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Cost Estimation Model (CEM) of Buildings by ANN (Artificial Neural Networks) – A Review

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Abstract: Cost estimating is one of the most important and challenging activities during project planning, which occurs at the early stages of a project life where limited information is available and many unknown factors affecting the project costs. ANN is a new advent that is used in cost estimation, which is able to lucubrate from experience and examples and deal with non-linear problems. It can perform tasks involving deficient data sets, fuzzy or insufficient information and for highly complex problems. The objective of this study is to review cost estimation models which used Artificial Neural Network (ANN) tool and to suggest the most effectual algorithm for cost prediction and the factors predominantly affecting the total construction costs of building projects. To build CEM, the most effective factors affecting cost in construction projects were identified based on a comprehensive survey among a collected sample of construction relevant model studies. The developed neural network model examines the data set into distinct cases classified on the basis of hidden layers. Each of them containing the independent input neurons, hidden layers and a dependent output neuron. The results of the trained models indicated that neural network reasonably succeeded in estimating the Total construction cost of building projects at the planning stage itself. The average error of test dataset for the adapted model was largely acceptable and can perform as a good indicator regarding the ability of the proposed model to predict the total construction cost of any future construction project at an appreciated degree of accuracy. This paper gives a clear review of implementing the ANN tool in prediction of total cost of building construction projects and the relevant factors affecting it.

Keywords: Artificial Neural Network (ANN), Cost Estimation Model (CEM)**,** effective algorithm, prediction.

I. INTRODUCTION

Project owners and construction project managers need a way to focus and prioritize their efforts to control project costs, when their efforts can have maximum impact on the total cost of the project. In the earliest phase of planning and design, only the most basic and functional decisions about the project have been made and the data available for predicting project costs is ambiguous and highly subject to change. Under these conditions, traditional methods for predicting the cost such as built-up, unit cost and expert system estimating become inaccurate or impossible to implement. Stakeholders responsible for controlling project costs are in need for an alternative technique to the traditional cost-based prediction methods to help them predict the cost of their projects using the limited available data in the early phase of the project. The limitations identified with the conventional models stimulated the researchers not to rest on their oars, the drive to evolve better method then became the order of the day. The existing models then were not challenged since they lack applicability until advocators stressed the need to depart from existing research status and go for research output that can be backed with solid theory. He doubts the reliability of existing forecasting models and urged the development of good forecasting method with solid framework for applicability. Artificial neural networks are nonlinear information (Signal) processing devices, which are built from interconnected elementary processing devices called neurons. 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. ANNs, like people, learn by example. 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.

An artificial neuron is characterized by Architecture (connection between neurons), Training or learning (determining weights on the connections) and Activation function. Artificial Neural Networks have been developed at the recent decades. Artificial Neural Networks are particularly effective for solving complex problems, such as cost estimating problems, where the relationship between the variables cannot be expressed by a simple mathematical relationship. The most important characteristics of Neural Networks is their ability to learn from a set of examples to detect by themselves the relationships that link inputs to outputs, this attribute expresses the capability of Artificial Neural Network not only to manipulate the historical data as human brain, but also to solve complicated problems by searching for the optimal or near optimal solution by using one of the evolutionary learning algorithms.

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Neural networks, unlike linear regression, are able to model interdependencies between input data which will inevitably occur when considering construction cost significant variables. For example, the model variables - such as number of storey, gross floor area and number of lifts - will almost certainly be correlated. The awareness of working with accurate cost has thus created a trend among various clients including private, corporate, as well as public clients (government), that prudency in resources allocation is a great necessity for successful execution of project works. However the neural network improves on existing modelling techniques by its use of existing project data is explained, and its role in early stage cost estimation in the 21st century outlined. In order to build such model, the cost factors affecting projects' construction cost that must be firstly investigated. Besides, genetic algorithms based software will be used to search for near-optimal solution of the network. Various types of algorithm are associated with ANN i.e. Back propagation algorithm, Levenberg-Marquardt algorithm, Gradient descent. The most significantly used is LM which is known as damped least-square method and has been designed specifically with loss function which takes the form of the sum squared error. Next section discusses in brief literature reviewed related to case studies and various tools used.

II. LITERATURE REVIEW

Hojjat Adeli (1989-2000) reviewed the application of Artificial Neural Network in the fields of structural engineering and construction engineering and management. Neural networks articles published in other civil engineering areas were also reviewed, including environmental and water resources engineering, traffic engineering, highway engineering, and geotechnical engineering. Recent works on integration of neural networks with other computing paradigms such as enetic algorithm, fuzzy logic, and wavelet to enhance the performance of neural network models are also reviewed.
Margaret W. Emsley, David J. Lowe, A. Roy Duff, Anthony harding and Adam Hickson (2002) developed a Neural network cost model using data collected from nearly 300 building projects. The data collected included final account sums and, so that the model could evaluate the total cost to the client, clients external and internal costs, in addition to construction costs. Models based on linear regression techniques were used for evaluation of the neural network models. The results showed that the major benefit of the neural network approach was the ability of neural networks to model the nonlinearity in the data. The 'best' model obtained showed a Mean Absolute Percentage Error (MAPE) of 16.6%, which includes a percentage (unknown) for client changes. This was compared with traditional estimating where values of MAPE between 20.8% and 27.9% have been reported.

In the "Conceptual cost estimation of building projects with regression analysis and neural networks (2004), Rifat Sonmez, NRC Canada" paper, the advantages and disadvantages of the previous conceptual cost estimation methods were discussed and the use of regression, neural network, and range estimation techniques for conceptual cost estimation of building projects were presented. Historical cost data of continuing care retirement community projects were compiled to develop regression and neural network models. Three linear regression models were considered to identify the significant variables affecting project cost. Two neural network models were developed to examine the possible need for nonlinear or interaction terms in the regression model. Prediction intervals were constructed for the regression model to quantify the level of uncertainty for the estimates. Advantages of simultaneous use of regression analysis, neural networks, and range estimation for conceptual cost estimating were discussed.

Following to this development in the use of ANN in cost prediction models; in 2004 Gwang-Hee Kim, Sung-Hoon An, Kyung-In Kang showed the performance of three cost estimation models. The examinations were based on Multiple Regression Analysis (MRA), neural networks (NNs), and Case-Based Reasoning (CBR) of the data of 530 historical costs. Although the best NN estimating model gave more accurate estimating results than either the MRA or the CBR estimating models, the CBR estimating model performed better than the NN estimating model with respect to long-term use, available information from result, and time versus accuracy trade. Further H.Murat Gunaydin, S. Zeynep Dogan (2004) Cost and design data from thirty projects were used for training and testing with eight parameters utilized in estimating the square meter cost of a reinforced concrete structural systems of 4-8 storey residential buildings in turkey and result showed an average cost estimation of 93%.

In Vietnam (Jan 2009), Van Truong Luu ,Soo Yong Kim developed a artificial neural networks (ANNs) in estimating TCC of apartment projects. Ninety-one questionnaires were collected to identify input variables. The input variables selected were rank of the project , Gross Floor Area (GFA), Number of floors, Year of construction, Petrol price(average price), Steel price(average price).Fourteen data sets of completed apartment projects were obtained and processed for training and generalizing the Neural Network (NN). MATLAB software was used to train the NN. A program was constructed using Visual C++ in order to apply the neural network to realistic projects. The results suggest that this model is reasonable in predicting TCCs for apartment projects and reinforce the reliability of using neural networks to cost models.

Viren Chandanshive and Ajay Kambekar (2011) focused on the development of early stage cost predication model for the for the building construction projects. Using database of 58 residential, commercial and public buildings in Mumbai

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and nearby regions; to develop a Neural Network Model in Matlab R2013a using resilent back propogation and Levenberg –Marquaedt algorithms.

III. CONCLUSION

Based on the above review it shows that Artificial Intelligence (AI) enhances the reliability and reasonability of parametric cost estimating method. It was discovered that ANN may potentially resolve some major drawbacks of conventional estimating techniques. The accuracy performance by Levenberg-Marquardt (L-M) algorithm was found significantly high. This review aimed at developing a new model for total cost estimation of residential building projects that is able to help parties involved in construction projects (owner, contractors, and others) in obtaining the overall cost information at the planning stages itself with limited available datasets. Moreover, factors contributing the total construction cost of various types of building projects were identified from previous researches, analysis and expert interviews, these factors are as the following: (1) Ground Floor Area, (2) Typical Floor Area, (3) Numbers of floors, (4) Structural parking area, (5) Shear wall, (6)Quantity of exterior wall, (7) Number of householders, (8) Quantity of plaster, (9) Flooring type, (10) Number of Columns, (11) Internal decoration,(12) Electrification,(13) Plumbing, (14) Number of lifts,(15) Type of foundation, (16) AC, (17) Water Requirement.

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