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A Survey on Back Propagation Neural Network

M. Sornam[1], M. Poornima Devi[2]
Department of Computer Science, The University of Madras, Chepauk, Chennai,
Email: madasamy.sornam@gmail.com, poornima16492@yahoo.in

Abstract— The main aim of this paper is to consider the concept of the basic Back propagation algorithm. The Back propagation algorithm is the principal for training Feed Forward Neural Networks. It is proposed for reduce the mean square error (MSE) between the real outputs of a multilayer feed-forward neural network and the preferred outputs. Back Propagation network has a great advantage of simplicity of implementation and computation compared to other mathematically complicated techniques. This paper concise the basic Back Propagation and continuous upturns over Back propagation technique used for classification in artificial neural networks (ANN) and associate with new methods like genetic algorithms (GA).

Keywords—Back Propagation (BP) algorithm; Particle Swarm Optimization (PSO); Adaptive Differential Evolution (ADE); Levenberg Marquardt (LM); Fuzzy Min-Max Neural Network.

I. INTRODUCTION

An Artificial Neural Network (ANN) is an information refinement model that is activated by the way biological nervous systems, such as the brain, process information. It is a compilation of a large number of highly interconnected processing elements (neurons) working in union to solve specific problems. An Artificial Neural Network is an necessity data refinement system containing of a large number of simple highly interconnected processing elements i.e. artificial neurons, in an architecture activated by the structure of the cerebral cortex of the brain. Artificial Neural Network Architectures was classified under Feed-forward network. It's a non-recurrent network which contains inputs, outputs, and hidden layers; the signals can only travel in one direction. Feed-back network also known as Recurrent Neural Networks (RNN), It has feed-back paths meaning they can have signals traveling in both directions using loops. All possible connections between neurons are allowed. Since loops are present in this type of network, it becomes a non-linear dynamic system which changes continuously until it reaches a state of equilibrium. An ANN learns by examples. Learning is essential to neural network architectures and the choice of a learning algorithm is a central issue in network development. Learning methods in Neural Networks can be broadly classified into three basic types: supervised, unsupervised and reinforced. Section II describes the different problems in existing system and Section III is about the conclusion of the problems.

II. RESEARCH SO FAR

A. Classification Problem

Dasa Kruzlicova et al. [2] illustrated that a multilayer Perceptron method using quick propagation and quasi- Newton propagation algorithm was used for classification of Slovak white wines. The developed methodology was applied to classify Slovak white wines of different variety, year of production and from different producers. The analytical data were evaluated by means of the ANN and the classification outcomes were compared with the analysis of variance (ANOVA). 87 samples were analyzed and classified, this set was separated into the training set of 72 samples and the test set of 15 samples. The architecture of the network was 19-2-3. The classification for producer was 69.4% and for the vintage was 80.6%, totally 100% classification achievement was recorded.

Maged M. M. Fahmy [6] suggested that the objective of research was to present online handwritten signature verification system based on discrete wavelet transform (DWT) features extraction to improve the variation between a genuine signature and its forgery. Low frequency sub-band signals of pen-position parameter and pen-movement angle parameter are measured as intrapersonal features. Classification was the method which has two phases: signal modeling and pattern matching. The database consists of 20 genuine signature and 20 skilled forgeries created by dissimilar 20 volunteers. The architecture of the network was 87-70-5. The rate of recognizing untrained genuine signature was 95% and also the rate of recognizing forgery signature was 8%. Malay Mitra and R. K. Samanta [7] implemented that the effort was attempted Correlation-based Feature Selection (CFS) with linear forward selection search. Incremental Back Propagation Neural Network (IBPLN) and Levenberg- Marquardt (LM) Classification tested on UCI database for classification accuracy, specificity, and sensitivity. Self Organizing Map (SOM), Support Vector Machines (SVM), Multilayer Perceptron (MLP), Markov Models and Fuzzy or Neuro-Fuzzy System is the different approaches. Total number of instance is 452. Mixture of CFS+IBPLN and combination of CFS+LM are the two combinations used for Cardiac Arrhythmia classification.

Nazri Mohd Nawi, Abdullah Khan and M. Z. Rehman [9] proposed that the Levenberg Marquardt (LM) based back propagation (BP) taught with Cuckoo search algorithm. LM algorithm was urbanized only for Layer-by-layer ANN topology. A latest mate-heuristic algorithm is used for replicating animal behavior. Getting stuck in local minimum and slow speed of convergence is the major drawback in the system. The benefit of the cuckoo search is the enhanced convergence speed and speedy of the hybrid neural networks learning methods and also reduces the error. Log sigmoid activation function was activation function. Ofelia Anjos et al. [12] implemented that the tool based on neural networks was used to forecast the botanical origin of honeys by means of physical and chemical parameters. The sample of 49 honeys

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from 14 dissimilar botanical origins was taken. The two different classes used are monofloral and multifloral. It reduces the error rate up to 5%. The major benefit is that the botanical origin of honey can be reliably and quickly recognized from the colorimetric information and the electrical conductivity of honey. The monofloral honey example was taken from different Portuguese and Spanish region. It uses the machine learning techniques and the outcome show the low error rates. Yudong Zhang, Shuihua Wang, Genlin Ji and Preetha Phillips [15] suggested that in order to distinguish fruits more accurately, a hybrid classification method established on Fitness- Scaled Chaotic Artificial Bee Colony (FSCABC) Algorithm and Feed forward neural networks (FNN) are used. Split-and-Merge Algorithm is used to take away the background of each image. K-fold cross validation technique is to enhance the generation capability of FNN. Eighteen different categories of fruits are used as sample data set. The FSCABC-FNN was seen to be effective and more accurate in classifying fruits.

B. Prediction

Abhijit Suresh, K. V. Harish and N. Radhika [1] proposed that the robust stochastic optimization technique called Particle Swarm Optimization (PSO) is compared with back propagation for training. The algorithm was evaluated based on error convergence, sensitivity, specificity, positive precision value and accuracy. The input data set consists of the following attributes: specialty, Day since First Stay (DSFS), primary condition group and charlson index. Specialty includes categories such as surgery, internal and emergency. The data set used is a randomly generated data set for the duplication of PHLOS approach and it is based on Heritage Health prize data. The architecture of the network was 4-4-1. The outcome shows that the most excellent validation performed reached a minimum faster and most favorable in the case of particle swarm when compared with BP. The advance research can be undertaken to research in depth on the impact of different variants of PSO by varying the neighborhood topologies such as pyramid and Von Neumann topology characterized based on the degree of connectivity and the quantity of clustering.

Fang Feng Ping and Fang Xue Fei [3] discussed that for enhanced accurate forecasting of port throughput, a back propagation neural network model with genetic algorithms was proposed. By means of analysis of influence factors for port throughput, the structure of the BP neural network model was determined. Then the connection weight matrix of the BP network was planned for chromosomes of genetic algorithms, which proved to optimize BP network. BP neural network was a precious method of training ANN, which is usually based on the error back propagation (BP algorithm) to the multi-layer neural network. In this network, sigmoid function was chosen as activation function. The port throughput of Guangdong province in China was used for certification, and the result of the experiment showed that GA-BP neural network model has enhanced accuracy, but consumes more time than a traditional BP network model.

Gan Gang-Ping Tan, Deng-Feng Wang and Qian Li g-Ping Tan [4] proposed that the interior vehicle acoustic quality evaluation to progress automobile comfort and set up a sound quality of prediction with BP network. The network was skilled using variable learning rate back propagation algorithm. The learning rule was the steepest descent method or delta rule. Topological structure of the model was 2-7-1. The original data were erratically divided into three groups, 50% of the data was taken as training data, 25% as validation data and 25% as test data. Comparing the neural network prediction result with multi-dimensional regression curve, the maximum absolute error of neural network prediction outcome was still less than the outcome obtained from multi-dimensional regression. Lin Wang, Yi Zeng and Tao Chen [5] described that this method with a hybrid approach that joined the adaptive differential evolution (ADE) algorithm with BPNN, called ADE–BPNN, was considered to get better forecasting accuracy of BPNN. ADE was first applied to search for the global initial connection weights and thresholds of BPNN. The electric load statistics consist of 64 monthly data and for calculating the metrics the Root Mean Square Error (RMSE), the Mean Absolute Percentage Error (MAPE), and the Mean Absolute Error (MAE) was used. The architecture of the network was 12-4-1. The proposed ADE–BPNN efficiently improved forecasting accuracy relative to basic BPNN, Auto Regressive Integrated Moving Average model (ARIMA), and other hybrid models.

Mengshan Li *et al.* [8] illustrated that a novel forecast method based on chaos theory, self-adaptive particle swarm optimization (PSO) algorithm, and the back propagation artificial neural network (BP ANN) was planned to predict gas solubility in polymers, henceforth called CSPSO BP ANN. The early convergence problem of CSPSO BP ANN was over-come by modifying the conventional PSO (Particle swarm optimization) algorithm using chaos theory and self-adaptive inertia weight issue. Modified PSO algorithm is used to optimize the BP ANN connection weights. The CSPSO BP ANN architecture is 2–8–1. Also, compared with conventional BP ANN and PSO ANN, CSPSO BP ANN shows improved performance and the statistical data demonstrate that CSPSO BP ANN has exemplary prediction capability and high accuracy.Nguyen Ngoc Son and Ho Pham Huy Anh [10] implemented that the Shape memory alloys (SMAs) are smart metallic materials, which had the capability to recover their shape when heated, even under high-applied load and large inelastic deformation. A new hybrid differential evolution (HDE) algorithm, which was a mixture between a traditional differential evolution algorithm and a back-propagation algorithm, was used to optimally produce the best weights of the AFNN model. The architecture of the network was 2-5-1. Due to the offline identification, the planned adaptive online displacement control can study the hysteresis behavior of the SMA actuator in advance and then provide online control signal resourcefully. Consequently, the displacement of SMA actuator was controlled robustly and further precisely.

Xiaoli Qiang and Zheng Kou [14] proposed that the novel technique was framed to expect the transmissibility of avian influenza A viruses and to predict which subtypes and strain of avian influenza virus will turn into capable of interspecies

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transmission. The technique used was established on the wavelet packet decomposition. Two categories of molecular patterns, named 'Y' and 'N' were among avian influenza A viruses, category 'Y' included patterns C and E, which could cross species barriers and category 'N' included patterns A, B, and D which may not have such capabilities. The architecture of the network was 21-43-1. The activation functions used are tansig and logsig.

C. Clustering

Nilam Upasani and Hari Om [11] described that the fuzzy logic is more suitable for handling uncertainty. Fuzzy min-max neural network (FMN) is used for outlier detection. FMN is a supervised learning algorithm and the membership values range between 0 and 1, 1 indicating full membership, 0 representing no membership and the value between 0 and 1 representing partial membership. It increased the recognition correctness. The drawback of the system is recall time increased as one more level of voting computation with serial time complexity of O(k) is added in the testing phase.

D. Regression

Sridevi. K *et al.* [13] recommended that the hybrid upflow anaerobic sludge blanket (HUASB) reactor, biodegradation in connection with biohydrogen production was calculated using distillery wastewater. The experiments were carried out at ambient temperature and acidophilic pH of 6.5 with constant hydraulic retention time (HRT) of 24 h at various Organic Loading Rates (OLRs) in continuous mode. A back propagation neural network (BPNN) model with network topology of 4-20-1 using Levenberg–Marquardt (LM) algorithm was urbanized and validated. A total of 231 data points were studied to look at the performance of the HUASB. The statistical qualities of BPNN models were important due to the high correlation coefficient, R2, and Lower Mean Absolute Error (MAE) between new and replicated data. It was accomplished that BPNN modeling could be applied in HUASB reactor for predicting the biodegradation and biohydrogen production by means of distillery wastewater.

TABLE I. Major functions for Backpropagation Algorithm.

S. No	***Author***	***Class Model and Classification Algorithm***	***Year***
1	Abhijit Suresh, K. V. Harish and N. Radhika [1]	Particle Swarm Optimization (PSO) is compared with back propagation algorithm.	2014
2	Dasa Kruzlicova *et al.* [2]	Multilayer Perceptron technique using quick propagation and quasi-newton propagation algorithm was used for classification of Slovak white wines.	2009
3	Fang Feng Ping and Fang Xue Fei [3]	For better accurate forecasting of port throughput, a back propagation neural network model with genetic algorithms was proposed.	2013
4	Gang-Ping Tan, Deng-Feng Wang and Qian Li [4]	The interior vehicle acoustic quality evaluation to improve automobile comfort and the network was trained using variable learning rate back propagation algorithm.	2011
5	Lin Wang, Yi Zeng and Tao Chen [5]	Hybrid approach that combined the adaptive differential evolution (ADE) algorithm with BPNN, called ADE–BPNN.	2015
6	Maged M. M. Fahmy [6]	The research was to present online handwritten signature verification system based on discrete wavelet transform (DWT) features.	2010
7	Malay Mitra and R. K Samanta [7]	The Work was attempted Correlation-based Feature Selection (CFS) with linear forward selection search. Incremental Back Propagation Neural Network (IBPLN) and Levenberg- Marquardt (LM)	2013
8	Mengshan Li *et al.* [8]	A novel prediction method based on chaos theory, self-adaptive particle swarm optimization (PSO) algorithm, and back propagation artificial neural network (BP ANN)	2013
9	Nazri Mohd Nawi, Abdullah Khan and M. Z. Rehman [9]	The Levenberg Marquardt (LM) based back propagation (BP) trained with Cuckoo search algorithm.	2013
10	Nguyen Ngoc Son , and Ho Pham Huy Anh, [10]	A new hybrid differential evolution (HDE) algorithm, which was a combination between a traditional differential evolution algorithm and a back-propagation algorithm.	2015
11	Nilam Upasani and Hari Om [11]	FMN is a supervised learning algorithm and the membership values range between 0 and 1.	2015
12	Ofelia Anjos *et al*. [12]	The botanical origin of honey can be reliably and quickly recognized from the colorimetric information and the electrical conductivity of honey.	2014
13	K. Sridevi *et al*. [13]	A back propagation neural network (BPNN) model using Levenberg–Marquardt (LM) algorithm was developed and validated.	2015
14	Xiaoli Qiang, and Zheng Kou [14]	The novel method was framed to predict the transmissibility of avian influenza A viruses.	2010

S. No	***Author***	***Class Model and Classification Algorithm***	***Year***
15	Yudong Zhang, Shuhua Wang, Genlin Ji, and Preetha Phillips [15]	A hybrid classification method established on Fitness- Scaled Chaotic Artificial Bee Colony (FSCABC) Algorithm and Feed forward neural networks (FNN).	2014

TABLE II. Comparison between different Back propagation Algorithm.

Reference and Year	***Architecture***	***Performance Measure***	***Objective***
[1] 2014	4-4-1	Sensitivity, Specificity, Positive precision value and accuracy.	To produce the accurate prediction of Length of Stay.
[2] 2009	19-2-3	Analytical data were evaluated for best accuracy.	To classify Slovak white wine s of different variety using Newton propagation algorithm.
[3] 2013	8-4-1	Mean Square Error, Absolute Error and Relative error.	Comparing GA with traditional BP algorithm to enhance the accurate forecast port throughput.
[4] 2011	2-7-1	Absolute Error was smaller.	To progress automobile comfort and set up a sound quality prediction with BP network.
[5] 2015	12-4-1	Root Mean Square Error (RMSE), Mean Absolute Percentage Error (MAPE), and the Mean Absolute Error (MAE).	To get the better forecasting accuracy of BPNN with ADE.
[6] 2010	87-70-5	Sensitivity and accuracy.	To present online handwritten signature to improve the variation between genuine and its forgery signature.
[7] 2013	14-8-4	Lowest validation Error.	To study the Cardiac Arrhythmia classification with the mixture of CFS+IBPLN and CFS+LM.
[8] 2013	2–8–1	Mean Square Error (MSE).	To predict gas solubility in polymers using CSPSO BP ANN.
[9] 2013	16–6–1	Mean Square Error (MSE).	To classify Cuckoo with cuckoo search algorithm with mate heuristic algorithm.
[10] 2015	2-5-1	Mean Sum of Square Error (MSSE).	To implement smart metallic materials to recover their shapes using Shape memory alloys.
[11] 2015	16-5-3	Data error and gradation error.	Fuzzy min- max neural network (FMN) used for outlier detection.
[12] 2014	49-14-2	Low error rate and accuracy.	To forecast the botanical origin of honeys by means of physical and chemical parameters.
[13] 2015	4-20-1	Mean Absolute Error (MAE) and Mean Square Error (MSE).	To predicting the biodegradation and biohydrogen production by means of distillery wastewater.
[14] 2010	21-43-1	Mean Square Error (MSE).	To predict which subtypes and strain of avian influenza virus will turn into capable of interspecies transmission.
[15] 2014	14-5-2	Median Square Error (MSE).	To distinguish fruits more accurately and effective.

III. CONCLUSION

This survey paper is all about the progression of the back propagation algorithm which is a supervised learning method to train the ANN. BP Algorithm is known for its mathematical simplicity and accuracy. BPA has its own limitations of slow convergence rate and local minima problem which is still a enormous problem when dealing with large complicated problems. FMN (Fuzzy Min-Max Neural Network) has the good ability of classification problem and can be successfully used for outlier detection.

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