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International Journal of Current Research
Vol. 4, Issue, 04, pp.236-239, April, 2012

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

NEURAL NETWORKS APPPROACH FOR THE PERFORMANCE ANALYSIS OF THE LEARNING MODEL – A CASE STUDY

[1]Srimani, P. K. and [2]Annapurna S Kamath

[1]Former Chairman, Dept of Computer Science and Maths, BU, Director, R&D, B.U., Bangalore, India
[2]Former H.O.D, MCA Department, Mount Carmel College, Director, Shishulok, Bangalore

ARTICLE INFO

Article History:
Received 15th January, 2012
Received in revised form
21st February, 2012
Accepted 22nd March, 2012
Published online 30th April, 2012

Key words:
Mathematical Pathway,
Learning Model,
Performance analysis,
Neural Network approach,
Data Mining, Novel.

ABSTRACT

This paper deals with the performance analysis of the learning model used to optimize the Mathematical Pathway – 'Ganitha Vithika'. Using the Mathematical Pathway Database generated by the Learning model that contains information of all the mathematical concept competencies a child has to achieve from class 1 to class 7 for a large population of children, the performance of an individual child is evaluated which indicates whether the child's progress is normal or exceptionally good or there is a need for guidance. The results obtained by the application of Neural Network approach for data mining and performance analysis shows that the Learning model used to generate the data set is highly accurate and this generic novel approach can be extended to other disciplines.

INTRODUCTION

Mathematical Pathway is an optimal learning progression that can be computerised to track children's progress in Mathematics and provide them with timely assistance and guidance to make maths learning effective. This is implemented using a Learning Model designed using Mathematical Modelling and Computer Based Techniques.
The Learning Model "Ganitha Vithika" comprises of Automated MP driver a tracking, assessment and guidance tool that tracks the progress of a child and can be used to diagnose any need for remedial learning or recognise extraordinarily bright children. This also generates a progress database based on mathematical competency of the children, which can be used for performance analysis. Performance Analysis is the analysis of the data stored in the Mathematical Pathway Database which tracks the progress of each child. The main objective of performance analysis is to evaluate the learning model using Neural Network approach which validates the accuracy and efficiency of the Learning model.

The Neural Network technique can also be used to perform analysis on the Mathematical Pathway data to identify levels of learning in mathematics in different geographical locations, different learning environments locally and globally and identify the learning gaps between the minimum level of learning identified by the educational departments and the actual learning scenario and aid in optimising the learning and providing quality in education which in turn enhances the nation's strength. Here mathematics has been chosen as the area of application as it has a very significant role in all disciplines implicitly or explicitly. Therefore the same techniques can also be extended to any other discipline. No work in this direction is available hence the present investigation is carried out, the results of which are of immense practical and academic interest. The paper is organised as follows: Section 2 deals with a brief review of the work pertaining to the subject of research. Section 3 deals with data set description. Section 4 deals with the methodology. Section 5 deals with the experimental results and discussion. Section 6 deals with the conclusion.

***Corresponding author:** anuskamath@hotmail.com

RELATED WORK

In this section a brief overview of the literature pertaining to the subject of research is presented. According to Aubrey (1996) the difference between data warehouses and ordinary databases is that there are actual manipulations and cross-fertilization of the data helping users make more informed decisions. Typically there are five common types of information: associations, sequences, classifications, clusters, and forecasting. According to Edelstein (1996), Neural networks, depending on the architecture, provide associations, classifications, clusters, and forecasting to the data mining industry. According to Kosko (1992) it is precisely the two abilities - pattern recognition and function estimation that make artificial neural networks (ANN) so prevalent a utility in data mining. As data sets grow to massive sizes, the need for automated processing becomes clear. With their "model-free" estimators and their dual nature, neural networks serve data mining in a myriad of ways. According to Sarle (1994) the purpose of supervised learning is to predict one or more target variables from one or more input variables. “Supervised learning is usually some form of regression or discriminant analysis.” Multi Layer Perceptrons or MLPs are the most common networks in the supervised learning family. According to Fausett (1994) Back propagation is a learning algorithm for multi layer neural nets based on minimizing the mean, or total, squared error. In all the above works only general remarks about use of Neural Network in various data mining situations are presented but no case study with regard to its application on a learning model is done. Therefore the present investigation is carried out in order to provide an excellent performance analysis with regard to a learning model, in particular with reference to the mathematical learning using Neural Network approach.

DATA SET DESCRIPTION

The data set is obtained from the learning model developed by the authors (Annapurna, 2011). As a child goes through the mathematical pathway his progress is tracked and stored in the Progress Tracking Database. The fields of the database are the various competencies a child should accomplish in each class from 1 to 7. This data is massive in size as it contains records of students belonging to a school, cluster or block or state. The data constitutes seven modules one for each class and each module consisting of 500 instances. The total number of instances 3500 and number of attributes is 99. The attributes are UID -Unique ID that represents each student, AGE, 87 concept competency parameters, ASSM1 to ASSM7 which are assessments per class, ASSLVL – Actual Assessment level, CHRLVL – Chronological Level and RESULT.

METHODOLOGY

Data mining is the process of extracting valid, authentic, and actionable information from large databases. In other words, data mining derives patterns and trends that exist in data. These patterns and trends can be collected together and defined as a mining model. A neural network is an interconnected group of nodes, akin to the vast network of neurons in the human brain. An Artificial Neural Network (ANN) is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain process information. The key element of this paradigm is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements (neurons) working in unison to solve specific problems. An ANN is configured for a specific application, such as pattern recognition or data classification, through a learning process. Learning in biological systems involves adjustments to the synaptic connections that exist between the neurons. This is true of ANNs as well. Neural networks essentially comprise three pieces: the architecture or model; the learning algorithm; and the activation functions. The main categories of networks are acyclic or feed forward neural networks (where the signal passes in only one direction) and recurrent neural networks (which allow feedback). Among the most popular feed forward networks are perceptrons, multi-layer perceptrons and radial basis networks.

Neural Network Topology – Feed forward neural network

The feed forward neural network is the first and simplest type of artificial neural network devised. In this network, the information moves in only one direction, forward, from the input nodes, through the hidden nodes and to the output nodes. There are no cycles or loops in the network. The data processing can extend over multiple (layers of) units, but no feedback connections are present, that is, connections extending from outputs of units to inputs of units in the same layer or previous layers.

Training Of Artificial Neural Networks

A neural network has to be configured such that the application of a set of inputs produces the desired set of outputs. Various methods to set the strengths of the connections exist. One way is to set the weights explicitly, using a priori knowledge. Another way is to 'train' the neural network by feeding it teaching patterns and letting it change its weights according to some learning rule. Supervised learning is associative learning in which the network is trained by providing it with input and matching output patterns. These input-output pairs can be provided by an external teacher, or by the system which contains the neural network (self-supervised). The purpose of supervised learning is to predict one or more target variables from one or more input variables. Supervised learning is usually some form of regression or discriminant analysis. Multi Layer Perceptrons or MLPs are the most common networks in the supervised learning family (Sarle ,1994)

Feedforward Neural Network

One of the simplest feed forward neural networks (FFNN) [Fig. 1], consists of three layers: an input layer, hidden layer and output layer. In each layer there are one or more processing elements (PEs). PEs is meant to simulate the neurons in the brain and this is why they are often referred to as neurons or nodes. A PE receives inputs from either the outside world or the previous layer. There are connections between the PEs in each layer that have a weight associated with them. This weight is adjusted during training. Information only travels in the forward direction through the network and there are no feedback loops.

The simplified process for training a FFNN is as follows:

Step 1: Input data is presented to the network and propagated through the network until it reaches the output layer. This forward process produces a predicted output.

Step 2: The predicted output is subtracted from the actual output and an error value for the networks is calculated.

Step 3: The neural network then uses supervised learning, which in most cases is back propagation, to train the network. Back propagation is a learning algorithm for adjusting the weights. It starts with the weights between the output layer PE’s and the last hidden layer PE’s and works backwards through the network.

Step 4: Once back propagation has finished, the forward process starts again, and this cycle is continued until the error between predicted and actual output is minimized.

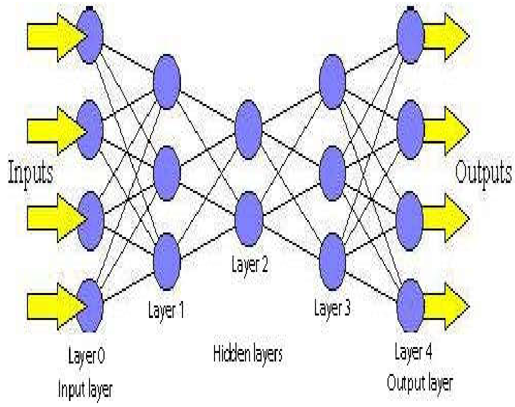

Fig. 1. Simple Feed Forward Network

The Back Propagation Algorithm: Backpropagation, or propagation of error [Fig. 2], is a common method of teaching artificial neural networks how to perform a given task. Back propagation is defined as a learning algorithm for multi layer neural nets based on minimizing the mean, or total, squared error. To train a neural network by back propagation is a three-step process: the feed-forward of the input training pattern, the calculation and back propagation of the associated error, and the adjustment of the weights (Fausett, 1994). The back propagation algorithm is used in layered feed forward ANNs. This means that the artificial neurons are organized in layers, and send their signals "forward", and then the errors are propagated backwards. The back propagation algorithm uses supervised learning, which means that we provide the algorithm with examples of the inputs and outputs we want the network to compute, and then the error, difference between actual and expected results is calculated. The idea of the back propagation algorithm is to reduce this error, until the ANN learns the training data.

The technique summarised is as follows:

Step 1: Present a training sample to the neural network.

Step 2: Compare the network's output to the desired output from that sample. Calculate the error in each output neuron.

Step 3: For each neuron, calculate what the output should have been, and a scaling factor, how much lower or higher the output must be adjusted to match the desired output. This is the local error.

Step 4: Adjust the weights of each neuron to lower the local error.

Step 5: Assign "blame" for the local error to neurons at the previous level, giving greater responsibility to neurons connected by stronger weights.

Step 6: Repeat the steps above on the neurons at the previous level, using each one's "blame" as its error.

A multilayer perceptron (MLP) is a feed forward artificial neural network model that maps sets of input data onto a set of appropriate output. An MLP consists of multiple layers of nodes in a directed graph, with each layer fully connected to the next one. Except for the input nodes, each node is a neuron with a nonlinear activation function. MLP utilizes a supervised learning technique called back propagation for training the network. MLP is a modification of the standard linear perceptron, which can distinguish data that is not linearly separable. An MLP can be viewed as a logistic regressor, where the input is first transformed using a learnt non-linear transformation Φ. The purpose of this transformation is to project the input data into a space where it becomes linearly separable. This intermediate layer is referred to as a hidden layer (Sarle, 1994).

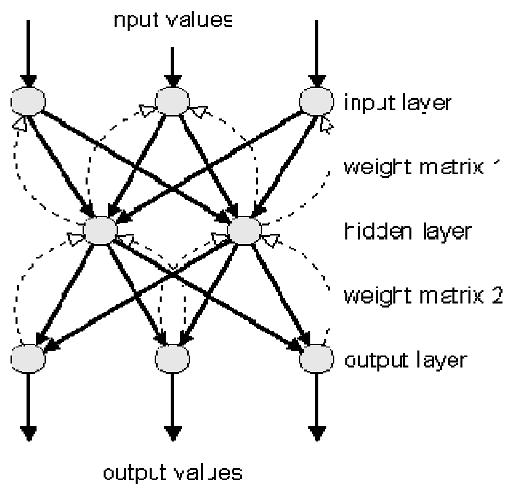

Fig. 2. Back Propogation Algorithm

Table 1: MLP on different classes

Class	Correctly Classified	Incorrectly Classified	Confusion Matrix	Kappa	Time	ROC
1	98.8	1.2	358 4 0 1 136 0 0 1 0	.9 7	866.2 2	99.5
2	99.9	0.1	354 1 0 145	.9	82.28	99.8
3	100	0	364 0 0 136	1	147.9 2	100
4	98	0.2	348 0 7 0 90 0 3 0 52	.9 5	96.13	99.8
5	100	0	422 0 0 78	1	5.29	100
6	100	0	416 0 0 84	1	4.7	100
7	99.8	0.8	476 4 0 20	0. 9	38.42	99.8

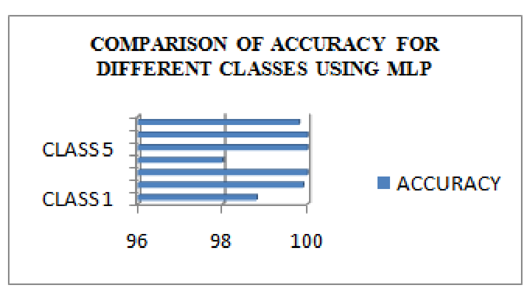

Fig. 3. Comparison Graph for accuracy using MLP

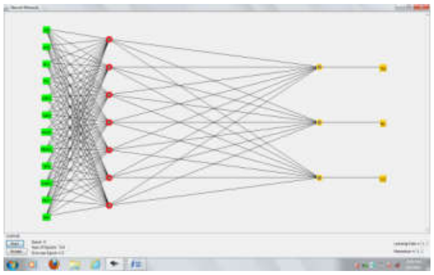

Fig. 4. Network Architecture for Class 1

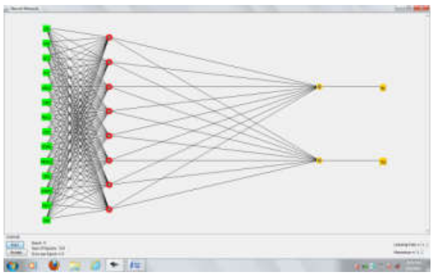

Fig. 5. Network Architecture for Class 2

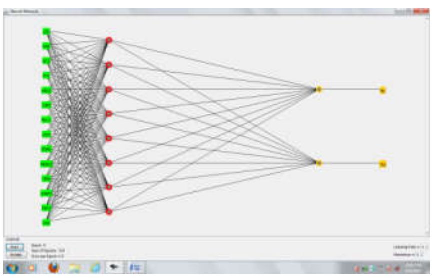

Fig. 6. Network Architecture for Class 3

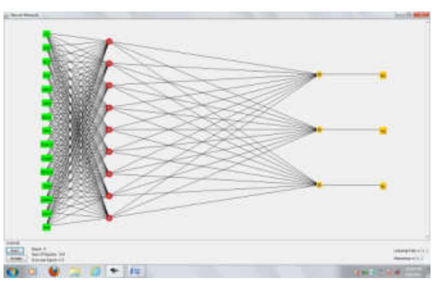

Fig. 7. Network Architecture for Class 4

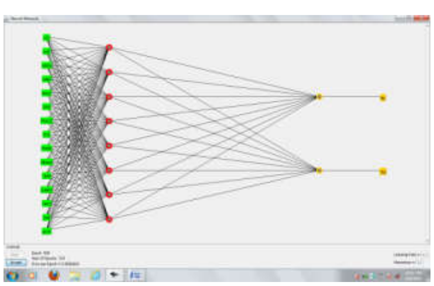

Fig. 8. Network Architecture for Class 5

EXPERIMENTS AND RESULTS

In this section the analysis is carried out on the data set generated by the learning model generated earlier. Neural Network approach is used for data mining. The results obtained from the experiments are presented in Tables 1 and

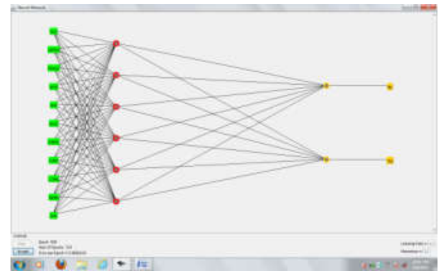

Fig. 9. Network Architecture for Class 6

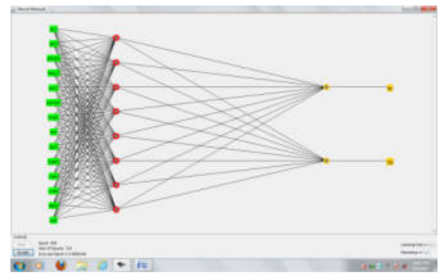

Fig. 10. Network Architecture for Class 7

Figures 3 to 10. The columns 2 and 5 show that the accuracy is very excellent. From Column 4 we infer that Class I and Class IV are 3-class problems and the remaining are 2-class problems. The graph presented in Fig. 3 is self explanatory. Figures 4 to 10 present the Network architecure for classes I to VII respectively.

CONCLUSION

The data set obtained from the learning model that consists of 3500 data instances and 99 attributes has been used for the present investigation. The results obtained by the application of Neural Network approach are highly encouraging and of practical interest. The performance analysis shows that the Learning model used to generate the data set is highly accurate. Finally it is concluded that the present methodology is unique and generic and can be extended to other disciplines. This is a novel approach and no work in this direction is available.

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