Application Artificial Forecasting Techniques in Cost Management (review)

Dr. Faiq Mohammed Sarhan Al-Zwainy
Assist Professor
Department of Civil Engineering
College of Engineering
Alnahrain University
faiq_faiqmohmed@yahoo.com

Neran Taher Hadal
M.Sc.Student
Department of Civil Engineering
College of Engineering
Baghdad University
neran_taher68@yahoo.com

ABSTRACT

For the duration of the last few many years many improvement in computer technology, software program programming and application production had been followed with the aid of diverse engineering disciplines. Those trends are on the whole focusing on synthetic intelligence strategies. Therefore, a number of definitions are supplied, which recognition at the concept of artificial intelligence from exclusive viewpoints. This paper shows current applications of artificial intelligence (AI) that facilitate cost management in civil engineering tasks. An evaluation of the artificial intelligence in its precise partial branches is supplied. These branches or strategies contributed to the creation of a sizable group of fashions such as difficulty evaluation, interpretation and prediction of various parameters. A list of decided on, updated fashions is provided, that challenge cost control for civil engineering initiatives. The models are analyzed in keeping with the pastime, discipline of operation, enter and output statistics and the techniques and strategies they implant. It will become clean that arterial Intelligence may be the destiny vital tool for each engineer and it's going to lead to sizable upgrades within the construction area.

Keywords: Artificial intelligence applications, Civil Engineering, Cost Management

تطبيقات تقنيات التنبؤ الذكية في ادارة الكلفة (استعراض)

د. فائق محمد سرحان الزويني
استاذ مساعد
كلية الهندسة / القسم المدني
جامعة النهرين

نيران طاهر هذال
طالبة ماجستير
كلية الهندسة / القسم المدني
جامعة بغداد

الخلاصة

طوال العقود القليلة الماضية اصبحت عدة تطورات في علم الحاسوب , البرمجيات وتطبيق وانتاج هذه البرامج تم اعتماده بمن قبل تخصصات هندسية متنوعة تركز هذه التطورات عموما على تكنلوجيا الذكاء الاصطناعي , لذلك عد من التعاريف قد تم تقديمها والتي تركز على مفهوم الذكاء الاصطناعي من وجهات نظر مختلفة . يعرض هذا البحث تطبيقات موجودة للذكاء الاصطناعي والتي تقوم بتسهيل ادارة التكاليف في مشاريع الهندسة المدنية . تحليل الذكاء الاصطناعي في فروعه الجزئية الخاصة قد تم تقديمه . هذه الفروع والمناهج اسهمت في ابتكار مجموعة كبيرة (او هامة) من النماذج التي تهتم (او تتعلق) بالتحليل ,التفسير و التنبؤ لمتغيرات متعددة, لقد تم تجهيز نماذج منتقاة حديثة والتي تتعلق بادارة التكاليف لمشاريع الهندسة المدنية . النماذج تم تحليلها وفقا لنشاط , ميدان العمليات , بيانات الادخال والاخراج والنظريات التي قاموا بترسيخها . لقد اصبح واضحا ان الذكاء الاصطناعي سيكون الاداة الاساسية المستقبلية لكل مهندس وسوف يقود الى تطورات كبيرة ومهمة في قطاع الانشاءات .

الكلمات الرئيسية : تطبيقات الذكاء الصناعي. الهندسة المدنية، ادارة الكلفة.

1. INTRODUCTION

Cost estimate is the most essential preliminary process for any construction project. So, construction cost estimations have the largest part of the research work in construction management. Estimation of cost is the important initial process to any construction project. For the construction industry, cost estimation is the process of predicting the costs required to perform the work within the scope of the project **Holm at el., 2005.** Accurate estimation for cost is crucial to confirm the successful completion for a construction project. Estimating construction cost is an example of a knowledge-intensive engineering task **French at el., 2003.** That is, it depends on the expertise of the human professional. Engineers require several years for developing the required expertise to conduct the process of cost estimation. Here the main problem is that the expertise of engineers is often not authenticated or documented. Hence, this expertise is disposed to subjectivity (i.e., it is defined to an extent for one's personal opinion). So, according to **Shane et al., 2009,** the accuracy and comprehensiveness for cost estimation are delicate subjects and can be simply affected by several different parameters; furthermore, each parameter must be well addressed in order to keep an acceptable level of the accuracy during the process. So, estimating construction cost to a reasonable degree of accuracy is generally impossible to achieve manually.

On the other hand, many problems are got by the inaccurate cost estimation, such as construction delay **Parmee, 2003.** Change order, or even business bankruptcy with the worst scenarios. The two factors, first the impossibility to conduct the cost estimation manually and second the effects of the incorrect cost estimation so encourage researchers besides construction companies to investigate smart solutions to handle the cost estimation problem.

2. CONSTRUCTION COST ESTIMATING

Good estimate depends on various factors including estimator's experience, time given to the estimator, and the wide range of assumptions regarding the project **Jrade and Alkass, 2007**. Construction cost estimating includes collecting, analyzing, and summarizing for all available data of a project **Holm et al., 2005**.

The construction cost estimate is a forecast of the whole cost for a construction project also it's estimator's responsibility for helping the owner of project to plan and to budget for the project construction **Choi, 2004.** At different stages of construction, three different types of estimates are used: conceptual, semi-detailed, and the detailed cost estimates **Holm et al., 2005**. The difference between the three methods of estimating is explained in **Table2**.

This paper will focus on conceptual cost estimating. Major difficulties which arise as conducting cost estimation through the conceptual phase are the lack of preliminary information, the lack of database of costs for road works, and lack of limited date cost estimation methods. Additional difficulties arise as a result of larger uncertainties caused by engineering solutions, environmental issues, and socio-economical. Parametric cost estimation or the estimation based on the historic database is extensively used in developed countries during the conceptual estimate phase. However, developing countries meet difficulties related to the creation of database of a road work costs that may be used for the cost estimation in either the conceptual stage or in the feasibility study to a project cycle **Jamshid, 2005.**

3. PURPOSE OF COST ESTIMATE

The early planning process is an important factor leading to project success. In recent decades, researchers and participants in construction industry have recognized the potential impact of

early planning to final project outcomes. Therefore, they started to put more emphasis on early planning process, where the project definition in **Wang, et al., 2012.**

The cost estimate becomes one of the main elements of information for decision making at preliminary stage of construction. Thus, the improving of cost estimation techniques will ease more effective control of costs and time in construction projects **Kim, et al., 2004**.

Actually, estimates are made and used for several different purposes including tendering phase, feasibility studies, and avoidance misuse of funds through the project, etc. The first purpose of cost estimation is to make an accurate and a reliable cost prediction of the construction project.

On the other hand, the cost which is predicted depends on requirements of customer and upon the information besides data available. Stated that the purpose of an estimate is to postulate the costs required to complete project in accordance with the contract plans and specification **Abdal-Hadi, 2010**.

Likewise and Weatney cited in **Jitendra, et al., 2011** outlined the purpose of cost estimate through the following points:

1. Provides an assessment of capital cost for a specified piece of project.
2. It can help to prioritize and classify projects of development with respect to a complete business plan.
3. Through defining the scope for work besides its associated estimation cost the base for planning and control is formed
4. Determines what resources to commit to the project with providing much of the basic information (hours, resources, tasks, and durations) which is needed for preparing a schedule.
5. When resources are well matched to actual needs, projects can be easily managed and controlled.
6. Provides the financial input required to prepare a cash flow curve.
7. Customers expect actual development costs to be in line with estimated costs.
8. Can be used to assess the impact of changes and support re-planning.

4. CONSTRUCTION COST FACTORS

According to **Shane et al., 2009** and **Ahiaga-Dagbui and Smith, 2012,** any construction cost estimation should be developed based on specific parameters such as type of project, material costs, size of project, likely design with scope changes, ground conditions, type of client, duration, and tendering method. So, in this paper these factors have been introduced as a measure to compare between the cost estimation plans.

Various different factors which affect cost estimation when constructing projects can be clustered into two distinct groups **Akinci and Fischer,1998** :

1) Estimator-Specific Factors and
2) Design and Project-Specific Factors.

4.1 Estimator Specific Factors

A cost estimator is one of the three gatherings: contractor, consultant, or owner. Based on the estimator's background and experience, cognitive biases or errors in cost estimates may occur accordingly **Akinci and Fischer, 1998.** In many cases, a cost estimator makes decisions established on the probable gains, or losses, of a project and not necessarily established on the actual outcome of the decision. Moreover, the individual estimator may customize pricing based upon best local practices, which differ from country to country.

4.2 Design and Project-Specific Factors

The factors are project size, ground conditions, type of project, material costs, type of client, expected design and scope changes, tendering method duration, **Shane et al., 2009** .

5. THE COST ESTIMATING METHODS

Estimates are done by humans not by tools; tools are means that are used by the analysts while dependable expert systems which can estimate the costs are still unfound. The estimates are based on the comparisons and they are based on the company data base. A handbook on costs that may allow the creation of a data base related to its activity still does not exist. In order to estimate, the technical knowledge of background, tools, products, technologies and the used means for production must be acquired. A number of estimating methods distinguished mainly by level of accuracy that is desired for the results, these include:

1. Analogy method
2. Parametric method
3. Analytical method

The method is not chosen randomly, so there must be a logic of the information clearly available, and it is worth considering progress of the project then what method may require for starting function.

5.1 Analogy Method

5.1.1 General principle

Analogy method of estimating of cost functions by comparing the suggested project to priory similar completed projects that the cost and functional definition is known.

So by comparison, a judgment must be got through the characteristics for two completed projects. Then this judgment must be worked out in a way which can be explained in terms of cost and the method must decrease the maximum of subjectivity.

This method has a principle that is implementing an extrapolation of like cases (source case) and a present case (target case). A source cases are abstracted by historical databases of project.

The construction of the target case may be different from source case. The case basis must be improved continuously by some new treated cases.

5.1.2 Conclusion on analogy method

As the use of Analogy method gives increase to certain concerns it is worth for stating its weaknesses

a. Analogy method leaves room to subjectivity, and such observation is largely hard, by putting the trust on the detailed level that limited enough in comparison with accomplishment which is finished and known.
b. Analogy method supposes that the comparisons that are made are valid, and such fact leads, to search for recent projects owing to the need of keeping pace with the rapidly developing technologies, but, this is not at all times attainable on one hand, so on the other hand, uniformity of projects stands a difficulty to find local completions to standardized the data on other hand.
c. It suggests that the progress and production logics must be the same to capable to assess the different; this is a serious problem in the measuring where an advanced level of estimate is required for the study. However, there exist no magic methods that can avoid asking such kind of question!

In fact, this method provides in a timely and responsive manner accurate estimate via low costs when it is rigorously applied. Also it allows having quick studies of sensitivity while it is worked

on coefficients of analogy. It can therefore be used as input for comparison of principles for solutions studied in the analysis of value. However, one must not expect extraordinary precision.

5.2 Parametric Method

5.2.1General principle and classification of parametric methods

Estimating of cost model that is used in design phase needs to be in coherence with project definition report. It is then better to consider the concept of product architecture. It is not known yet how these products will be produced, but a number of physical characteristics or parameters like the mass, the volume, the energy absorbed or number of input-output can be accessed and this is obtained for the information purposes at beginning of development phase.

Parametric estimate has been built specifically to create the costs to estimate from these parameters. For management, it must go from the high techniques that characterizes product and owned with the engineering design to economic necessary data.

The two types of parametric methods that are highlighted are distinguished both through their design and their usage.

a. Cost list.
b. Statistical models or the cost estimates formula.

This method includes more complex calculations than calculations for analogy method.

This method only works on the family products (or projects) with identical structure that is differing only in size. Here calculations are computerized on a spreadsheet for example Excel. The application of parametric assessment can be used or reached within an unskilled operator on the contrary, the development of cost estimation formula is complex and requires an expert experienced in statistical calculation

5.2.2 Conclusions on the parametric method

- It is more complex calculations than analogy method.
- It works on family products (or projects) with identical structure different only in size.
- The calculations are computerized on a spreadsheet for example Excel.
- The application of parametric assessment can be usde within an unskilled operator, on the contrary, the development of cost estimation.

5.3 Analytical Method

5.3.1 General principle

The analytical method is the oldest, the most classic and the most widespread among other cost estimating methods. It requires very detailed information on the product to encode and on its development process.

The most complex form for this method is to decompose each activity into the elementary tasks so that the time is known. This method makes it possible to calculate the actual cost of past achievements and to build up a data bank.

The projects that have already been completed must be a source of experience for better anticipation and management of costs and risks of a new project.

5.3.2 Conclusions on analytical method

The method permits to have accurate estimate of costs. However, it requires much detailed information on both the product and tools used in a given operative range. The analytical method is therefore focused on as being chosen to be the subject of our studies although it requires the manager to be rigorous, since it is more detailed than others and it does not represent any subjectivity.

6. INTELLIGENT CONSTRUCTION PROJECT COST ESTIMATION METHODS

In this section, analysis of the surveyed intelligent construction cost estimation methods was conducted. These methods have been categorized into five groups, based on the intelligent technique that is used in each group:

1) Machine-learning (ML).
2) Knowledge -based systems (KBS).
3) Evolutionary systems (ES).
4) Agent-based system (ABS).
5) Hybrid systems (HS).

At the first step, each group is explored to highlight their strengths and weaknesses. Subsequently, the methods are analysed in depth in terms of coverage of construction cost estimation techniques. In each proposal, four key questions have been highlighted for analysis. These questions are:

(1) Which intelligent technique is used?

(2) How the input datasets are collected?

(3) How the proposed method is validated?

(4) Which construction cost estimation factors are covered?

In the following subsections, firstly, the intelligent techniques employed are discussed, where the findings of which are considered as an answer to the first question. Secondly, each proposal is analysed individually, which answers question 2. The content of **Table 2,** illustrates the answer of question 1, while the content of **Table 3** illustrates the answer of question 2.

6.1 Machine Learning (ML) Systems

ML systems have been defined as a construction of a system that can learn from data. In general, the main strengths of ML are (i) the ability to deal with uncertainty, (ii) the ability to work with incomplete data, and (iii) the ability to judge new cases based on acquired experiences from similar cases. On the other hand, the main weakness of ML is the lack of technical justification; that is, the causes beyond the decision are not available. This type of decision is called a black box decision. However, in the construction management, the artificial neural network (ANN) and the support vector machine (SVM) are the most common ML techniques. In the next paragraph, the construction cost estimation proposals that are based on ML are analysed.

One of the earliest papers to introduce the benefits and the implementation of ANN in the civil engineering community is published by, **Flood and Kartam, 1994**. This research has opened the door for many proposals that suggest ML as the preferred method to tackle various challenges in the construction industry.,**Petroutsatou et al., 2012** introduced the ANN as a technique for early cost estimation of road tunnel construction. The data collection strategy of this research was based on structured questionnaires from different tunnel construction sites. **Wilmot and Mei, 2005** introduced an ANN model for highway construction costs. This research used the following factors as a base for cost estimation: price of labor, price of material, price of equipment, pay item quantity, contract duration, contract location, quarter in which the contract

was let, annual bid volume, bid volume variance, number of plan changes, and changes in standards or specifications. The main contribution of this work was that it covered all required factors**. ,Jafarzadeh et al., 2014** proposed the ANN method for predicting seismic retrofit construction costs. This study selected data from 158 earthquake-prone schools. The validation of this method is not clear**. An et al., 2007** proposed SVM for assessing conceptual cost estimates. Although this proposal is introduced as an assessment tool, still it might be considered as a cost estimation method. The method was developed on the basis of data from 62 completed building construction projects in Korea. Furthermore, **Hola and Schabowicz, 2010** developed an ANN model for determining earthworks' execution times and costs. Basically, this model was developed on the basis of a database created from several studies that were carried out during large-scale earthwork operations on the construction site of one of the largest chemical plants in central Europe.

Son et al., 2012 developed a hybrid prediction model that combines principal component analysis (PCA) with a support vector regression (SVR) predictive model for cost performance of commercial building projects. They used 64 related variables to define the pre-project planning stage. They developed their dataset based on information from 84 building projects in South Korea. **Cheng and Hoang, 2014** developed cost estimation at completion technique using least squares support vector machine. The data sets that are used in this research were collected from 13 reinforced concrete building projects executed between 2000 and 2007 by one construction ompany headquartered in Taiwan.

6.2 Knowledge - Based Systems (KBS)

This category includes any technique that uses logical rules for deducing the required conclusions. The main strengths of KBS are (i) the ability to justify any result and (ii) uncomplicated methods (i.e., it is relatively easy to develop (KBS). On the other hand, the limitations of KBS are (i) the difficulty of self-learning and (ii) time consumption during the rule acquisition process. Expert system and case-based reasoning are the common techniques used in KBS. The accuracy of case-based reasoning is highly dependent on the number of selected cases. Recently, KBS has been combined with other techniques to handle the limitation of the self-learning process. However, this mixture will be discussed in more details in the section of this paper that deals with hybrid systems.

Ji et al., 2012, proposed case-based reasoning to prepare strategic and conceptual estimations for construction budgeting. The data for this project were collected from 129 military barrack projects. **Choi et al., 2014** proposed a cost prediction model for public road planning. The research data had been collected from a total of 207 real public road projects. **Choi et al., 2014** used rough-set theory to control the data collection and a genetic algorithm to optimize the rough-set model. Their work was classified as CBS since the authors implemented the case-based reasoning component in their cost estimation**. Kim K. J. and Kim K., 2010** developed a cost estimation model using KBR. This research overcomes the uncertainty in choosing the correct case by using a genetic algorithm. For this research, data were collected from 65 projects that constructed 585 bridges over a 5-year period.
Kim, 2013 developed a cost estimation model based on case-based reasoning and analytical hierarchy process (AHP). In this project, data have been selected from literature and only 13 studies have been analyzed. **Kim, 2013** developed his model based on data from high-way construction projects. The validation has been conducted based on case study that contains data from 48 construction projects.

6.3 Evolutionary Systems (ES)

ES is a group of intelligent systems concerned with continuous optimization with heuristics. As the results of ES are generated based on specific heuristics, they are very difficult to generalize, which is considered to be the main limitation of ES. The ability to solve complicated and uncertain problems is the main motivation for researchers to use ES. Evolutionary systems are used mainly as optimization tools where there are many solutions; however, the ES algorithm assists in obtaining the correct solution. **Rogalska et al., 2008** proposed a method based on genetic algorithm to deal with the problem of construction project scheduling. **De Albuquerque Et Al., 2012** developed a tool for estimating the cost of concrete structures. This tool is developed based on genetic algorithm. The cost has been estimated in all construction phases, such as manufacture, transport, and erection. **Afshar et al., 2009** developed a multicolony ant algorithm to solve the time/cost multiobjective optimization problem. This method estimated both direct and indirect costs. **Zhang and ng, 2012** developed a decision support system (DSS) for cost estimation based on ant colony system**, Zhang and Ng, 2012** used synthetic data to develop their DSS and they do validate their system by comparing it with a standard academic project. However, validation is done. Still validation with real projects provides more accurate results.

6.4 Agent- Based Systems (ABS)

ABS has been considered as one of the main tracks in artificial intelligence, simulating the actions and interactions of autonomous agents with a view of assessing their effects on the system as a whole. In ABS, the generalization of extracted results is the main challenge. **Karakas et al., 2013** developed a multivalent system (MAS) that simulates the negotiation process between contractor and client regarding risk allocation and sharing of cost overruns in construction projects. This MAS was tested by interviewing eight professionals from the construction industry. In addition, **Rojas and Mukherjee, 2006** developed a general multivalent simulation framework that can be used as an effective training environment. This framework could be used to estimate direct and indirect costs for construction projects.

6.5 Hybrid Systems (HS)

HS is defined as a collection of techniques used together to solve a specific problem. Usually, researchers use HS to overcome the techniques' individual limitations. Implementation of HS could represent a challenge, due to the unavailability of computational tools that could support its implementation. **Cheng et al., 2013** proposed a hybrid intelligence system for estimating construction cost. This hybrid system was developed based on support vector machine (SVM) and differential evolution (DE). In this proposal, data were collected across a number of public projects in Taiwan. **Kim et al., 2005** proposed hybrid models of ANN and GA for cost estimation of residential buildings, in order to predict preliminary cost estimates. In **Kim et al.**'s proposal, data were collected from residential buildings constructed in the years between 1997 and 2000 in Seoul, Korea**. Yu and Skibniewski, 2010** proposed integrating a neurofuzzy system with conceptual cost estimation to discover cost-related knowledge from residential construction projects. The data used in this proposal was based on historical data from previous construction projects collected by the ministry of construction of PRC in the years between 1996 and 2002. Most recently, **Cheng et al., 2009** proposed web-based conceptual cost estimates for construction projects, using an evolutionary fuzzy neural inference model. Data were collected from 28 construction projects spanning the years from 1997 to 2001 in Taiwan.

Table 2 shows the comparison of surveyed proposals, based on two issues. The first issue is the intelligent technique used in a proposal. The second issue is the type of validation that is used to

prove the applicability of the proposal. **Table 3** shows the comparison of surveyed proposals, based on design and project-specific factors used to estimate construction cost in each proposal. The letter "y" means that this factor has been considered in this proposal, while the letter "N" means that this factor has not been considered. It is very obvious that there is no proposal that satisfies all the design and project-specific factors.

7. HISTORICAL COST DATA

The preparing of cost estimates normally requires usage of historical data on the construction costs. The data historical cost will be valuable for cost estimation only when they are collected then organized in a technique that is compatible with the future applications. Organizations that are engaged in estimation of cost continually ought to keep a file for the own use. The information need to be updated with the respect to changes which will inevitably occur. The format of the cost data, such as the unit costs of various items, must be organized according to current standard of the use in the organization.

The data historical cost must be used cautiously and changes in relative prices that may have substantial impacts on the construction costs that have increased in the relative price. Unluckily, systematic changes over the long period of time and for such factors are hard to predict. The errors in analysis serve to introduce uncertainty in the cost estimates. Of course it is difficult, to forecast all problems that may occur in construction as well as operation of facilities. Some evidence to estimate costs of construction and operating have tended to persistently minimize the actual costs. So this is by reason of the effects in costs for greater than anticipated increases, changes in design through the construction process. A lot of data is required to construction cost estimating on building elements, equipment, material, labor, as well as other related information.

These data need to be organized in a way that they can be easily accessed. One way to solve the problem is to use a database for storage of the data. A database is a storage facility or a collection of related records or documents.

Databases are designed, constructed, and populated with information data for a specific purpose then has an intended group for users and some applications by which the users are interested. The estimating software is designed to estimate adopts database technology for storing all the information that necessary for the estimating.

Some of the reasons for using databases are **Phuwadol, 2010**:

1. Compactness: The Databases help for maintaining the large quantities of data, and therefore completely replace voluminous the paper files.
2. The Speed: Searches for a specific piece of information or data in the database are faster than the sorting through paper piles.
3. Less drudgery: It is dull work to keep files by hand; so by using a database fully eliminates such maintenance.
4. Currency: Database systems can easily be updated and so provide accurate information all the time and on demand.

8. CONCLUSIONS

This centered evaluation of the continuing strategies screen the prolonged and growing adoption of AI within the management of Civil Engineering initiatives and particularly task cost management. It has become obvious inside the previous couple of years that each software of AI has its strong and susceptible points. As quickly as those factors had been identified, the brand new methods are targeted on hybrid structures. The latter ones are structures which integrate two or more one-of-a-kind AI. The preceding analysis, concluded that the most commonplace and

appropriate processes of artificial intelligence, which can be used to expand fashions for production projects are Fuzzy good judgment, Neural Networks, support vector machine and Genetic Algorithms. Those techniques combined with data and particularly regression evaluation may want to produce predicting fashions easy to use, and at the equal time green and correct. Subsequently, because the hardware is becoming extra robust and green, and at the same time applications aim at a total integration, the resulting systems will exhibit remarkable overall performance.

In this paper, a survey and analysis have been done on extraordinary proposals as a way to address the trouble of growing production cost estimation based totally on clever techniques. A systematic methodology has been designed to enforce this survey. The method of the offered paper becomes based on parts. The first component turned into worried with a literature survey to have a look at the present day nation of sensible answers in the construction industry. Concerning this relies, the journals that specialize in both statistics technology and construction management are chosen solely. Period is enough to surround the instructions of research in a selected place. The second one part became involved with analysis of the proposals accrued inside the first element. Four key questions were selected to analyze every concept. This paper offers contributions to this vicinity of understanding: (1) an analysis of construction price estimation proposals and (2) a well-known survey methodology that may be utilized in any destiny surveys that deal with construction price estimation. Consistent with the effects of this studies paper, the studies gaps which have been deduced from this survey are as follows. (1) there may be a critical necessity for a price estimation method that covers all estimation elements from each type; that is, there's a need for one approach that includes all “estimator precise” and “design and challenge-particular” elements. In desk 1, it is obvious that no proposal has a complete row of “Y.” (2) there is a real need for a widespread validation method which can be used to determine the accuracy stage of a value estimation proposal. (3) there are many proposals that be afflicted by a loss of medical justification for the consequences, that is, loss of describing how technically the outcomes had been executed.

REFERENCE

- Abdal-Hadi, M., 2010**.,** *Factors Affecting Accuracy of Pre-tender Cost Estimate in Gaza Strip*., **.** Master thesis in construction management, The Islamic University of Gaza Strip.

- Afshar A., Ziaraty A. K., Kaveh A., and Sharifi F.,2009, *No Dominated Archiving Multicolony Ant Algorithm In Time Cost Trade-Off Optimization*, Journal of Construction Engineering and Management, vol. 135, no. 7, pp. 668–674.

- Akinci B. And Fischer M.,1998, *Factors Affecting Contractors Risk Of Cost Overburden***,** Journal of Management in Engineering, vol. 14, no. 1, pp. 67–76.

- An S.-H., .Park U.-Y, Kang K.-I., Cho M.-Y., and Cho H.-H.,***2007,*** *Application of Support Vector machines in Assessing Conceptual Cost Estimates*, Journal of Computing in Civil Engineering, vol. 21, no. 4, pp. 259–264.

- Cheng M.-Y., Tsai H.-C., and Hsieh W.-S.,2009, *Web-Based Conceptual Cost Estimates for Construction Projects Using Evolutionary Fuzzy Neural Inference Model***,** Automation in Construction, vol. 18, no. 2, pp. 164–172.

- Cheng M.-Y. and Hoang N.-D., **2**014**,** *Interval estimation of construction cost at completion using least squares support vector machine***,** Journal of Civil Engineering and Management, vol. 20, no. 2, pp. 223–236.

- Cheng M.-Y., Hoang N.-D., and Wu Y.-W.,2013, *Hybrid Intelligence Approach Based on LS-SVM and Differential Evolution for Construction Cost Index Estimation: A Taiwan Case Study* **,***Automation in Construction*, vol. 35, pp. 306–313.

- Choi S., Kim D. Y., Han S.H., and Kwak Y. H.,2014, *Conceptual Cost Prediction Model for Public Road Planning Via Rough Set Theory and Case-Based* .

- Choi, Ying-Kit.,2004, *Principles of Applied Civil Engineering Design. New York*: American Society of Civil Engineers.

- de Albuquerque A. T., El Debs M. K., and Melo A. M. C.,2012, *A Cost Optimization-Based Design of Precast Concrete Floors Using Genetic Algorithms*, Automation in Construction, vol. 22, pp. 348–356.

- Flood I. and Kartam N., 1994, *Neural Networks in Civil Engineering. Principles and Understanding*, Journal of Computing in Civil Engineering, vol. 8, no. 2, pp. 131–148

- French S., Fischer M., Kunz J., and Paulson B.,2003, *A generic Feature-Driven Activity-Based Cost Estimation Process***,** Advanced Engineering Informatics, vol. 17, no. 1, pp. 23–39.

- Hola B. and Schabowicz K.,2010, *Estimation Of Earthworks Execution Time Cost By Means Of Artificial Neural Networks***,** Automation in Construction, vol. 19, no. 5, pp. 570–579.

- Holm L., Schaufelberger J. E., Griffin D., and Cole T., 2005, *Construction Cost Estimating Process and Practices*, Pearson Education, Upper Saddle River, NJ, USA.

- Jafarzadeh R., Ingham J. M., Wilkinson S., Gonz´alez V., and Aghakouchak A. A.,2014, *Application of Artificial Neural Network Methodology for Predicting Seismic Retrofit Construction Costs*, Journal of Construction Engineering and Management, vol. 140, no. 2.

- Jamshid S., 2005**,** *Cost Estimation of Highway Projects in Developing Country: Artificial Neural Network Approach. Graduate Project*, Department of Civil and Environmental Eng., Saitama University.

- Ji S.-H., Park M., and Lee H.-S.,2012, *Case Adaptation Method of Case-Based Reasoning for Construction Cost Estimation in Korea*, Journal of Construction Engineering and Management, vol. 138, no. 1, pp. 43–52.

- Jitendra, Vikas, Kuldeep & Samiksha, 2011, *Cost Prediction Using Neural Network Learning Techniques***,** IJCSMS International Journal of Computer Science and Management Studies.

- Jrade, Ahmad, and Sabah Alkass., 2007, *Computer-Integrated System for Estimating the Costs Of Building Projects.* Journal of Architectural Engineering 13.4.

- Karakas K., Dikmen I., and Birgonul M. T.,2013, *Multiagent System to Simulate Risk-Allocation and Cost-Sharing Processes in Construction Projects***,** Journal of Computing in Civil Engineering, vol. 27, no. 3, pp. 307–319.

- Kim G. H., Seo D. S., and Kang K. I.,2005, *Hybrid Models of Neural Networks and Genetic Algorithms for Predicting Preliminary Cost Estimates***,** Journal of Computing in Civil Engineering, vol. 19, no. 2, pp. 208–211.

- Kim K. J. and Kim K., 2010, *Preliminary Cost Estimation Model Using Case-Based Reasoning and Genetic Algorithms,* Journal of Computing in Civil Engineering, vol. 24,no. 6, pp.499–505.

- Kim S., 2013, *Hybrid Forecasting System Based on Case-Based Reasoning and Analytic Hierarchy Process for Cost Estimation***,** Journal of Civil Engineering and Management, vol. 19, no. 1, pp. 86–96.

- Kim, G.-H., An, S.-H. & Kang, K.-I., 2004**.** *Comparison of Construction Cost Estimating Models Based on Regression Analysis, Neural Networks, and Case-Based Reasoning*. Building and Environment, February, Volume 39, p. 1235 – 1242.

- Parmee I. C., 2003, *Computational Intelligence and Civil Engineering- Perceived Problems and Possible Solutions,* in Towards a Vision for Information Technology in Civil Engineering.

- Petroutsatou K., Georgopoulos E., Lambropoulos S., and Pantouvakis J. P., 2012, *Early Cost Estimating 0f Road Tunnel Construction Using Neural Networks***,** Journal of Construction Engineering and Management, vol. 138, no. 6, pp. 679–687.

- PhuwadolSamphaongoen, B.S.,2010**,***A Visual Approach to Construction Cost Estimating***,** A MS.c Thesis submitted to the Faculty of the Graduate School, Marquette University.

- Rogalska M., Bozejko W., and Hejducki Z., 2008, *Time Cost Optimization Using Hybrid Evolutionary Algorithm in Construction Project Scheduling,* Automation in Construction, vol. 18, no. 1, pp. 24–31.

- *Rojas E. M.* And Mukherjee A.,2006, *Multi-Agent Framework For General-Purpose Situational Simulations In The Construction Management Domain***,** Journal of Computing in Civil Engineering, vol. 20, no. 3, pp. 165–176.

- Shane J. S., Molenaar K. R., Anderson S., and Schexnayder C.,2009, *Construction Project Cost Escalation Factors***,** Journal of Management in Engineering, vol. 25, no. 4, pp. 221–229.

- Son H., , and Kim C.,2012, *Hybrid Principal Component Analysis And Support Vector Machine Model For Predicting The Cost Performance Of Commercial Building Projects Using Preproject Planning Variables***,** Automation in Construction, vol. 27, pp. 60–66.

- Wang, Y., Yu, C. & Chan, H., 2012. *Predicting Construction Cost and Schedule Success Using Artificial Neural Networks Ensemble And Support Vector Machines Classification Models.* International Journal of Project Management, Volume 30, p.470–478.

- Wilmot C. G. and Mei B., 2005, *Neural Network modeling Of Highway Construction Costs***,** Journal of Construction Engineering and Management, vol. 131, no. 7, pp. 765–771.

- Yu W.-D. and Skibniewski M. J.,2010, Integrating Neurofuzzy System With Conceptual Cost Estimation To Discover Cost-Related Knowledge From Residential Construction Projects, Journal of Computing in Civil Engineering, vol. 24, no. 1, pp. 35–44.

- Zhang Y. and Ng S. T.,2012, *An Ant Colony System Based Decision Support System For Construction Time-Cost Optimization***,** Journal of Civil Engineering and Management, vol. 18, no. 4, pp. 580– 589.

Table 1. Three types of construction cost estimating methods.

Type of Estimate	Construction Development	Expected Error
Conceptual	Programming and schematic design	± 10-20%
Semi-Detailed	Design development	± 5-10%
Detailed	Plans and specification	± 2-4%

Table 2. Comparison of proposals based on technique and validation

Proposal	Technique	Validation
Wilmot and Mei	ML, ANN	Comparison with methods for assessing conceptual cost estimates
An et al	ML,SVM	Comparison with methods for assessing conceptual cost estimates
Petroutsatou et al.	ML, ANN	By comparison with other models in literature
Jafarzadeh et al.	ML, ANN	Have not been mentioned
Hola andSchabowicz	ML, ANN	Have not been mentioned
Son et al.	ML,SVM	Comparison with other techniques such as ANN and a decision tree (DT)
Cheng and Hoang	ML,SVM	Have not been mentioned
Ji et al	KBS: case-based reasoning	Using case study
Choi et al.	KBS: case-based reasoning	By comparison with previous conceptual cost estimation studies
K. J. Kim and K.	KBS: case-based	Have not been mentioned

Kim	reasoning	
Karakas et al.	ABS: MAS	Interview with expert
Rojas and Mukherjee	ABS: multiagent	Have not been mentioned
kim	KBS: case-based reasoning and analytical hierarchy process	Case study
de Albuquerque et al.	ES: genetic algorithm	Have not been mentioned
Rogalska et al.	ES: hybrid genetic evolutionary algorithm	By comparing the result with case studies from literature
Afshar et al.	ES: ant colony	By comparing the results with case studies in construction optimization
Zhang and Ng	ES: ant colony	By comparing the results with an academic benchmark
Cheng et al.	HS: SVM and DE	By comparing the result with other methods
Kim et al.	HS: ANN and GA	Have not been mentioned
Yu and Skibniewski	HS: ANN and fuzzy system	By using a case study of residential building construction projects in China
Cheng et al.	HS: ANN, GA, and fuzzy system	Have not been mentioned

Table 3. Comparison of the proposals based on design and project-specific factors.

Work	Project size	Project type	Ground conditions	Type of client	Likely design and scope changes	Contract type	Material costs	Duration	Tendering method
Wilmot and Mei	Y	Y	Y	Y	Y	Y	Y	Y	N
An et al	Y	Y	Y	Y	Y	N	N	N	N
Petroutsatou et al.	Y	Y	Y	Y	Y	Y	Y	N	N
Jafarzadeh et al.	Y	Y	Y	Y	Y	N	N	N	N
Hola andSchabowicz	Y	Y	Y	N	N	N	Y	Y	Y
Son et al.	Y	Y	N	Y	Y	N	N	Y	N
Cheng and Hoang	Y	Y	Y	N	N	N	N	Y	N
Ji et al	Y	Y	Y	N	Y	N	Y	N	N

Choi et al.	Y	Y	Y	Y	N	N	N	N	N
K. J. Kim and K. Kim	Y	Y	Y	Y	N	N	N	N	N
Karakas et al.	N	N	Y	Y	Y	N	Y	N	N
Rojas and Mukherjee	Y	Y	Y	N	N	N	N	N	N
kim	Y	Y	Y	N	N	N	N	N	Y
deAlbuquerque	Y	Y	Y	N	N	N	Y	N	N
Rogalska et al.	Y	Y	Y	N	N	N	N	N	N
Afshar et al.	Y	Y	Y	N	N	Y	Y	Y	Y
Zhang and Ng	Y	Y	Y	N	N	N	N	N	N
Cheng et al.	Y	Y	Y	N	N	N	Y	Y	N
Kim et al.	Y	Y	Y	N	N	N	Y	Y	N
Yu and Skibniewski	Y	Y	Y	Y	N	N	Y	Y	N
Cheng et al.	Y	Y	Y	Y	N	N	Y	Y	N