Analysis Of 2-D Howe Type Truss Using MATLAB's Artificial Neural Network Module

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Abstract: Artificial neural network is the tool which can solve many structural engineering related problems with less effort. Analysis of truss involves calculating axial forces in each member of the truss. Member forces varies as per loading and analysing entire truss takes time even in software. Hence an attempt is made in this work to connect the analysis of truss with Neural Networking to get the results without using design software. In the present work, fifteen number of trusses of varying span, height, number of panels, number of members and point loads are used to generate data for training, simulating and testing the network created from MATLAB's ANN module. Another aim of the study is to decide ideal pair of transfer function which are to be specified before developing a network. At the end of simulation, it was found that the results obtained by simulation of network are same as that calculated by software with very minimal errors. Moreover, it was determined that the combination of tansig-purelin as transfer functions between input, hidden and output nodes validates to be the best pair as the root mean square error for this pair of transfer function is nearly zero.

***IndexTerms* – Artificial Neural Network, MATLAB, Transfer Function, truss, member forces.**

I. INTRODUCTION

1.1Truss

Trusses are most widely used structures for longer span. This is because the bending moment capacity is most efficiently governed by the depth of section. If only a single section is used, a large portion of the web actually is unused. Besides, a single big section will be very costly and also infeasible in erection and fabrication. Whereas a truss is useful when there is plenty of depth and relatively light loading.

It can look very complicated, but it can be the simpler case in calculation when compared to a beam especially when all the joints are considered pinned.

1.2 Artificial Neural Network: An Overview

An Artificial Neural Network(ANN) is an information processing system which was developed as a generalization of mathematical model of human cognition. An ANN is a mathematical model that tries to simulate the structure and functionalities of biological neural networks. Its network works in a similar way to a human brain. It finds solution (i.e. produces an output) for a problem in given situation (i.e. from given input).

The basic processing elements of neural networks are called artificial neurons or simply neurons. Often, they are simply called as nodes. Neurons perform as summing and non-linear mapping junctions. The nodes acquire knowledge through a process of learning by changing the weights associated with each input. They store this knowledge in terms of weights on completion of learning process and use it to find the output

A neural network is a network made up of such inter-connected neurons which is inspired from studies of the biological nervous system.

II. METHODOLOGY

2.1 ANN Module in MATLAB

There are 3 basic methods in which ANN is been articulated in MATLAB.

APPLICATION FOR NEURAL NETWORK FITTING(nftool)

1. NEURAL NETWORK TOOLBOX(nntool)
2. USING MATLAB EDITOR

In the present work, Neural Network/Data Manager toolbox (nntool) is used for developing network.

2.2 ANN IN TRUSS ANALYSIS

A truss acts like a deep beam. A beam becomes stronger and stiffer when it is deeper. But when the span is long and just carries a light load, it may waste a lot of material just carrying itself.

This is because the bending moment capacity is most efficiently governed by the depth of section. If only a single section is used, a large portion of the web actually is unused. Besides, a single big section will be very costly and also infeasible in erection and fabrication. Whereas a truss is useful when there is plenty of depth and relatively light loading. It can look very complicated, but it can be the simpler case in calculation when compared to a beam especially when all the joints are considered pinned. Abundant literature is available on analysis of trusses of variety of shapes. The truss structures are required to be designed in such a way that they have enough strength and rigidity to satisfy the strength and serviceability limitation. It is not difficult to conceive that there are quite a number of structures with different shapes which meet the requirement. But among them it is the most economical one that interests the structural engineer the most.

There are several methods normally used for the analysis of trusses. Among the general one are method of joints, method of sections, graphic statics, flexibility method, stiffness method and finite element method.

In the present work, STAAD Pro software is employed to analyze truss for static load and to generate data set for MATLAB ANN module.

III. PROBLEM SOLVED

3.1 Data Generation

Howe roof truss has been analyzed for only point loads. Table 1 shows the properties of the truss analyzed:

Table 1 Specifications of truss for data generation

SPAN (M)	HEIGHT (M)	NO. OF PANELS	NO. OF MEMBERS	NO. OF JOINTS	NO. OF POINT LOADS
15	3	10	37	20	9
20	5	10	37	20	9
20	5	12	45	24	11
25	4	12	45	24	11
26	4.5	14	53	28	13

A total of 15 sets of point loads are applied to each of the above truss geometry and analyzed in STAAD. Trusses with same number of panels were analyzed for same point loads. As a result of this 75 data sets are generated.

3.2 Network Creation

Data generated from above procedure consists of a sum of 75 sets including length of each member, joint loads for each case and axial forces in each member.

While creating a network, target for the network are taken as the member axial forces whereas the length of the member and set of point loads are taken as inputs to the network.

Number of members for the truss of 10 panels consists of 37 members and is analyzed for 9-point loads. Similarly, for truss of 12 panels, members are 45 and analyzed for 11-point loads. And for 14 paneled trusses, 53 members are analyzed for 13-point loads.

Thus, for the longest truss there will be 53+13+53=119 values in one data set for one load case. Since it was planned to generate only one ANN model to solve all the above truss geometries, single data base is to be supplied to ANN module for all the trusses. This require same length in each pattern. But the number of values for all geometries is not same. for e.g. For truss of 15 m span total number of values in one pattern is 37+37+9 = 83.

This problem of difference in the numbers of members and point loads is tackled by introducing zeros above and below the data set so that the main data remains in the center i.e. to make the set for 10 paneled trusses, to get 53 data values, 8 zeros are added above and 8 below. Similarly, to make count of point load as 13, 2 zeros above and 2 below are added.

So, we have a data of size 119x75, from which input data are the 53-member lengths and 13-point loads. For testing purpose, 1 data from each truss is taken and remaining 70 sets of data are taken for training. Thus, input data is of size 66 x 70 and target data is of size 53x70.

A try for creating a network, taking input as only the point loads and target as the axial load, was made, which gave huge errors due to difficulty in creating a strong network and due to a huge difference in input and output parameters.

MATLAB’s Neural Network/Data Manager toolbox (nntool) is used to develop ANN network. Effect of transfer function on the network performance is studied by selecting three different transfer functions. Transfer function for Input – Hidden nodes and Hidden-Output nodes are altered amongst *purelin tansig* and *logsig*.

IV. RESULTS

Results obtained after training are shown in the table 2.

Table 2 Network Performance for Various Transfer Functions

TRANSFER FUNCTION I-H	TRANSFER FUNCTION H-O	EPOCHS	PERFORMANCE(MSE)	R	TIME (mm:ss)	TESTING ERROR (RMSE)
PURELIN	PURELIN	45	27.2	0.99347	02:19	2.921
PURELIN	TANSIG	144	21.4	0.9948	05:36	2.199
PURELIN	LOGSIG	71	382	0.9275	03:19	18.11
TANSIG	PURELIN	151	0.0846	0.99998	07:00	0.804
TANSIG	TANSIG	181	0.121	0.99997	08:06	9.097
TANSIG	LOGSIG	73	363.59	0.93162	03:26	21.744
LOGSIG	PURELIN	151	0.10439	0.99998	07:10	2.013
LOGSIG	TANSIG	80	475.115	0.8906	03:45	18.141
LOGSIG	LOGSIG	117	516.4941	0.88495	05:47	20.339

Snaps of some of the networks from the above list are shown in **Fig.1, Fig.2, Fig.3,** and **Fig.4** along with their plots of performance, regression and training state. These figures are enough to judge the complete proceeding of the training process.

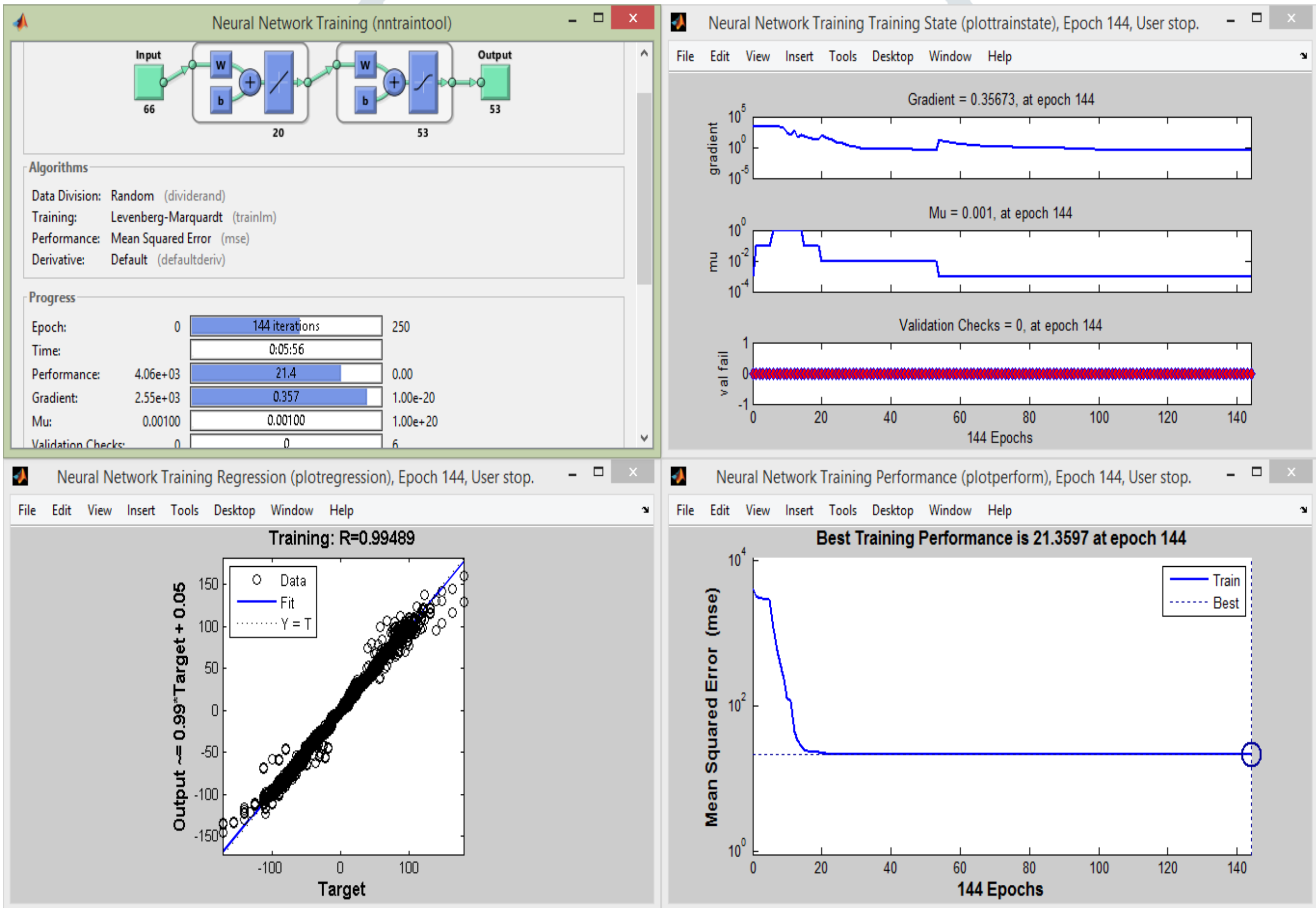

Fig.1 Position at the End of Training for Purelin-Tansig Case

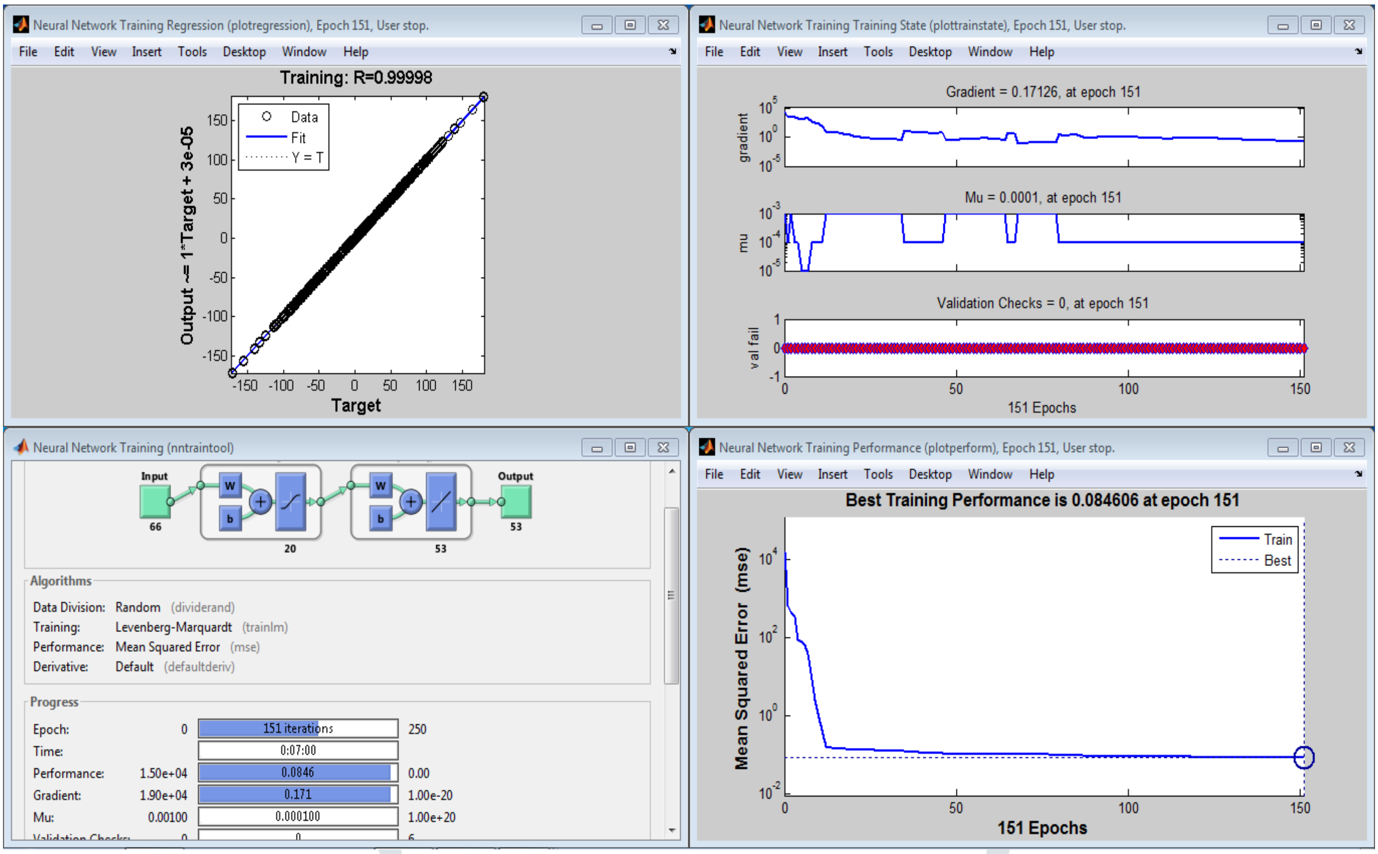

Fig.2 Position at the End of Training for Tansig -Purelin Case

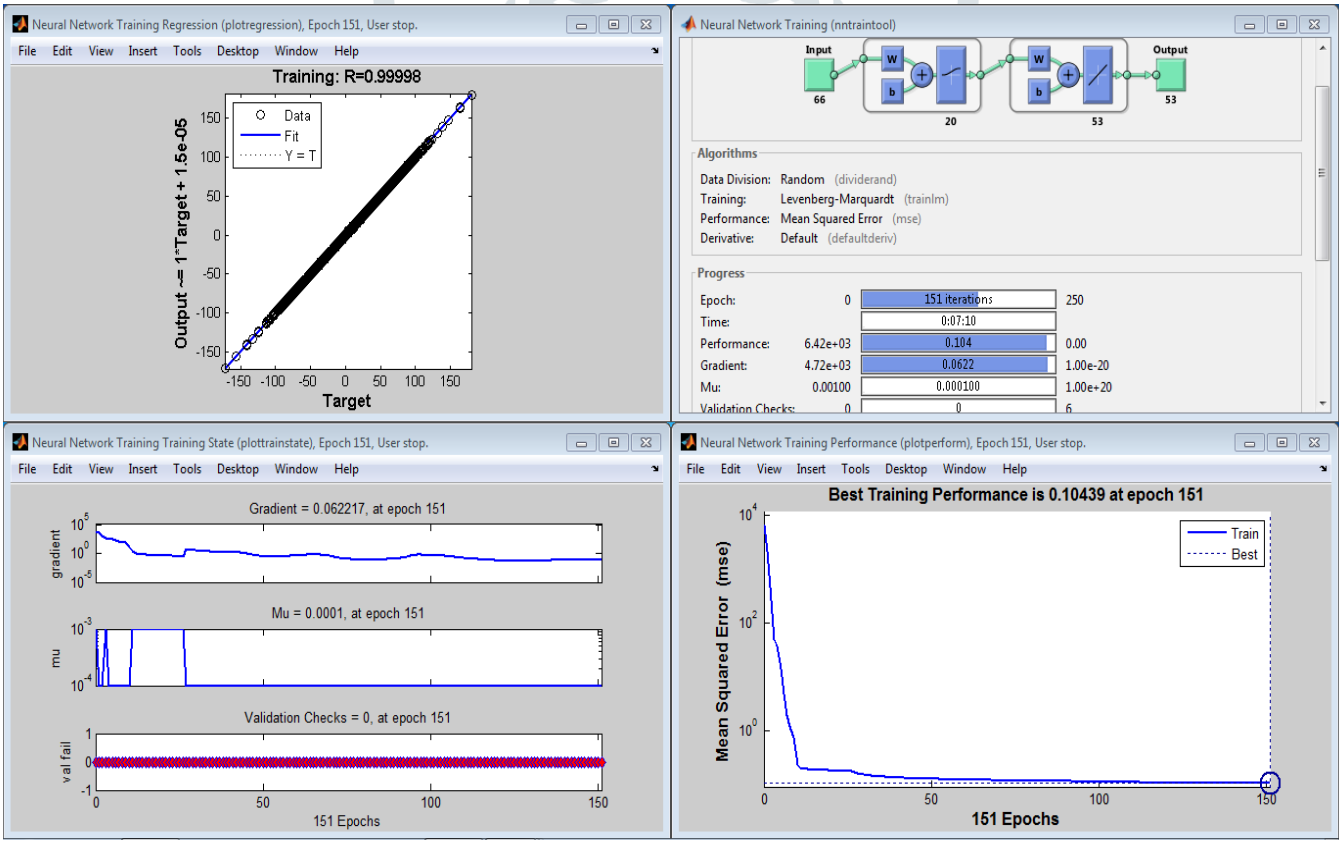

Fig.3 Position at the End of Training for Logsig-Purelin Case

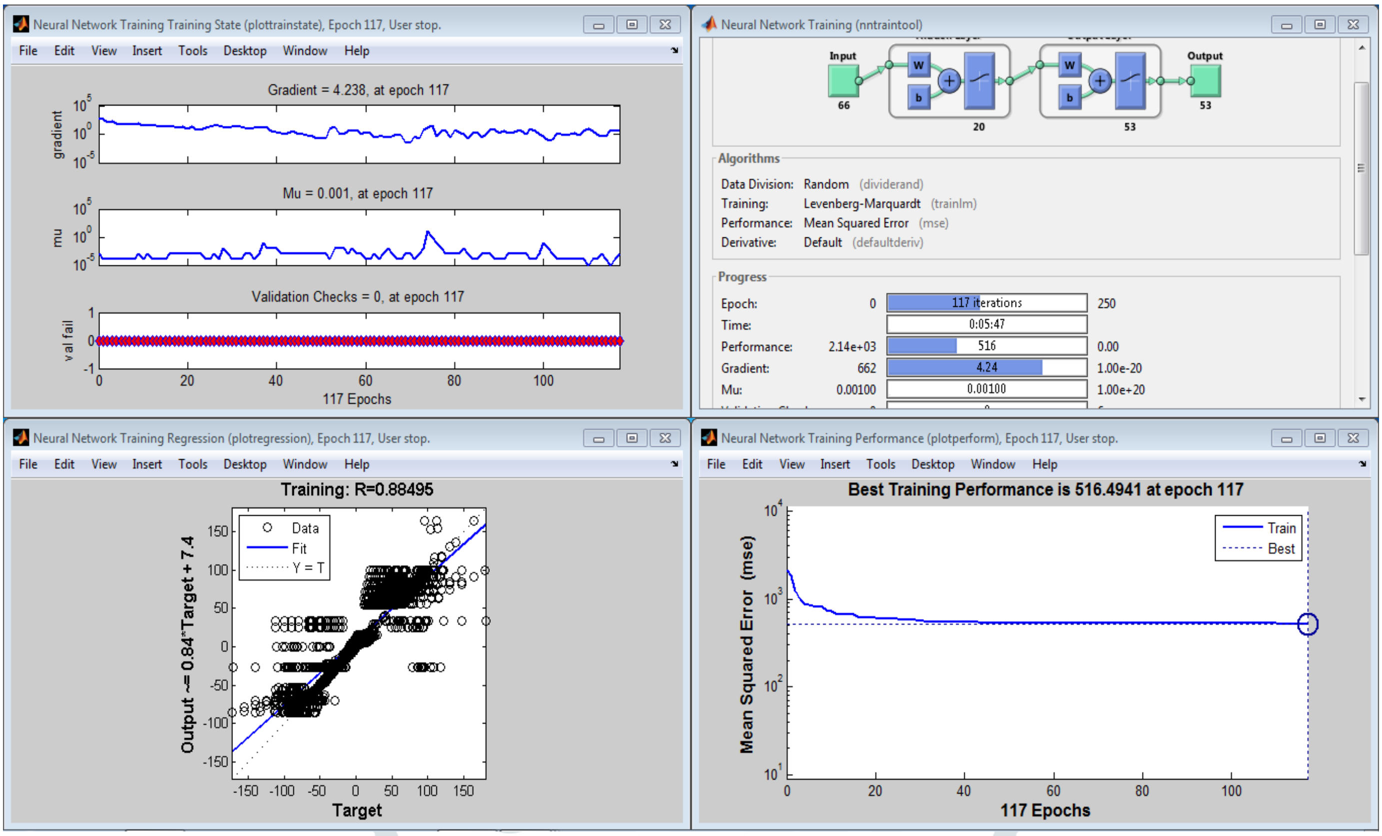

Fig.3 Position at the End of Training for Logsig-Logsig Case

V. CONCLUSIONS

1. First of all, it can be deduced that by using proper variables and parameters while creating network, such type of complex structural engineering problems can be solved.
2. From the performance point of view, best result is obtained with combination of tansig – purelin. Hence, if one wants to create a network for any other structural engineering problem, this pair of transfer functions can be taken as a preliminary pair.
3. Looking to testing error for tansig-purelin it can be said that the results obtained are reliable.
4. It is also seen that performance of purelin as a transfer function between hidden and output node is better than any other function.
5. Logsig as a transfer function for the first layer showed distracted results.

VI. REFERENCES:

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