Use of Artificial Neural Network for pre Design Cost Estimation of Building Projects

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***Abstract*:** The motive of this study is to apply Artificial neural network (ANN) for pre design cost estimation of building projects to investigate and overcome problems of cost estimation at initial stages of building construction. And develop & test a Graphical User Interface (GUI) model of cost estimating for reinforced concrete buildings in the early design phase. An ANN GUI model can help the designers in taking decisions about implementation of the project at the initial phases of the design process.

Key Words- *Artificial neural network,Early stage cost estimation, Reinforced concrete buildings,Cost estimation (GUI) model.*

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1. Introduction

Cost is an important factor for everyone, including to those in the construction industry. Every feasibility study, for any investment (project), requires accurate cost estimation in order to inspire the decision makers to either move forward or cancel this investment. Moreover,cost estimating is very important tool for construction project management. For instance, it provides the founders with an excellent image for the predicted cash flow throughout the project life cycle. The faithfulness & trustworthiness, of these estimates is greatly affected by many uncertain but predictable factors. So, it is worthy to pay extensive effort to achieve a more reliable estimation of the final construction cost.

Early stage cost estimating is very important activity during project planning. Every project begins its life from concepts proposed by the owner and refined by the designers. Planning decisions in this early stage of any project are vital, as it can have the biggest influence on the subsequent outcome of the project. Planning decisions are based on several planning activities, one of which is the conceptual cost estimating. Early stage cost estimation is the determination of the project's total cost based only on general early concepts of the project. Like other planning activities early stage cost estimation is a challenging work. This is due to the nature of planning, which occurs at the early stages of a project where limited information is available and many unknown factors affecting the project costs. Moreover, the uncertainties plaguing the construction industry further complicate the planning processes.

2. Literature survey

2.1 *"Early Stage Cost Estimation of Buildings Construction Projects using Artificial Neural Networks".*Journal of Artificial Intelligence 4 (1): 63-75, 2011, ISSN 1994-5450 IDOl: 10.3923/jai.2011.63.75 Department of Civil Engineering, The Islamic University of Gaza, P.O. Box 108, Palestine.

This study focused on developing an efficient model to estimate the cost of building construction projects at early stages using artificial neural networks. Gaza Strip region was selected for study and datasets from 71 projects were collected. To find out cost of building many different parameters were found out which can be obtained from detailed drawings and data at the pre-design stage of the project. The ANN model which was developed had a hidden layer and seven neurons. The achieved results from the models after training indicated that neural networks reasonably succeeded in predicting the early stage cost estimation of buildings using basic information of the projects and without the need for a more detailed design. After sensitivity analysis it was seen that there many effective factors like ground floor area number of storeys type of foundation and number of elevators in the buildings influencing the early estimates of building cost.

2.2 *"An Artificial Neural Network Approach to Structural Cost Estimation of Building Projects in the Philippines",*Roxas, Cheryl Lyne C.1, Ongpeng, Jason Maximino C.2, March 2014, Civil Engineering Department, De La Salle University Manila, 2401 Taft Avenue, Manila, Philippines.

This study focused on developing a model using artificial

neural network which can predict the overall cost of building projects in the island country of Philippines. For this study datasets were collected from 30 completed projects and were randomly divided into three sets 20% for validating the performance 60% for training and 20% generalization of network. Mainly six parameters as inputs were identified which are floor area volume of concrete area of formworks weight of reinforcing steel number of storeys and number of basements. These several variables were first put into the ANN structure and simulation done in MATLAB. The back propagation of feed forward technique was used to develop the best model for the total structural cost. The ANN structure which can be considered as best consists of 7 nodes of the hidden layer, 1 output node and 6 variables as input. The ANN model developed also predicted the complete structural cost of buildings with sufficient training and outcomes of testing phase.

2.3 "*A neural network approach for early cost estimation of structural systems of buildings*" International Journal of Project Management 22 (2004) 595–602. H. Murat Gunaydın *, S. Zeynep Do gan April 2004, Faculty of Architecture (Mimarlık Fakultesi), Izmir Institute of Technology (_Izmir Yuksek Teknoloji Enstitusu), Gulbahc_e Koyu,Urla, 35430 Izmir, Turkey.

The objective of this research was to use artificial neural network system to solve cost estimation problems in pre design phase of building projects.To train and test the artificial neural network system cost sheets and design datasheets were collectedfrom 30 different building projects with 8 different factors. In the estimation of the reinforced concrete structures per meter square cost of 4 - 8 storied residential buildings in turkey region accuracy of 93% was achieved in cost estimation.

2.4*"A Neural Network Model for Construction Projects SiteOverhead Cost Estimating in Egypt*"Ismaail ElSawy1, Hossam Hosny 2 and Mohammed Abdel Razek 3, May 2011,1 Civil Engineering Department, Thebes Higher Institute of Engineering Corniche Maadi, Cairo, Egypt.

This study focuses on use of Artificial Neural Network (ANN) methodology for developing a cost estimation model for identifying overhead costs which frequently occur at site in Egypt region. To develop and train the model different cases of 52 building projects which were constructed in Egypt during the duration of seven years from 2002 to 2009 were collected and used as input data. The developed model of Artificial neural network was introduced for the estimation of overhead costs occur at site of total cost of the project.

2.5*"Conceptual Cost Estimate of Libyan Highway Projects Using Artificial Neural Network",Emad Elbeltagi1, Ossama Hosny2, Refaat Abdel-Razek3 and Atif El-Fitory4 April 2014, 1Structural Engineering Department, Faculty of Engineering, Mansoura University 2Construction and Architectural Engineering Department, The American University in Cairo.

This study focuses on supporting decision makers to predict the conceptual cost of highway projects in Libya region. The factors that mainly affect highway construction projects are identified at the beginning. After identification of factors next step was to develop an artificial neural network model for prediction of the cost of highway projects. Sixty Seven completed projects datasets were used for the training and testing of the network. Training of the model is administered via back-propagation algorithm. The programming of model was done and implemented using MATLAB to facilitate its use. For minimization of error of the predicted cost an optimization module was added to the Artificial Neural Network model. Then validation of model was done and the results shown better predictions of conceptual cost of highway projects in Libya region.

3. Problem Statement

At initial stage of a construction projects, there is a limited available data and a lack of appropriate cost estimate methods, where estimate techniques which are used commonly in Pune are still inadequacy traditional methods. All involved parties in construction project are in need of reliable information in the initial stages about the cost of a project. Therefore, many researchers are still searching and developing a new technique that is capable of dealing with very limited data and giving more accurate cost estimate.

Many researchers recently have used ANN method in various fields of engineering for prediction and optimization, but many authors reckon that the researches and studies on estimation of the construction cost using neural networks at different stages are very limited until now.

4. Research Significance

The contributions of this thesis are expected to be relevant to both researchers and practitioners:

- To researchers, the findings should help to investigate the accuracy of applying Artificial Neural Network model on several building types (not only one type), in addition to identifying the most influential factors on the buildings complete cost.
- As for practitioners, the findings should help to easily estimate the cost of new building projects after programming the developed model into marketing programs.

5. Cost Estimation

Cost estimating is an essential part of construction projects, where cost is considered as one of the major criteria in decision making at the early stages of building design process (Gunaydin & Dogan, 2004). The accuracy of estimation is a critical factor in the success of any construction project, where cost overruns are a major problem, especially with current emphasis on budgets which are fixed. Indeed, cost overruns can result in cancellation of a project. In some cases, a potential overrun may result in changing a project to a design-to-cost task (Feng, et al., 2010).

Subsequently, the cost of construction project needs to be estimated within a specific accuracy range, but the largest obstacles standing in front of a cost estimate, particularly in early stage, are lack of initial information and large amount of uncertainties as a result of engineering solutions. As such, to overcome this lack of initial information in detail, cost estimation techniques are used to approximate the cost within an acceptable accuracy range (Verliinden, et al, 2007).

Cost models provide an effective alternative for conceptual estimation of project construction costs. However, development of cost models can be challenging as there are many different factors which affect project costs. There are usually various and various data available for modeling (Sonmez, 2011).

6. Artificial Neural Networks

6. 1 Introduction

Artificial Neural networks (ANNs) try to reproduce the generalization abilities of a human neural system. ANNs are mainly effective for estimating problems which are complex in nature, where the relationship between the variables cannot be expressed simply by making mathematical equations. They are computer programs simulating the biological human brain structure which consists of hundreds of computing units which are interconnected called neurons. For simulation of the action of a human expert in a complicated decision situation Artificial Neural Networks (ANNs) can be constructed.

6. 2 Neural Network Structure

Neural network structure plays a important role in model accuracy. (Dindar, 2004). However, there are no applicable rules for the optimal setting of control variables and topologies (Caputo & Pelagagge, 2008).

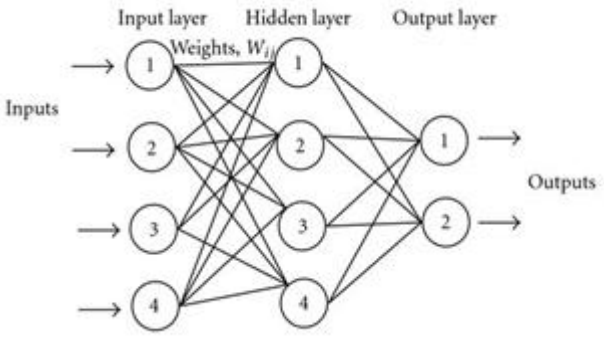

Figure: General feed-forward artificial neural network configuration

Otherwise, over fitting and Generalization is directly related to the artificial neural network architecture to model the data, since training iterations and the number of hidden units are key elements during the training of the network, and adjusting these elements could lead to great improvements in the networks modeling capability (Dindar, 2004). Bouabaz & Hamami, (2008), demonstrated that there is a number of factors for selecting the neural network structure and rules, such as the nature of the problem, characteristics of data, data complexity and the number of sample data. The network architecture refers to the no. of hidden layers and the no. of nodes within every hidden layer. As a matter of fact, there are two questions in designing a neural network that have no specific answers because they are mainly depend on application; the first is the data required for training of a network, and the best no. of hidden layers and nodes to be used. Generally, the more data and the fewer hidden layers and hidden nodes that can be used, is the better. There is a subtle relationship between the no. of facts and the no. of hidden layers/nodes. Having too few facts or too many hidden layers/nodes can cause the network to "Memorize". When this happens, it performs well during training but tests poorly (ElSawy, et al., 2011). As a rule of thumb, determining the number of hidden layer/neurons is one of the main drawbacks of NNs, because there is no specific rule and it requires many trial and error processes while sufficient time must be spent (Kim, et al., 2004). Hegazy & Moselhi, (1995) stated that one hidden layer with a number of hidden neurons as 0.5 m, 0.75m, m, or 2m+1, where input neurons are denoted by m, is suitable for most applications.

The main building elements of ANNs are neurons or nodes and the links connecting between them. Each link has a weight parameter associated with it. These nodes or neurons are assorted into three categories, which are input, output, and hidden neurons. Every neuron is interconnected and neighboring neurons provide stimulus to each neuron, processes the information and produces an output. Input neurons are those which receive stimulus from outside of the network (i.e., not from neurons of the network). Output

neurons are those whose end results outputs are used independently or externally. Hidden neurons are those which receive stimulus from different neurons and whose output act as stimulus for other neurons in the neural network. Information can be processed by a neuron in many different ways, and different ways of connecting the neurons to one another. In general, different neurons or nodes are used to construct various artificial neural network (ANN) structures and by the specific manner in which they are connected (Cengiz, et al., 2005).

Figure 2.3 displays the above structure of ANN, which consists of 3 basic layers, input layer, hidden or intermediate layer and output layer. Each one contains several neurons except output layer; it contains one neuron that represents the output of training process. For hidden neurons, Figure presents the schematic diagram that shows weight's summation part and transfer function part inside these neurons.

7. Conclusion

The Artificial Neural Networks models developed can be used as a management tool for enhancing current automation research in the big construction industry. ANN model can be prepared for predicting the expected construction cost of any future project in the initial phase of the building project life cycle.

This study aimed at exploring the ANN technique which can be used to predict the total structural cost of buildings at the early stages of project with limited available information and to determine or find out the parameters or factors affecting the buildings overall cost of buildings.

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