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Cost estimation for building construction projects in Benghazi using Artificial Neural Network (ANN)

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ملخص البحث

يلعب تقدير التكلفة للمشاريع الانشائية في المراحل المبكرة دورا هاما في نجاح أي مشروع انشائي , لاسيما وان جميع الأطراف المعنية في بناء المشروع كأصحاب المشاريع والمقاولين والجهات المانحة في حاجة الي معلومات موثوق بها عن التكلفة الكلية في المراحل المبكرة من المشروع في ظل عدم توافر تفاصيل ومعلومات ورسومات كافية. يهدف هذا البحث الي تطوير نموذج لتقدير تكلفة المشاريع الانشائية بدرجة عالية من الدقة ودون الحاجة الي معلومات او رسومات تفصيلية وذلك من خلال استخدام برنامج يحاكي الشبكات العصبية , حيث تعتبر الشبكات العصبية احد اهم الأساليب الحديثة في تقدير تكاليف المشاريع الانشائية والتي تتميز بالقدرة على التعلم من التجارب السابقة،لذلكتم جمعالعديدمنالبياناتلمشاريعالبنيةالتحتيةمدينة بنغازي في الفترةالواقعةبين2014م الي 2018م.

Abstract

Early stage cost estimate plays a significant role in the success of any construction project. All parties involved in the construction of a project; owners, contractors, and donors are in need of reliable information about the cost in the early stages of the project, where very limited drawings and details are available during this stage. This research aims at developing a model to estimate the cost of building construction projects with a high degree of accuracy and without the need for detailed information or drawings by using Artificial Neural Network (ANN). ANN is new approach that is used in cost estimation, which is able to learn from experience and examples and deal with non-linear problems. It can perform tasks involving incomplete data sets, fuzzy or incomplete information and for highly complex problems.

Keywords: Cost Estimate, A.I, ANN.

1. Introduction

Cost is one of the three main challenges for the construction manager, where the success of a project is judged by meeting the criteria of cost with budget, schedule on time, and quality as specified by the owner (Rezaian, 2011). In which, poor strategy or incorrect budget or schedule forecasting can easily turn an expected profit into loss (Cheng, et al., 2010). Therefore, effective estimating is one of the main factors of a construction project success (Al-Shanti, 2003). Accordingly, cost estimate in early stage plays a significant role in any construction project (Ayed, 1997), where it allows owners and planners to evaluate project feasibility and control costs effectively (Feng, et al., 2010). In addition, the cost of a building is significantly affected by decisions made at the early phase. While this influence decreases through all phases of building project (Gunaydın&Dogan, 2004). Due to this prominence of cost estimate in early stage and

limited availability of information during the early phase of a project, construction managers typically leverage their knowledge, experience and standard estimators to estimate project costs. As such, intuition plays a significant role in decision-making. Inasmuch the essential needs of project owners and planners to a tool to help them in their early decisions; researchers have worked hard to develop cost estimate technique that maximize the practical value of limited information in order to improve the accuracy and reliability of cost estimation work (Cheng, et al., 2010). Thus, many methods either traditional or artificial intelligence methods were studied and examined for their validity in estimating the project cost at conceptual stage.

In the last years a new approach, based on the theory of computer systems that simulate the learning effect of the human brain as Artificial Neural Networks (ANNs) has grown in popularity (Cavalieri, et al., 2004). One major benefit of using ANN is its ability to understand and simulate more complex functions than older methods such as linear regression (Weckman, et al., 2010). In addition, it can approximate functions well without explaining them. This means that an output is generated based on different input signals and by training those networks, accurate estimates can be generated. (Verlinden, et al., 2007).

1.1 Problem Statement

All parties involved in construction project are in need of reliable information about the cost of a project in the early stages. 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.

2. Research strategy

Research strategy in general means a plan of action which the research objectives can be questioned, and it can be classified into two types namely, quantitative approach and qualitative approach (Naoum, 2007).

Qualitative approach seeks to gain insights and to understand people's perceptions, or opinion towards a particular object. As well, it is used when a limited amount of knowledge about the topic are available (Naoum, 2007).

Quantitative approach seeks to collect factual data and to study relationship between facts and how such facts and relationships accord with theories and findings of any research executed previously (Al-Shanti, 2003).

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.

The purpose of this research is to develop a model of ANN to use in estimating cost of building projects as an alternative technique of traditional approach.

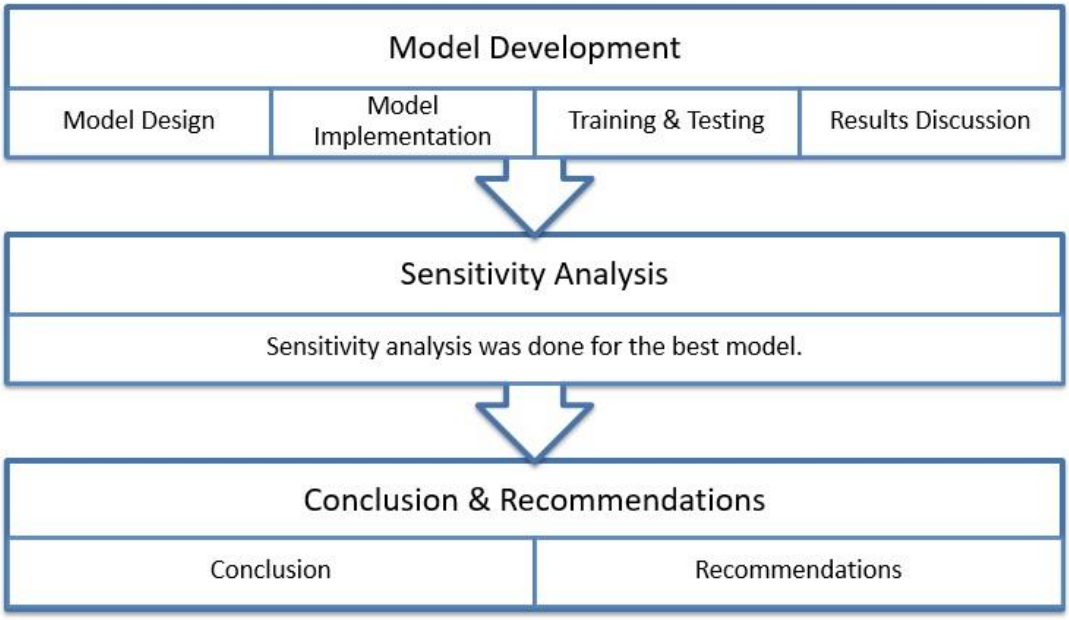

Figure 19 - Research design

As shown in Figure 1 the adopted methodology for the completion of this study follows the following stages:

Data collection phase

A structured questionnaire in addition to expert interviews were used together in this research, to identify the main parameters affecting cost of building projects in Benghazi. For the need of many data in building the neural network models, many historical building projects that were done between 2009 and 2012 in Benghazi were collected from municipalities.

Model Development phase

After analyzing the data, many models were built and trained with various structures by using NeuroSolution 5.07. Accordingly, the best model was tested and the sensitivity analysis have been assessed by variation in the cost of projects.

Conclusion and recommendation phase

In this stage, the content of the thesis was written and the research chapters were covered. Moreover, the research was summarized in the conclusion section with many recommendations.

3. Data Collection

3.1. Factors Affecting Cost of the Building Projects

In fact, one of the most significant keys in building the neural network model is identifying the factors that have real impact on the cost of building projects. Depending on this great importance of selecting these factors, several techniques were adopted carefully to identify these factors in Benghazi building projects; as reviewing literature studies and bill of quantities (BOQ), surveying a questionnaire, and Delphi technique by conducting expert interviews.

3.2. Data Validation

Data validation is paramount before developing any predictive model, which allows identifying uncommon cases, invalid cases, erroneous variables and incorrect data values in the dataset. If the data is prepared properly, it will be able to develop a more realistic parametric cost model and give better results.In order to overcome any defect in collected data, some basic assumptions and criteria were defined and performed, which are:

- The project has to be completely finished or has approval for the funding (Arafa&Alqedra, 2011).
- Project implemtation period less than one year (Arafa&Alqedra, 2011).
- Implementation of the project was during the period 2009 – 2012.
- Unifying currency of projects prices.
- Incomplete data, missing one or more values.
- Duplicate data, two projects are the same in all related values.
- Misleading data.
- The maximum amount of projects in a single category should not be more than 95% (Islam, et al., 2009).
- the maximum amount of categories with count of one (1) should not be more than 90% (Islam, et al., 2009).

As a result of this filtering and checks, 24 projects of 193 projects were eliminated. Subsequently, 169 projects were used to build the model.

3.3. Data Encoding

Artificial networks only deal with numeric input data. Therefore, the raw data must often be converted from the external environment to numeric form (Kshirsagar&Rathod, 2012). This may be challenging because there are many ways to do it and unfortunately, some are better than others are for neural network learning (Principe, et al., 2010). In this research data were converted to numeric form as shown inTable 4.20

Table 4.20 Inputs/Output encoding

No	Input Factors	Encode	Code
1	Use of project	- Residential	**=1**
		- School extension	**=2**
		- Schools	**=3**
		- Comershall	**=4**
		- Mosques	**=5**
2	Type of foundation	- Isolated	**=1**
		- Strap	**=2**
		- Piles	**-3**
		- Raft	**=4**
3	Area of typical floors	- 100 – 200 m2	**=1**
		- 200 – 300 m2	**=2**
		- 300 – 400 m2	**=3**
		- 400 – 500 m2	**=4**
		- 500 – 600 m2	**=5**
		- 600 – 700 m2	**=6**
		- 700 – 800 m2	**=7**

		- 800 – 900 m2	**=8**
		- 900 – 1000 m2	**=9**
		- 1000 – 1100 m2	**=10**
		- 1100 – 1200 m2	**=11**
		-1200 – 1300 m2	**=12**
		-1300 – 1400 m^2	**=13**
		- 1400 – 1500 m2	**=14**
		-1500 – 1600 m2	**=15**
		-1600 – 1700 m^2	**=16**
		- 1700 – 1800 m2	**=17**
		-1800 – 1900 m2	**=18**
		-1900 – 2000 m^2	**=19**
4	Number of story's	Number from	**(1-7)**
5	Number of elevators	Number from	**(0-4)**
6	Type of slab	- Solid	**=1**
		- Ribbed	**=2**
		- Drop beams	**=3**
7	Type of external finishing	- Normal plaster	**=1**
		- Marble	**=2**
		- Curtain walls	**=3**
8	Area of curtain walls	- None	**=1**
		–Less than 50 m^2	**=2**
		-50-100m^2	**=3**
		- 100-150m^2	**=4**
		- 150-200m^2	**=5**
		- 200-250m^2	**=6**
		-250-300m^2	**=7**
		- 300-350m^2	**=8**
		-350-400m^2	**=9**
		-400-450m^2	**=10**
9	Firefighting and alarm works.	-not exist	**=1**
		- exist	**=2**
10	Volume of HVAC works.	- None	**=1**
		- Central AC+False ceiling	**=2**
		- Split unit	**=3**
11	Type of electrical works	- Basic	**=1**
		- Luxury	**=2**
12	Type of Aluminum works	- ITL	**=1**
		- EGY	**=2**
		- LYB	**=3**
		- PVC	**=4**

4. Model Training

The objective of training neural network is to get a network that performs best on unseen data through training many networks on a training set and comparing the errors of the networks on the validation set (Dindar, 2004). Therefore, several network parameters such as number of hidden layers, number of hidden nodes, transfer functions and learning rules were trained multiple times to produce the best weights for the model.As a preliminary step to filter the preferable neural network type, A test process was applied for most of available networks in the application. Two types Multilayer Perceptron (MLP) and General Feed Forward (GFF) networks were chosen to be focused in following training process due to their good initial results. It is worthy to mention that, previous models that have been applied in the field of cost estimation by neural networks used earlier two types of networks because of giving them the best outcome.

The following chart illustrates the procedures of training process to obtain the best model having the best weight and minimum error percentage.

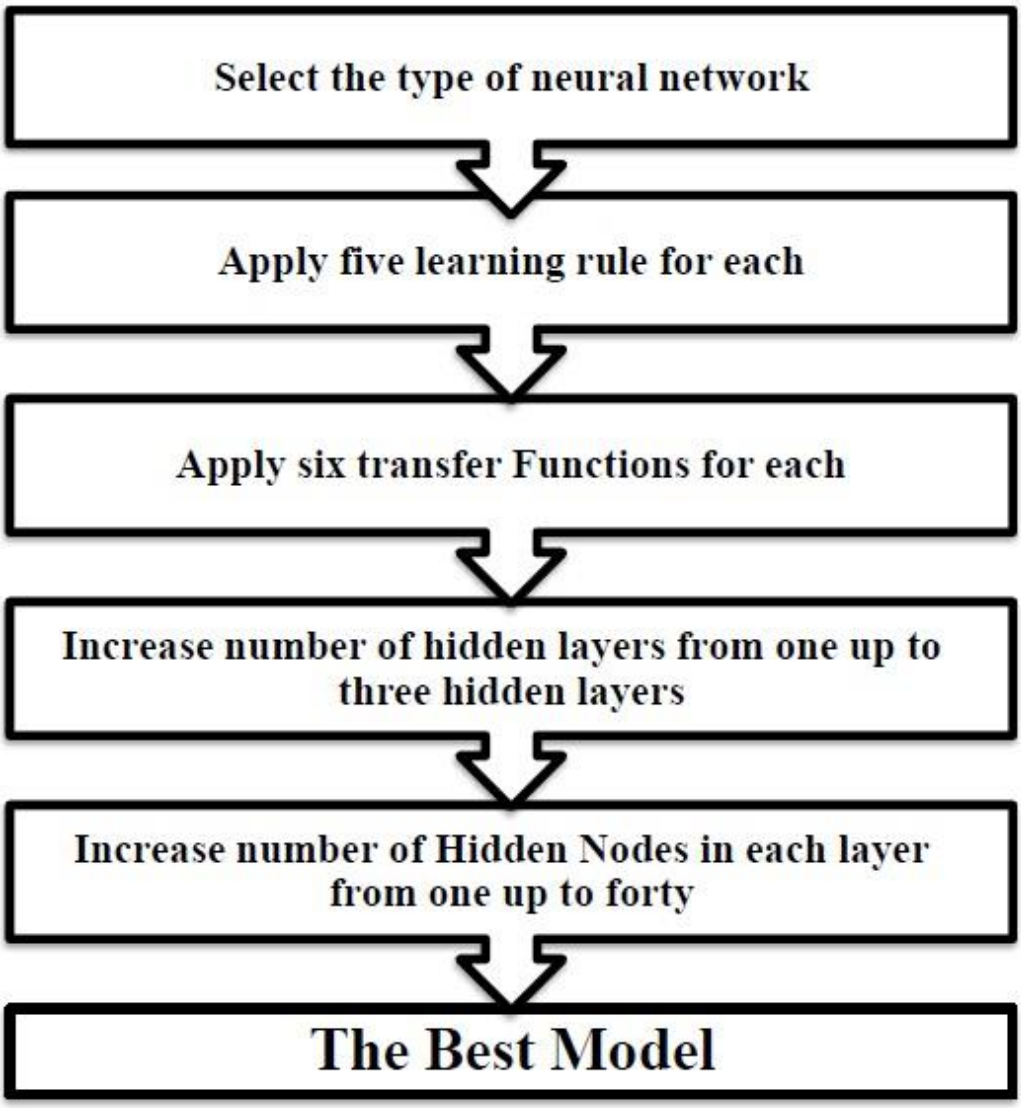

Figure 20 - The procedures of training process

5. Conclusion

This study aimed at developing a new technique for early cost estimate of building projects in Benghazi, 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.

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