Artificial Neural Network Based Graphical User Interface for Estimation of Fabrication Time in Rig Construction Project

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Abstract—This paper addresses the problem of estimation of fabrication time in Rig construction projects through application of Artificial Neural Network (ANNs) as this is the most crucial activity for successful project management planning. ANN is a non-linear, data driven, self adaptive approach as opposed to the traditional model based methods, also fast becoming popular in forecasting where relationship between input and output is not known but vast collection of data is available. Around 960 data regarding fabrication activity has been collected from ABG Shipyard Ltd., Dahej. 3 input parameters have been considered for estimation of output as fabrication time. 11 Feed Forward Back Propagation neural networks with different network architectures were made. Network N10 was able to predict the output with MSE 1.35337e-2. Coding was done for the Graphical User Interface (GUI) so that the GUI runs, simulates network N10, and displays the fabrication time for different combination of inputs.

Keywords: Fabrication time, Artificial Neural Network, Graphical User Interface, GUI coding.

I. INTRODUCTION

In the construction projects (ex. Rig building) it is crucial to minimize risks in the project estimation phase. This is an early project stage in which different resources are estimated. One of the important estimations is also the necessary number of fabrication/construction hours or days. The estimation phase is commonly a human expert driven (intuitive method) activity which is sensitive to the expert's bias (judgement / experience). This bias can lead to an underestimation of project resources, when the estimator is overconfident, or to over-estimation of project resources when the estimator does not have sufficient confidence that all aspects of the project can be properly covered. Both scenarios, based on the expert's estimation, have a negative impact on the future business decisions. In case of underestimation, the project will bring economic loss, and in case of overestimation, it will most likely be assigned to a competitive supplier. The estimator's key competence is to properly collect and evaluate all the information which is significant for making the project estimation. The paradigm lies in the fact that the estimator should spend minimal time necessary on estimation activity.

One of the main obstacles in this process is to accurately define the relationship between product characteristics and the construction/fabrication time necessary to manufacture the product. Earlier studies (Zhang and Fu, 2009) showed that the scientific and reasonable performance evaluation is advantageous to promote the comprehensive management level of engineering projects. At present the fields of academia and engineering had been achieved some results on this issue. Iranmanesh and Zarezadeh (2008) stated that the researchers have done lot of research in the area of application of Artificial Neural Network (ANN) in project success, project evaluation, project cost forecasting. As there are a few studies on application of ANN in project estimation, there is a good opportunity to accurately forecast time of fabrication in construction projects through applying ANN approach.

The main aim of this paper is to develop the model that fits into intuitive method for estimating fabrication time. Three input variables are considered as height of job, max. plate thickness of job and inspection criteria of job. Inspection criteria is dependent on the value of max. plate thickness. From this input value output as productivity factor is decided by the intuitive method. Fabrication time in number of days is calculated by dividing quantity of job (tonnes) by productivity factor. We have developed detailed step by step neural network model of the expert driven estimation approach. Through this model, an effort is made to capture the experience of the data available, which can be further used to predict new combination of inputs. We have also developed a Graphical User Interface(GUI) so that the ANN model can be used without any prior knowledge of ANN.

II. METHODOLOGY

A. Data

To train the ANN, 960 readings from already completed jobs were collected from ABG Shipyard Ltd., Dahej, Bharuch. Out of them 15 sample readings are shown below (see Table I)

Sr. No.	Activity/ Job	Height (m)	Max Thickness Of Plates (mm)	Inspection Criteria (%)	Productivity Factor	Quantity Of Activity (Tonnes)	Duration (Days)
1	BOW	8.20	16.00	20.00 %	0.8	108.50	136
2	CS1	5.00	63.00	100.00 %	0.5	147.18	294
3	CS2P	8.00	80.00	100.00 %	0.5	50.65	101
4	CS3S	7.50	75.00	100.00 %	0.5	71.16	142
5	MD1	1.50	25.40	50.00 %	1	33.22	33
6	LB2P	2.00	22.50	50.00 %	1	26.65	27
7	LB2S	1.00	22.50	50.00 %	1	24.90	25
8	CS7	8.00	29.00	50.00 %	0.5	58.39	117

9	SPUDCA NFW	6.00	57.00	100.00 %	0.8	346.7 6	495
10	CSG2P	2.00	89.00	100.00 %	0.2	1.66	8
11	CSG3P	3.30	57.00	100.00 %	0.2	10.52	53
12	CSG4P	2.00	89.00	100.00 %	0.2	1.76	9
13	CSG5P	1.50	32.00	50.00 %	0.2	4.41	22
14	LQ5	10.0 0	19.00	20.00 %	0.8	90.62	113
15	LQ6	6.50	25.40	50.00 %	0.8	54.38	68
Min.(all 960 jobs)		1.00	6.00	20%	0.2	0.50	-
Max.(all 960 jobs)		30.0 0	90.00	100%	1	350	

Table. 1: Data on 15 samples of activities from ABG Shipyard Ltd., Dahej, Bhrauch

B. Application of Artificial Neural Network

Earlier studies (Jha) stated that ANNs are non-linear data driven self adaptive approach as opposed to the traditional model based methods. ANN is one of the branches of Artificial Intelligence (AI). ANNs are powerful tools for modelling, especially when the underlying data relationship is unknown. ANNs can identify and learn correlated patterns between input data sets and corresponding target values. After training, ANNs can be used to predict the outcome of new independent input data. ANNs imitate the learning process of the human brain and can process problems involving non-linear and complex data even if the data are imprecise and noisy.

Neural network fitting tool (nftool-MATLAB (7.8.0) R2009a) was used for creating the network. The multilayer Feed forward back-propagation neural networks were selected for the modelling as it's the most common and suitable for this study. Different parameters were carefully selected to achieve the best performance.

11 different Neural Networks (N1 to N11) with different neural network architectures were created. All the networks consist of three layers of neurons with three neurons for three inputs in input layer and one neuron for one output in the output layer. The number of neurons in the hidden layer varies in different neural networks (Fig. 1).

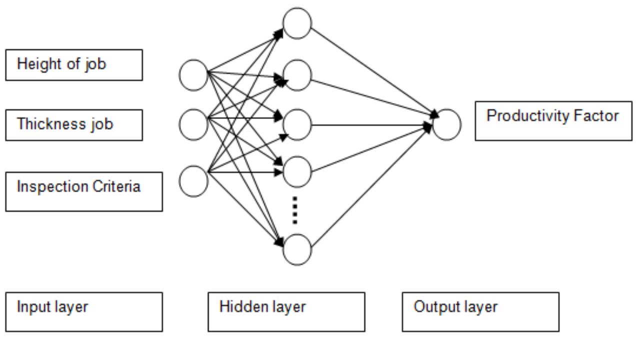

Fig. 1: Structure of the neural network

1) Transfer function

Each neuron has its own transfer function f, which produces the output a of that neuron based on the net input n from the previous layer.

$$a = f(n) \qquad \ldots(i)$$

where, $n = \Sigma (p_i w_i + b_i)$ …(ii)

p= scalar input
w=weight
b=bias
i = 1 to N,
N = Number of inputs.

Tan-Sigmoid & Pure-linear transfer functions were used as an activation or transfer function. Tan-Sigmoid squashes the output between -1 to 1 by using equation

$$f(n) = [2 / (1 + e^{-2n})] - 1 \qquad \ldots(iii)$$

and Pure-linear uses the equation

$$f(n) = n \qquad \ldots(iv)$$

2) Training

All the networks were trained using Levenberg-Marquardt back propagation algorithm which uses the following equation to update weight and bias of the network:

$$x_{k+1} = x_k + \frac{J^T e}{J^T J + \mu I} \qquad \ldots(v)$$

Where, x_i = matrix of all weights and bias in i^{th} training cycle

J = Matrix that contains first derivatives of the network errors with respect to the weights and biases

μ = scalar value (μ α performance function)

I = Identity Matrix

All the network networks were trained for 1000 epochs (training cycle). The initial value for μ was taken as 0.001. μ is multiplied by μ decrease whenever a step would reduce the performance function and multiplied by μ increase whenever a step would increase the performance function.

3) Weights and Bias

Each neuron has its bias b and weights (w) equal to neurons in the previous layer. Initial weights and bias were selected randomly by the software. After the training, all the weights and bias were saved for all the networks.

4) Performance function

At the end of each cycle, the performance of the network is calculated by its performance function. Mean Squared Error (MSE) was taken as the performance which uses the following equation.

$$\mathrm{MSE} = \frac{1}{Q}\sum_{k=1}^{Q} e_k^2 \qquad \ldots(vi)$$

Where,
Error, e = actual output - network output
Q = no. of readings used for training = 672

5) Testing and Comparison

After 1000 training cycles, All the networks were simulated with training set of 672 (70%) readings and unknown validation and testing set of 144 (15%) and 144 (15%) reading respectively. Comparison of networks was made on the bases of MSE and Regression values given by MATLAB for training and testing dataset (see Table II).

Network	set	Network Architecture Input-hidden-output (Transfer Functions)	MSE	Regression value
N1	train	3 – 5 – 1 (t) (l)	2.62710e-2	7.81577e-1
	test		2.88462e-2	7.82512e-1
N2	train	3 – 10 – 1 (t) (l)	2.68554e-2	7.79208e-1

	test		2.24624e-2	8.18538e-1
N3	train	3 − 15 − 1 (t) (l)	2.48288e-2	8.07704e-1
	test		2.62807e-2	7.67928e-1
N4	train	3 − 20 − 1 (t) (l)	2.21643e-2	8.26944e-1
	test		3.05855e-2	7.52987e-1
N5	train	3 − 25 − 1 (t) (l)	2.43133e-2	8.07415e-1
	test		2.55221e-2	8.02421e-1
N6	train	3 − 30 − 1 (t) (l)	1.94257e-2	8.46247e-1
	test		3.57585e-2	7.13734e-1
N7	train	3 − 35 − 1 (t) (l)	2.16734e-2	8.31115e-1
	test		2.24649e-2	8.15882e-1
N8	train	3 − 40 − 1 (t) (l)	1.76361e-2	8.65306e-1
	test		2.05272e-2	8.38827e-1
N9	train	3 − 45 − 1 (t) (l)	1.81221e-2	8.57222e-1
	test		2.56533e-2	7.98515e-1
N10	**train**	**(t) (l)**	**1.35337e-2**	**9.0077e-1**
	test		**1.95865e-2**	**8.53534e-1**
N11	train	3 − 55 − 1 (t) (l)	1.58471e-2	8.78835e-1
	test		2.53753e-2	7.98257e-1

Table. 2: Performance comparison of 11 different network after 1000 training cycles

t = tan-sigmoid
l = pure linear

C. *Graphical User Interface Development*

The GUI was developed using GUIDE (MATLAB's Graphical User Interface Development Environment). GUIDE stores GUIs in two files: MATLAB Figure file (ANN.fig) and MATLAB M file (ANN.m), which are generated when the GUI is saved or run for the first time.

1) GUI layout

GUI figure file (MATLAB figure file) contains the GUI figure layout and the components of the GUI. There are 3 inputs and 1 output. For each input, three objects were created : Static Text, Slider and Edit Text. Static text object contains label of the input (Fig. 2).

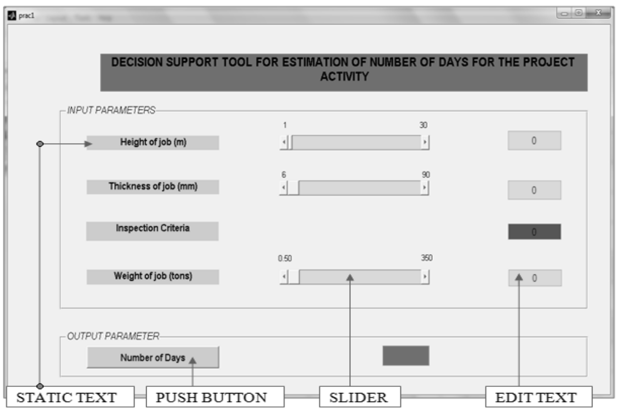

Fig. 2: Objects in GUI

A desired value of an input can be entered in Edit text object. Slider object can also be used to change the value with slider. Slider and edit text objects have their value range. For each slider and edit text, Min and Max value were selected based on the training dataset. Inspection criteria is dependent on max. plate thickness of the job so its value is directly displayed by the tool depending upon the value of max. plate thickness.

D. *GUI Coding*

GUI Code file (MATLAB M-file) contains the code that controls the GU, including the call-backs for its components. This is referred as GUI M-file. Complete coding was done in such a manner that the GUI will not run the network N10 and display an error message if the inputs are not in range. A call-back was assign to analyze the push button. If any of the input parameters is not in range, an error message will be displayed, otherwise the call-back will display the final output as the number of days by simulating the network.

III. RESULTS

Among the 11 different network, network N10 with architecture 3-50-1 was selected on the bases of least MSE value (see Table II) 1.35337e-2. The performance graph of network N10 with respect to the epochs (training cycle) was generated. Epochs were shown on X-axis and network's performance (MSE) was shown on the Y-axis. The best validation performance was 0.021178 at 93 epoch (Fig. 3).

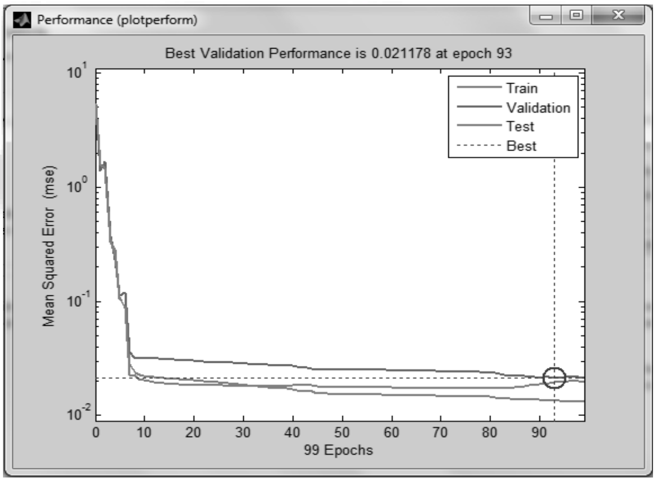

Fig. 3 : Performance graphs of the network N10

IV. CONCLUSION

In this paper a neural network approach to estimate time of fabrication in Rig construction project was studied. Multilayer feed forward back propagation network can be implemented successfully to estimate number of days of the fabrication activity. The result show least errors (see Table II) in 960 sample activities are acceptable and it can be hopeful for researcher to applying this method with new hypothesis on network structure and product characteristics. It is notable that this study is an introductory study and can be extended in various areas such as changing NN structure, input variables, variable range and so on. The GUI developed for the model would proved to be efficient to be used by the end user without prior knowledge of ANN.

However, this research has some limitations. First, the fabrication activity dataset is limited to one industry

ABG Shipyard only. Therefore it is necessary to collect more sample datasets from various-sized industries. Second, the variables for estimating fabrication time are used with restricted project inputs i.e. height, max. plate thickness and inspection criteria of job that too within given range (see Table I). Therefore, it is necessary to conduct more studies using more input parameters and a wide range of each input parameters. Third, GUI can be run by MATLAB's GUIDE tool only. An independent software tool can be developed which can run the network and the GUI which does not need MATLAB to run the network.

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