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Construction Prediction of Cost Overruns Using Artificial Intelligence

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ABSTRACT: Pre-tender estimates are susceptible to inaccuracies (biases) because they are often prepared within a limited timeframe, and with limited information about project scope. Inaccurate estimation of project uncertainties is the underlying cause of project cost overruns in construction. Typically, cost engineers and quantity surveyors would add contingency reserve to a pretender estimate in order to account for any unforeseen cost that may arise between the date of the estimate and the projected completion date of the project. The traditional 10% rule of thumb for estimating contingency is subjective - based on experience and expert judgment, and are often inadequate. The proposed study is the learning algorithms trained to use the known characteristic of completed projects could allow quantitative and objective estimation of the inaccuracies in pretender building cost estimates of new projects. The study assumes that the accuracy in the initial estimate (bias) of a completed project is the difference between the actual project completion costs minus the pre-tender cost forecast expressed as a percentage of the actual project completion costs. The trained ANN model can be used as a decision making tool by cost advisors when forecasting building cost at the pretender stage. The model can be queried with the characteristics of a new project in order to quickly predict the error in the estimate of the new project. The predicted error represents the additional contingency reserve that must be set aside for the project in order to cater for possible cost overruns. The model can also be extended to forecast the likely cost of a project.

I.INTRODUCTION

1.1 Objectives

The principal objectives of this study are:

1. Identify the most prominent parameters affecting the accuracy of estimating the building project cost .
2. Develop a comprehensive tool for parametric cost estimation using the optimum Neural Network model.

1.2 Scope and Limitation

It focuses on buildings sector of construction projects in Kerala; including the main two phases of construction building; skeleton and finishing phases. Thus, many building projects that were implemented between 2012 and 2018 were collected, and some types of these building projects.

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1.3 Definitions

1.3.1 Cost and Price Concepts

Cost as defined by (Stewart, 1991), as the total amount of all the resources required to perform the activity. However, the price is the total amount paid for that activity. Mathematically, price equals the cost plus the desired profit (Price = Cost + Profit).

1.3.2 Cost Engineering

Cost engineering is a field of engineering practice that engineering judgment and experience are utilized in the application of scientific principles and techniques to problems of estimation, cost control, business planning and management science, profitability analysis (AACE International Recommended Practice, 2010).

1.3.3 Cost Estimate

Association for the Advancement of Cost Engineering (AACE) International defines the cost estimation as it provides the basis for project management, business planning, budget preparation and cost and schedule control (cited in (Marjuki, 2006).

The Society of Cost Estimating and Analysis (SCEA) defined the cost estimation as "the art of approximating the probable worth or cost of an activity based on information available at the time" (Stewart, 1991).

1.3.4 Construction Cost

The sum of all costs, direct and indirect, inherent in converting a design plan for material and equipment into a project ready for start-up, but not necessarily in production operation; the sum of field labor, supervision, administration, tools, field office expense, materials, equipment, taxes, and subcontracts (AACE International, 2007).

1.4 Types of Construction Cost Estimates

The type of estimate is a classification that is used to describe one of several estimate functions. However, there are different types of estimates which vary according to several factors including the purpose of estimates, available quantity and quality of information, range of accuracy desired in the estimate, calculation techniques used to prepare the estimate, time allotted to produce the estimate, phase of project, and perspective of estimate preparer (Humphreys, 2004; Westney, 1997).

1. Conceptual estimate: a rough approximation of cost within a reasonable range of values, prepared for information purposes only, and it precedes design drawings. The accuracy range of this stage is -50% to +100% .

2. Preliminary estimate: an approximation based on well-defined cost data and established ground rules, prepared for allowing the owner a pause to review design before details. The accuracy range in this stage is -30% to +50%.

1.5 Definition of ANN

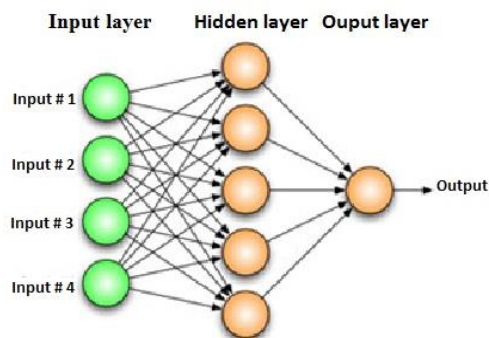
There is no universally accepted definition of Neural Network (NN), but most of definitions are similar to some extent with each other, as such, Swingler (1996) defined neural networks as "statistical models of real world systems which are built by tuning a set of parameters. These parameters, known as weights, describe a model which forms a mapping from a set of given values known as inputs to an associated set of values the outputs".

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Artificial neural network structure

II.METHODOLOGY

2.1 DATA COLLECTION

Primary Data

Factors affecting the accuracy of pre-tender building cost estimates According to Seo et al (2002) attributes used as inputs for ANN model . They must be meaningful to the estimator and the design team at the pre-tender stage hence should consist of attributes that are known during that stage. It is also useful that the attributes should, as much as possible, be high-level project characteristics.

Quantitative approach seeks to collect factual data and to study relationship bet In this study both qualitative and quantitative approaches were used to get the factual information of the main factors affecting the cost of building projects in Gaza Strip at conceptual phase. As well as collecting the data from several resources, by filling a form for each project, which contains the input factors and the actual cost of the project.

Secondary Data

It is decided that the most appropriate approach was to carry out structure interviews with a number of experts, engineers, and contractors in order to get a better understanding of most important factors affecting the cost estimating of construction projects. The structured interviews schedule also sought information regarding the following areas:

1. Characteristics of responding organizations in term of position of respondent, years of experience for the organization and total number of employees.
2. Factors affecting cost estimating.
 - a. Type Of Respondents
 - b. Position Of Respondents
 - c. Estimating Method
 - d. Construction cost estimation

2.2 DATA ANALYSIS

Questionnaire Analysis

Questionnaires were distributed to various engineering institutions, where, as a response rate 71% of the total number of questionnaires, have been correctly answered and submitted. These questionnaires were cleaned, and some of them were omitted due to incomplete or inaccurate data. More details and analysis are discussed in this section for the questionnaire results. The questionnaire survey of this study revealed that 48% of respondents always apply time and cost controls to their project and a further 25% indicated that they frequently apply time and cost control techniques. Only 10% respondents indicate that they rarely or do not apply time but applying the cost control during

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their projects. The application of cost control is more irresistible with 75% of respondents specifying that at every time they apply their cost control method and 13% indicating that they often applied cost control methods to their projects. None of the respondents point out that they rarely or do not use cost control techniques supporting the importance placed on cost control by construction project experts in the construction industry. The most standard time control technique is Gantt Bar Chart, which used by 40% of contractors and 38% consultants.

After an analysis, 20 factors are shortlisted for the survey.

- Increasing of prices(Inflation)
- Currency fluctuations/Un-certainty in exchange rate
- Irregular/Un-stable government policies
- Lack of proper regulations in work control
- Un-even weather conditions
- Material Procurement
- Tax liabilities
- Un-skilled labor(man power)
- Risks associated with projects
- Unstable interest rates
- Poor project management/Construction management
- Lack of proper professional software
- Inaccurate evaluation of projects time/duration
- Lack of communication between parties i.e. (project client project contractor/sub-contractor).
- Project fraud and corruption
- Frequent design changes
- Funding problems for completed works
- Complexity of works(Large/Medium/Small)
- Illogical contract documentation
- Conflicts between the project parties(client/contractor)

III. CONCLUSION

This study aimed at developing a new technique for early cost estimate of building projects in Gaza Strip, through developing a model that is able to help parties involved in construction projects (owner, contractors, and others) in obtaining the total cost information at the early stages of project with limited available information.

Several steps and procedures were conducted in order to achieve this aim as following:

1. A questionnaire survey, expert interviews and exploratory search of previous studies were used to identify the cost effective factors on building projects. Eleven key parameters were adopted as most influential factors on building costs which are use of building, area of typical floor, number of floors, type of foundation, type of slab, number of elevators, type of air conditioning, external finishing, type of tile, type of electricity, and type of sanitary.
2. Historical data of building projects were collected. The projects were executed between 2009 and 2012 in Gaza Strip, from government ministries, UNRWA, engineering institutions, contractors and consultants. The data was analyzed and some of data were excluded due to some basic conditions. The final available data were 169 projects which were divided randomly into three sets as training set (116 projects), cross validation set (27 projects), and testing set (26 projects).
3. Developing ANN model passed through several steps started with selecting the application to be used in building the model. The Neurosolution5.07 program was selected for its efficiency in several previous researches in addition to its

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ease of use and extract results. The data sets were encoded and entered into MS excel spreadsheet to start training process for different models.

4. Many models were built but the best model that provided more accurate results was Multilayer Perceptron network model (MLP) which structured from one input layer included 11 input neurons, one hidden layer contained 22 hidden neurons, one output neuron, tanh transfer function, and Moentum learning rate which belongs to Backpropagation algorithm.

5. The accuracy performance of the adopted model recorded 94% where the model performed well and no significant difference was discerned between the estimated output and the actual budget value. The acceptable error rate in early stage of building projects as mentioned in researches and studies is ranging between (20-50%) while the average percentage error of this model is 6%.

6. In order to ensure the validity of the model in estimating the cost of new projects, many statistical performance measures were conducted i.e; Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), Total Mean Absolute Percentage Error (Total MAPE), and Correlation Coefficient (r). The results of these performance measures were acceptable and reliable, where the mean percentage error of the model was 6%, and the total mean absolute percentage error was 10%.

7. Sensitivity analysis was performed using Neurosolution tool to study the influence of adopted factors on building costs, the concept of calculating sensitivity analysis of input factors based on determining the standard deviation of each. However, the performed sensitivity analysis was in general logically where the area of typical floor and number of floors had the highest influence, then number of elevators, sanitary type, number of elevators, electricity type, type of external finishing, type of electricity, type of foundation, type of building, type of slab, and type of tilling respectively had less effect respectively.

8. The approach as presented is capable of providing accurate estimates of project cost by using eleven parameters at the early design phase.

9. Some assumption and limitation were assumed in the study according to available collected data. These limitations include the available choices of each factor as Area of typical floors for example, has limited area between 60 m² to 1000 m², as well as the other input factors.

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