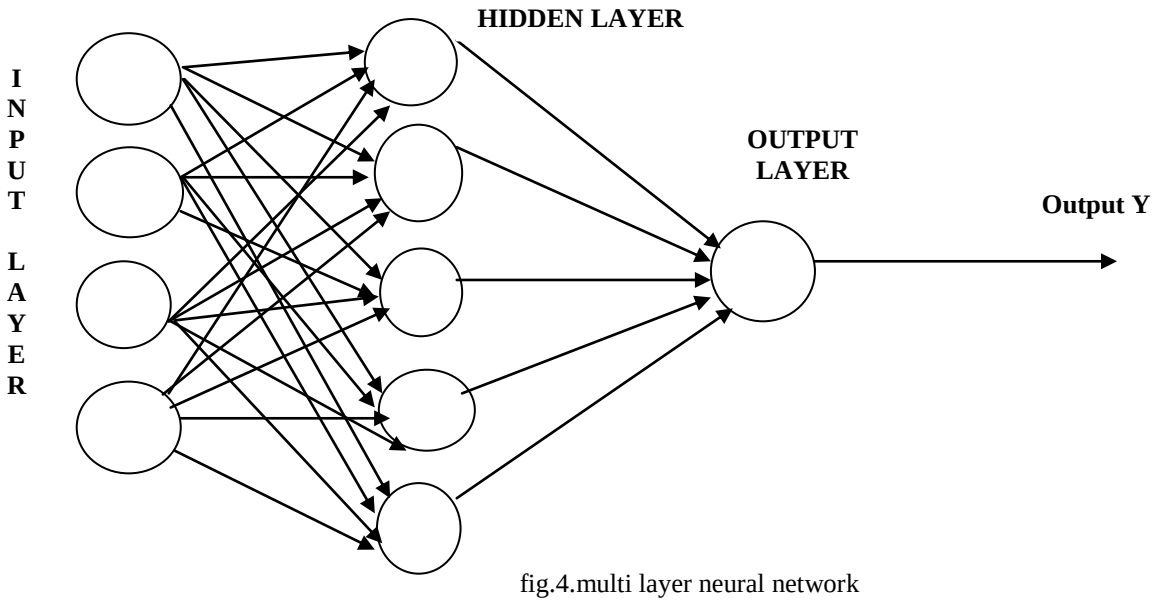

fig.4.multi layer neural network

Figure 4 shows a simple multilayer neural network having one hidden layer between the input and output layer. There can be several hidden layers between input and output layer.

Now depending upon the direction of signal flow, neural networks can again be categorized as
3.Feed forward neural networks
4.Feedback neural networks
4.3.A feed forward neural network is a network in which the direction of flow of signals is only in forward direction i.e. from input through hidden layer to output layer. There is no flow of signal from output layer back to the same or preceding layer. Neural networks shown in figures 3 and 4 can be considered as feed forward neural network.
4.4.A feedback neural network is a network in which the outputs can be directed back as feedbacks to the same or previous layers i.e. it allows flow of signals both in forward and backward directions as shown in figure 5.

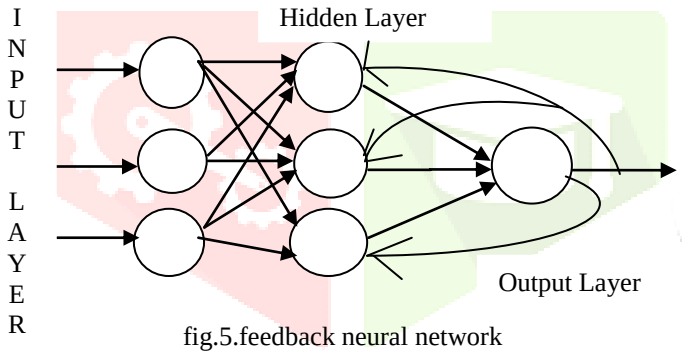

fig.5.feedback neural network

V. LEARNING: The notable property of ANN is its capability to learn from examples and experiences just like human beings. Learning is a process by which a neural network learns to produce desired output corresponding to particular input by adjusting its parameters.
Learning in ANN can be classified into three categories:
i. Supervised
ii.Unsupervised
iii.Reinforcement

5.1.Supervised learning- Supervised learning is learning under the supervision of a teacher or supervisor [3]. In ANN it means the network is informed precisely about the class of the object i.e. the target vector corresponding to the particular input vector during training process.The actual output and target output are compared and an error signal is generated if there exists a difference.The error signal is again fed back to the network and the process is repeated till the desired output is produced.

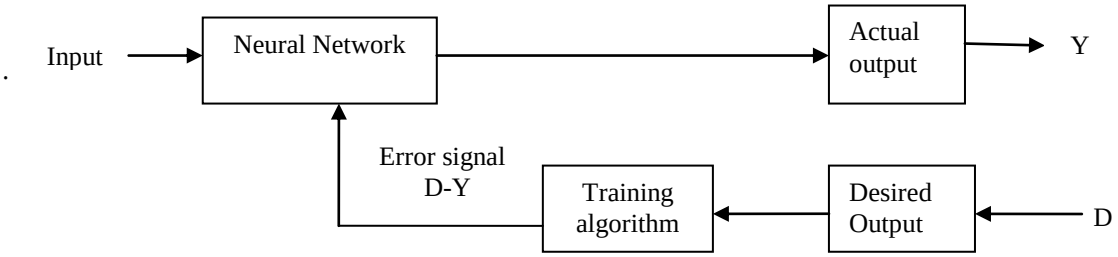

fig.6.supervised learning process
Source: Sivanandam, S. N., & Deepa, S. N. (2013). Principles of soft computing (2nd ed.). New Delhi: Willey India Pvt. Ltd.

5.2. Unsupervised Learning- In unsupervised learning there is no teacher to supervise the learning process i.e. learning by self. Neural network is not informed about the class of the object or the target vector corresponding to particular input vector. During training process the network clusters objects of similar features or pattern in one class. When an input pattern is supplied, the network will give the class of the pattern by matching its features as response. If no match is found a new class will be generated.

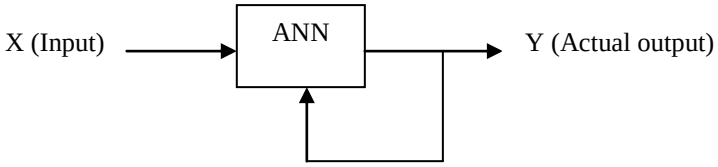

fig.7.unsupervised learning process
Source: Sivanandam, S. N., & Deepa, S. N. (2013). Principles of soft computing (2nd ed.). New Delhi: Willey India Pvt. Ltd.

5.3. Reinforcement learning – Here the exact output is not available to the network but some evaluative or critic information about the output is given to the network so that it can adjust its weights accordingly to produce more correct output. It is a form of supervised learning because there is some feedback from the environment about the output. This feedback signal is called reinforcement signal.

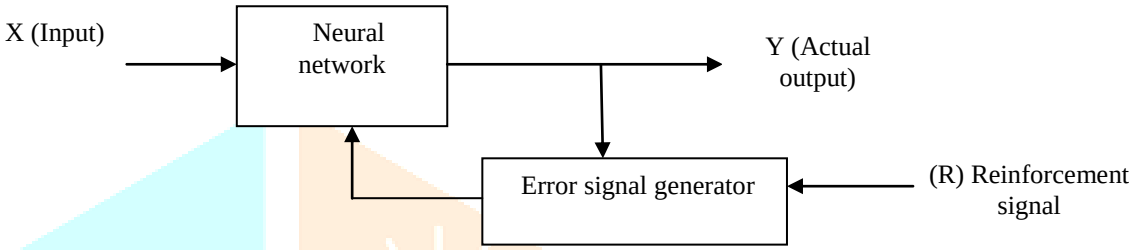

fig.8.reinforcement learning process
Source: Sivanandam, S. N., & Deepa, S. N. (2013). Principles of soft computing (2nd ed.). New Delhi: Willey India Pvt. Ltd.

VI. REVIEW OF SOME APPLICATIONS OF ARTIFICIAL NEURAL NETWORK (ANN)

6.1.Credit card fraud detection: Application of ANN includes work of Khan et al., 2014, [4] who trained a feed forward neural network using simulated annealing algorithm for credit card fraud detection on real world financial data. The network was then able to classify the new online transactions as genuine or fraudulent.
Another work was performed by Patidar et al., 2007, [5] who employed ANN combined with Genetic algorithm to detect fraudulent credit card transactions. A three layer, feed forward network was trained on previous years data using back propagation learning rule on various categories of credit card usage information like age, occupation and income of card holder in one category while the number, frequency and location of large purchases in another category. Despite this neural network was also trained about some previous credit card frauds faced by a particular bank. Genetic algorithm was used to select parameters like topology of the network, weights, number of layers, nodes etc .When a transaction arrives, based on the pattern of use of credit card, the network is able to classify it as fraudulent or non fraudulent .

6.2. Prediction of road traffic accidents: Jadaan et al., 2014, [6] developed a prediction model for future traffic accidents in Jordan using ANN approach by analyzing the relationship between accidents and factors affecting them. The input data consisting of number of registered vehicles, population, total length of paved roads and GDP was divided into training data, validation data and testing data. The model produced good results and could be used to predict future road traffic accidents.
Ali et al., 2012, [7] developed an ANN model to predict traffic accident causalities in Sudan using historic data from 1991-2009 like population growth (POPG), the gross domestic product (GDP) of Sudan, the number of registered cars (NOCR) and the total length of paved roads (NKPR). Above four factors were assumed to be functions of the year (Y), and were chosen as input vectors for the ANN architecture and the output of the model was the number of car accident casualties (NOAC).The network was trained using back propagation algorithm using above historic data and weights were adjusted using common delta rule. After completion of training process %age contribution of the four factors on increasing the accident casualties was computed and it was found that population growth and number of cars had substantial influence of 43% and 32% respectively whereas GDP and length of paved roads contributed 7% and 18% respectively. It was observed that the prediction done by the developed model was very close to the actual data with slight difference of 1.84%.

6.3. Prediction of student performance: Another important application of ANN includes development of a neural network model by Oladokun et al., 2008, [8] for prediction of student performance who were aspiring to take admission in University using data of five generations of graduates from an Engineering Department of University of Ibadan, Nigeria. Following factors that influence a student's performance were considered as input variables:
1)UME(Universities Matriculation Examination score), 2) O/level results in Physics, Chemistry, Mathematics, English 4) student's age at the time of admission, 5) Time elapsed between graduating from secondary school and gaining university admission, 6) Educational background of parents, 7) Zone in which student's secondary school is located, 8) Type of secondary school attended (government, state or private), 9) University location and place of residence, and 10) Gender of student.
The output variable was performance of a student as Good, Average and Poor.
The network model was Multilayer perceptron trained with back propagation. The number of Processing elements was varied in the study from 1 to 5 nodes, to give the best performance. A total of 112 students records were used in the analysis of which 56% of the total data (i.e. 62 candidates) were used as the training set, 30% (i.e. 34 candidates) as the testing set, and 14% (i.e. 16 candidates) were used for cross validation. After classifying the data a multilayer perceptron consisting of two hidden layers and five nodes per layer was built. After training

and cross validation network was tested and it was found that the network gave an accuracy of 82% for Good, 53% for Average and 88% for the Poor classification as output. The overall accuracy of the model developed was 74% which shows that it can be efficiently used to predict student's performance and selection criteria for seeking admission in university.

6.4. Face recognition system: Face recognition finds important applications in authentication, system security etc. Shivdas, 2014,[9] proposed a face recognition system by integrating principle component analysis (PCA) and discrete cosine transform (DCT) combination feature extraction using artificial neural network. PCA was used for feature extraction and dimension reduction. Face recognition involves various steps like face detection, normalization, feature extraction and then finally face recognition. This system compares the face to be recognized with the faces already trained to the neural network and then gives the best matching face as the output. The images are stored in the form of feature vectors in database which are found by projecting every trained image to the set of Eigen faces obtained.
PCA Algorithm: PCA is applied on Eigen faces approach to reduce the size of a large data set for recognizing a test image. Features of the face images are extracted using PCA.
The neural network is trained using back propagation algorithm. It consists of 3 layers: input layer consisting of 45 neurons, hidden layer and output layer consisting of 1 neuron. The network is trained with the ccalculated eighen faces of the face images. Eighen faces image distance is compared with each other. The mathematical function used in output layer is log sigmoid function. Errors are calculated at the output layer and sent back to the hidden layer. Weights are updated accordingly to minimize the error. The iteration used is 500, learning rate 0.03 and the training continuous till the mean square error reaches 0.0001.
For testing purpose the eigenfaces images of the test face image is projected by feature extraction using PCA.This Eigenfaces image is fed to the trained neural network and compared with the Eigenfaces of the trained neural network using the Log-sigmoid function values for the best match. It was found that the smallest distance between the tested Eigenfaces image and the trained Eigenfaces image was not as much of as the threshold value.

VII. Conclusion

Neural networks have been a key area of research from the past 20 years. It's remarkable feature to learn from experiences just like human beings and then solve complex real world problems has made them an integral part of AI (artificial intelligence) research. They have important contributions in areas of science and engineering, defense, medical, robotics, education, operation research, transportation, aeronautics and countless to mention. They are slowly replacing human experts in respective fields. But there are some challenges as well like developing more robust, efficient and fast algorithms that require less training duration and produce outputs with much higher precision which will definitely be overcome by continuous efforts of researchers and scientists across the world.

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