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EFFICIENCY OF NEURAL NETWORK IN THE ANALYSIS OF TRUSSES

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Abstract: Neural networks are simply known as the biological nervous system. An Artificial Network (ANN) is an information processing system that is inspired by the way biological Nervous System, such as the brain, process information. The key element of ANN 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. ANNs, like people learn by example. They can be trained with a known example of a problem. Once trained, the network can be put to use in solving unknown and untrained problems. An ANN is configured for a specific application , such as pattern recognition or data classification, through a learning process. Learning in biological system involves adjustment to the synaptic connection that exist between the neurons. This examines the efficiency of neural networks. Taking into consideration type of ANNs such as Generalized Regression (GR) neural network. Radial Basis Function (RBF) neural networks, Linear Layer (LL) neural network efficiency of ANNs is checked in the design of trusses. The neural networking tool available in MATLAB is used. To train ANNs, various input and output data are provided using an analysis and design package STAAD PRO. The ANNs are trained with some values and are tested for both interpolation and extrapolation Then percentage error is calculated in all three ANN. Based on percentage error, the efficiency of each ANNs is compared in the design of trusses. The study is made by increasing the number of training, by increasing the number of input and output variables, by training in the matrix form, etc. From these results the suitability of each ANN is studied and conclusions are drawn.

Keywords: Neural networks, Truss, General Regression Neural Network, Generalized Regression

I. INTRODUCTION

ANNs are great at solving algorithmic and math problems, but often the world can't easily be defined with a mathematical algorithm. Facial recognition and language processing are an example of problems that can't easily be expressed into an algorithm, however, these tasks are of importance to humans. The key to Artificial Neural Networks is that their design allows them to process information in a similar way to our own biological brains, by drawing the idea from how our own nervous system functions. This makes them useful for solving problems like facial recognition, which our biological brains can do easily. Dr. Robert Hecht-Nielsen was the inventor of one of the first neuro-computers. ANN is defined as a computing system made up of a number of simple, highly interconnected processing elements, which process information by their dynamic state repose to external inputs. Neural networks are typically arranged in layers. Layers are made up of a number of interconnected 'nodes'. These interconnected nodes contain an 'activation function'. Patterns are sent to the network through the input layer, which Communicates to one more 'hidden layer' here the actual processing is done through a System of weighted connections. The hidden layers are then connected to an 'output Layer' where he answer is output.ANNs are used in the optimization of structures and in the field of concrete technology.

Optimization of structures is the analysis and design procedure and it requires a lot of time. These ANNs save time in concrete technology, it is difficult to conduct several sets of experiments for finding the best admixtures and concrete with different strengths. ANN model can be developed and best admixture and concrete strength can be known and verified experimentally.Character recognition has become very important as handheld devices like the palm pilot are becoming increasingly popular. Neural networks can be used to identify handwritten characters Neural networks can receive and process large amounts of information at once, making them useful in image compression. With the Internet explosion and more sites using more images on sites, using neural networks for image compression is worth. Business of the stock market is extremely complicated. Many factors weigh in whether a given stock will go up or down on any given day. Since neural networks can examine a lot of information quickly and sort it all out, they can be used to predict stock price.

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II. LITERATURE SURVEY

Nagaradjane et al[9] used artificial neural network for their analysis on compression members confined with fiber reinforcement polymer wraps shows the rise in strength. The impact of slenderness ratio on strength by covering concrete cylinders has been investigated using ten cylindrical specimens of varying slenderness ratio. An ANNs based model is proposed for guessing the force attained fiber reinforced polymer wrapped columns for several slenderness ratios. They concluded saying that, an ANN based model predicts the strength and strain parameters with logical accuracy. The general regression neural network has calculated the combined impact of slenderness ratio and glass fiber reinforcement polymer thickness on compressive strength, ultimate axial stain and ultimate lateral stain capacities.

Rogers James et.al[14] proved that the auxiliary examination programs utilized as a part of taking care of outline issues are as often as possible computationally costly. Acquiring ideal arrangements ordinarily requires numerous cycles including investigation and improvement programs. He took into account some instruction for design and training a neural network to stimulate a structural analysis program is developed. Those instructions include the selection of training pairs and determining the numbers of nodes on the hidden layer and following those instruction a neural network can reduce the amount of time it takes an optimization process to join to an optimum design. He addressed some benefits from simulating structural analysis with neural network is the ability to receive an optimum design in very less time and once the neural network has been trained, then it can be used to perform various design studies with the model.

Mukherjee et al[8] showed the prediction of buckling load of columns using artificial neural network. Neural system prepared with the tentatively gotten values for a basic load. They reasoned that, the outcomes are motivating for embracing the neural system. The system could crevice the connection between the slenderness ratio, the modulus of elasticity and buckling load. The preparation and testing input is taken straightforwardly from the test comes about. The learning limit of the neural network system could be lauded by contrasting yields.

A detailed analysis was carried out by Noorzaei et al[11] on improvement of Artificial Neural Network (ANNs) in forecast of compressive quality of cement-concrete following 28 days. To foresee the compressive quality of cement-concrete mixture input parameters that are bond, water, silica seethe, super plasticizer, fine aggregate and coarse aggregate which were seen and distinguished. Various 639 unique informational collections comprises of 400 information sections, and the rest of the information passages for testing. Different blends of layers, numbers of neurons, activation capacities and diverse esteems for learning rate were considered and itemized think about was done, considering two hidden layers for the engineering of neural system. The cxamination demonstrates that the utilization of neural systems has a few huge favorable circumstances over other ordinary techniques.

Srinivas et al [16]took into consideration neural network system for responses of bridge desks, they accomplish this strategy by believing that, the procedure of busic outline starts with a preparatory model which is to be broke down to get the plan reactions and those are utilized to assess the plan in view of settled assessment criteria. While going for optimization of bridge decks, all the more far reaching results are fundamental in view of part emphases which arduous and tedious. At that point they took neural systems (ANN) in getting the plan reactions via preparing the system with a few examples of various arrangements of specific sort of bridge deck. For preparing of neural system they utilize a three layer feed-forward back propagation engendering neural system utilizing distinctive arrangements of information relating to different bridge deck designs. They saw that the prepared ANN is equipped for coordinating the contribution with output designs inside the adequate error resilience and conjecture the responses with mistake under 4.2% when another test informational collection is given to the system.

Akhtar et al[15] presented a study on cable layout design which is the most important step in the design of prestressed concrete structures. In the study, artificial neural networks were taken into consideration for cable layout design of prestressed concrete beams. Most often cables are idealized as parabola in different spans. The training data were employed from FE based cable layout design in which cable is modeled as B-spline. The trained networks were tested on several new problems and it was observed that designed profiles are quite close to the simulation based counterparts. This approach cuts short design time to certain extent and lessen up the dependencies on the design software. They said neural network approach will prove to be an efficient tool of the design engineers, who are not very versed to FE simulation, to select the initial designs.

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III. METHODOLOGY

- To develop an ANN model for truss analysis, a networking tool available in MATLAB is used.
- The analysis is carried out by considering single, two, and three input parameters. To train ANN, various input and output data are necessary.
- The ANN has been analyzed by using the STAAD PRO 2006 result. Once ANN is trained it is tested for several values within the trained range effectively and calculated their percentage error by comparing with STAAD. Pro 2006 results. After analyzing the neural network performance one over the other for these results conclusions are drawn.
- Further study is carried out by using the MATLAB program and ANN is trained and tested for several values, calculating the percentage error of ANN compared to the Matlab program values. After studying the performance of the neural network one over the other and from these results conclusions are drawn.
- The network is then trained and used in solving untrained instances of the problem in the design of trusses.

IV. DIFFERENT ANN'S USED FOR STUDY

Regularly neural systems are prepared and examined with the goal that a specific input gives particular target output. Such a condition is demonstrated as follows. There, the system is balanced, in view of a correlation of the output and the objective, until the point when the system output coordinates the target. Regularly numerous such input/target sets are utilized, in this directed learning, to prepare a system. Fig -1: Flow chart for training of neural network In the present investigation, Generalized Regression (GR), Radial-Basis- Function (RBF), Linear Layer (LL) neural systems are utilized for approximating the yield of examination of the trusses.

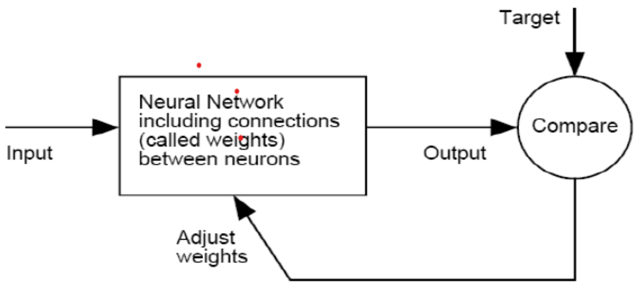

Fig 1. Flowchart for training of neural network

RBF's are embedded in a two layer neural network, where each hidden unit implements a radial activated function. The output units implement a weighted sum of hidden unit outputs. The input into an RBF network is nonlinear while the output is linear. In order to use a Radial Basis Function Network we need to specify the hidden unit activation function, the number of processing units, a criterion for modeling a given task and a training algorithm for finding the parameters of the network. Finding the RBF weights is called network training. If we have at hand a set of input-output pairs, called training set, we optimize the network parameters in order to fit the network outputs to the given inputs. Radial basis functions are embedded into a two-layer feed-forward neural network. Such a network is characterized by a set of inputs and a set of outputs. In between the inputs and outputs there is a layer of processing units called hidden units. Each of them implements a radial basis function

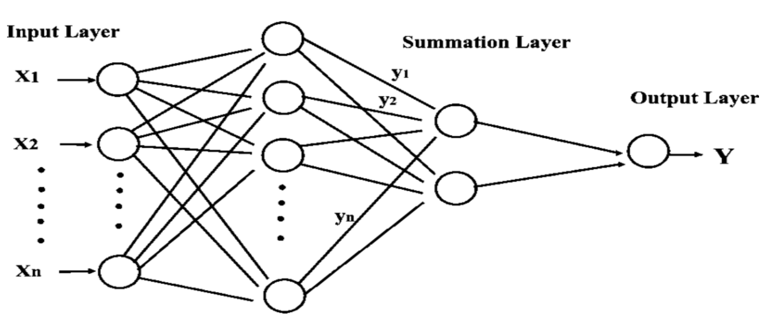

Fig 2. Radial Basis Neural Network

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The General Regression Neural Network (GRNN) is one of the most well-liked neural networks. They a parallel structure where the learning is one fold that is input to structure to output there is no iterative learning present such as in the case or Multi Layer Perceptrons (MLP) making them fast to some extents. Also they carry out well on noisy data then say Back-propagation Neural Network (BPNN) if the available data is huge enough. These is one of the reasons the GRNN are being used in medical classification, predictive and diagnostics problem because a large amount of noisy data is present is such cases. GRNN is also very unswerving and as the size of the data set increases the error reaches towards zero. The GRNN works quite exactly with light datasets**.**

The GRNN infrastructure consists of four layers input, hidden, summation and output layer.

- The input layer simply transports the data attributes to the next layer in a parallel archetype.
- The second layer has all the training samples.
- In the summation layer the summation units or neurons perform a dot product on the attributes of the weight vector of the second layer.
- Then in output layer the respective local output are separated to get the predictions.

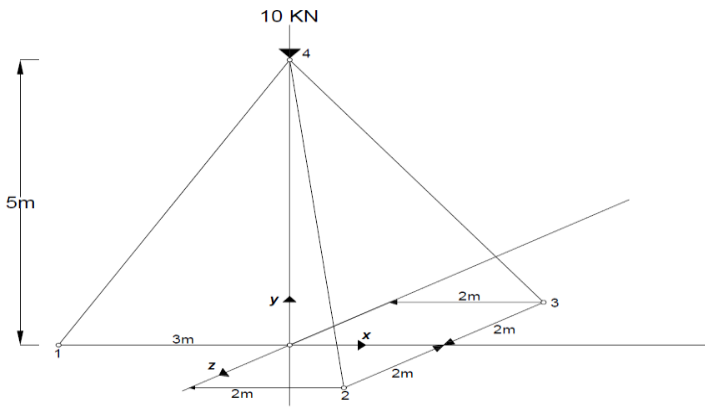

Fig 3. Generalized Regression Neural Network

V. RESULTS AND DISCUSSION

The various artificial neural networks (ANNs) available in MATLAB such as Generalized Regression (GR), Radial Basis Function (RBF) and Linear Layer (LL) are produced for various trusses by training with STAAD PRO results. Then the neural networks tested for the values in the range within which the network has been trained and even outside the range of trained values i.e the ANNs are tested and trained for both interpolation and extrapolation. Then the percentage error is calculated and suitability of each neural networks is obtained. The study is carried out as follows.

1. TRUSS 1- OUTCOME OF SPREAD CONSTANT ON THE PERFORMANCE OF GR AND RBF NEURAL NETWORKS

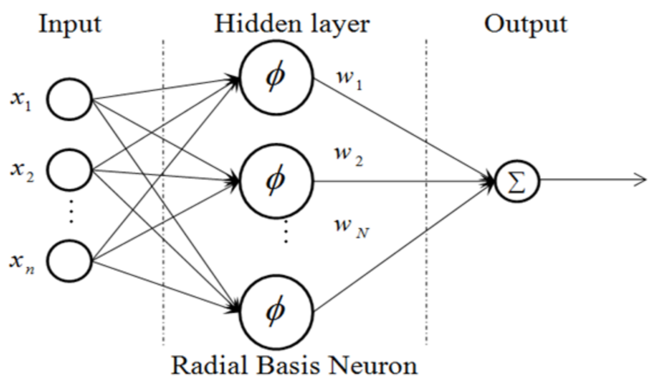

Fig 4. TRUSS 1

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2. TRUSS 1- OUTCOME OF NUMBER OF TRAININGS ON THE PERFORMANCE OF ANNs

Similarly for truss shown in Fig.4.1, the ANNs (GRR, RBF and LL) are built up to find the force in each member of the truss for several heights. ANNs are trained and tested heights varying from 5m to 10m with values 5, 6, 7, 8, 9, 10m. These ANNs are tested and analyzed for both interpolation and extrapolation for set of heights varying from 4m to 11m with values 4, 4.5, 5.25, 6.25, 7.25, 7.75, 8.25, 8.75, 9.25, 9.75, 10.5, 11m. The percentage error is calculated for all the 3 ANNs I cases of both interpolation and extrapolation.

Test for	STAAD	G.R	%Error	RBF	%Error	LL	%Error
Height(m)	F1(KN)	F1(KN)		F1(KN)		F1(KN)	
4.00*	-5	-4.8397	3.3	-5.0009	-0.22	-4.7714	4.8
4.50*	-4.807	-4.7628	0.9	-4.807	-0.004	-4.7177	1.9
5.25	-4.607	-4.616	-0.2	-4.606	0.002	-4.6372	-0.7
5.75	-4.512	-4.525	-0.3	-4.512	-0.002	-4.5835	-1.6
6.25	-4.437	-4.4513	-0.3	-4.437	-0.00	-4.5299	-2.1
6.75	-4.377	-4.3914	-0.3	-4.376	0.00	-4.4762	-2.2
7.25	-4.329	-4.3413	-0.3	-4.328	0.002	-4.4225	-2.1
7.75	-4.289	-4.2995	-0.2	-4.288	0.002	-4.3688	-1.8
8.25	-4.256	-4.2651	-0.2	-4.256	-0.002	-4.3151	-1.4
8.75	-4.229	-4.2371	-0.2	-4.229	-0.01	-4.2614	-0.8
9.25	-4.205	-4.2138	-0.2	-4.205	0	-4.2078	-0.1
9.75	-4.185	-4.1939	-0.2	-4.185	-0.002	-4.1541	0.7
10.50*	-4.16	-4.1707	-0.3	-4.160	-0.002	-4.0735	2.1
11.00*	-4.146	-4.1611	-0.4	-4.1461	-0.002	-4.0199	3.1

Table 1. Tested results for force in First Member(F1) of Truss 1

TRUSS 1- OUTCOME OF NUMBER OF TRAINING ON THE PERFORMANCE OF ANNs (WHEN THE NUMBER OF OUTPUT VARIABLES ARE INCREASED)

For the similar truss shows in fig 1, the ANNs are built to find the force in each member of the truss and the displacement in X, Y -direction i.e., number of output variable have been increased. ANNs are trained and tested for heights varying from 5m to 10m with values 5, 5.5, 6, 6.5, 7, 7.5, 8, 8.5, 9, 9.5, 10m and tested and analyzed for the same set of heights as in table 9 and 10. The percentage error is been found for ANNs in case of interpolation and extrapolation.

Test for	STAAD	G.R	%Error	RBF	%Error	LL	%Error
Height(m)	F1(KN)	F1(KN)		F1(KN)		F1(KN)	
4.00*	-5	-4.7831	4.5	-5.0001	-0.002	-4.7354	5.6
4.50*	-4.807	-4.7034	2 .20	-4.8069	-0.002	-4.6841	2.6
5.25	-4.607	-4.583	0.5	-4.6079	0.00	-4.067	0.00
5.75	-4.512	-4.5118	0.004	-4.512	-1.1	-4.5557	-0.9
6.25	-4.437	-4.4481	-0.2	-4.437	0.00	-4.5043	-1.5
6.75	-4.377	-4.3911	-0.3	-4.377	0.00	-4.453	-1.7
7.25	-4.329	-4.3413	-0.3	-4.329	0.00	-4.4016	-1.6
7.75	-4.289	-4.2995	-0.2	-4.289	0.00	-4.3502	-1.4
8.25	-4.256	-4.2651	-0.2	-4.256	0.00	-4.2989	-0.10
8.75	-4.229	-4.2375	-0.2	-4.229	0.00	-4.2475	-0.4
9.25	-4.205	-4.2156	-0.3	-4.205	0.00	-4.1962	0.2
9.75	-4.185	-4.1982	-0.3	-4.185	0.00	-4.1448	0.10
10.50*	-4.16	-4.1777	-0.4	-4.1602	-0.005	-4.0678	2.3
11.00*	-4.146	-4.1673	-0.5	-4.146	0.00	-4.0164	3.2

Table 2. Tested results for force in First Member (F1) of Truss 1

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VI. CONCLUSION

- As per the analysis on the results of GR, RBF and LL neural networks the following conclusions are obtained
- Extrapolation should not be taken into consideration in GR, RBF and LL neural networks.
- Taking in account interpolation, the results of GR, RBF is reduced as the spread constant is increased.
- In interpolation, the results of results of RBF is excellent as compare to GR. GR shows excellent results for the values away from trained end values. RBF and LL shows good performance for all analysed values.
- When ANNs are trained, analyzed and tested for large number of values, there is little improvement in the results of ANNs.
- ANNS remains constant even if output variables are increased.
- If the output variables are increased there is very much improvement in the results of ANNs.
- If the input variable are increased there in reduction in results of ANNs.
- Taking into consideration matrix form training results of RBF is better than GR and LL and GR
- shows better results than LL or vice-verse. AS number of trainings are increased there is improvement in the results of ANNs.
- RBF proves to be poor for large number of training and input variables.
- Results of GR and LL is reduced as there is increase in number of input variable.

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