An integrated system for conceptual cost estimates

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ABSTRACT: Construction projects pass through several phases during their life cycle. However, during the initial level where feasibility studies are conducted, conceptual estimates are generated to assist decision makers in approving or rejecting proposed projects. The common practice followed during this level starts by consultations between owners, practitioners and experts with the deficiency of documents, specifications and drawings. Own experience and wide range of assumptions control the preparation of conceptual estimates, where extensive assortment of errors and unsound decisions are anticipated to occur. Therefore, the availability of accurate cost data is necessary to overcome this problem. This is achieved by the relevance of Management Information System, where cost data and 3D-CAD drawings can be stored and manipulated to fit user's needs. Moreover, decision makers are in need for a reliable system to use during the feasibility stage of new proposed projects. This paper presents the design and implementation of a decision support system, which helps in selecting the best project type given the budget. The system integrates 3D-CAD drawings with relational databases so that any modification in the drawing's parameters such as: floor area, floor-to-floor height and building perimeter; will result in the generation of a new conceptual estimate taking into consideration the required adjustments.

1 INTRODUCTION

Preparing parametric cost estimates is a challenge for cost engineers and estimators. Owners normally require accurate estimates of the cost of constructing a project originated on initial ideas without supplying physical documents. At this stage, wide range of assumptions governs the preparation of such estimates. Parametric estimate is usually prepared before the facility is designed, and must therefore, rely on the historical cost data collected from similar projects built in the past (Hendrickson, 2000). Bajaj et al. (2002) judge parametric cost estimates as being quiet accurate if the historical data are properly captured from the source. Parametric cost estimating process may generate reliable cost estimates by using factors based on engineering. These engineering parameters are generated from historical cost databases, construction practices, and engineering/construction technology (Meyer and Burns, 1999). On the other hand, one must first have a few available parameters and cost data for a completed project that is comparable to the new project. The simplest method to establish the reasonableness of a facility costs is to identify the costs of similar projects and compare these costs with the cost of the new facility (Melin, 1994); (Ellsworth, 1998). The parametric approach to cost estimating is a procedure involving the use of constant parameters (with variable values) as a reference for other variables (Melin, 1994). These parameters include physical properties that describe project definition characteristics such as size, building type, exterior closure materials, roof type and material and number of floors (Meyer and Burns, 1999). However, these parameters can be extracted directly from the 3D-CAD drawing with slight modifications to the drawings. The most common methods used in approximate estimates is the square-foot method, where historical building costs data are used to get an estimate of the cost per square foot of the type of building under consideration. The estimated unit cost is then multiplied by the gross floor area of the proposed building after being adjusted for factors as location, size, height, perimeter and inflation.

The availability of historical data is indispensable for the preparation of parametric cost estimates. Nonetheless, this data has to be properly organized and convenient for cost engineers and estimators whenever needed. That is realized by applying Management Information System in the course of Databases. MIS is a computer system capable of integrating data from many sources to provide data and information useful to support operations and decision-making (Hegazy, 1993). Management information is normally produced from a shared database that stores data from many sources. Thus data analysis and database design become critical to MIS design (Whitten and Bentley, 1998). A database is characterized by its simplicity of data management, independence of logical user views from the physical data storage structure, and the availability of simple but powerful relational operators. These characteristics translate into a collection of tables that are composed of rows and columns (Kibert and Hollister, 1994). Once the pertained databases are designed and necessary data are stored, these can be accessed and queried through using Structure Query Language (SQL). SQL allows sophisticated data management processes to be performed on databases that are based upon highly orthogonal yet simple principles (Kibert and Hollister, 1994).

This process could be automated through system integration to develop a Decision Support System (DSS) to assist users in making major decisions regarding the feasibility of proposed projects. Decision Support Systems are computer-based tools that help managerial decision-making by presenting information and interpretations for various alternatives, such systems can assist managers in making strategic decision (Pal and Palmer, 2000). DSS are becoming significant to the construction industry where data warehousing is one of its prime parts by providing an interaction of storing, retrieving and manipulating any type of data. DSS has made significant contributions in the data/knowledge storage and in the communication of results to the end user; i.e., databases are principle components of all DSSs (Nemati, and al., 2002). Courtney (2001) describes the decision making process as consisting of three phases: intelligence, design and choice. The first is used in the military sense to mean searching the environment for problems, that is, the need to make a decision. The second involves the development of alternative ways of solving the problem, and the third consists of analyzing the alternatives and choosing one for implementation. Whereas, Pal and Palmer (2000) consider three important approaches in the development of DSSs:

1. Rule-based reasoning (RBR), where the specialized domain knowledge is represented as a set of IF *[precondition(s)]* THEN *[conclusion(s)]* rule format.
2. Case-based reasoning (CBR), where the past experiences are used in solving a new case.
3. Hybrid (i.e., a combination of RBR and CBR).

The ability of such systems in processing knowledge has led to cost savings, faster decision process, and significant competitive advantage (Bonarini and Maniezzo, 1991).

This paper presents a methodology pursued in developing a decision support system that automates the preparation of parametric cost estimates after making essential parameters adjustments for building projects. Rule-based reasoning (RBR) approach is used in the system implementation. Modeling the preparation of these estimates is advantageous particularly when explicit methods and techniques are followed and the pertained parameters are normalized. The accessibility, types and sources of historical data do impact the accuracy of the estimate. Thus storing the required data into databases would speed the process of retrieving, querying and modifying practice when desired. The data used is based on R.S. Means Square-Foot-Cost Data published in year 2000. Microsoft Visual Basic 6.0, MS Access 2000 and AutoCAD 2000 were used in the implementation of the system.

2 DEVELOPMENT OF METHODOLOGY

The system requirements are set based on the literature review along with the characteristics to be considered in a practical system. The process of introducing a valuable methodology is considered in order to enhance the benefits of the system under its categorized requirements and development constraints. The methodology is divided into four steps of design and development. The first step consists of designing and implementing the system's cost databases. Theses are needed to generate parametric estimates. Another separate database to store 3D-CAD drawings to be used by the DSS is also developed. The second step encompasses the customization of AutoCAD drop down menus to meet the system requirements. Also to design internal modules that automate the process of retrieving necessary parameters from the 3D-CAD drawing and writing them to an external database designed for that purpose. The third step consists of designing a global module to be used as gateway to manage the project cost data retrieval and execute the required normalizations and calculations. Finally, the fourth step includes the design and implementation of a decision support system that aids users in selecting the most appropriate project together with its 3D-CAD drawing that meets the users requirements terms of budget.

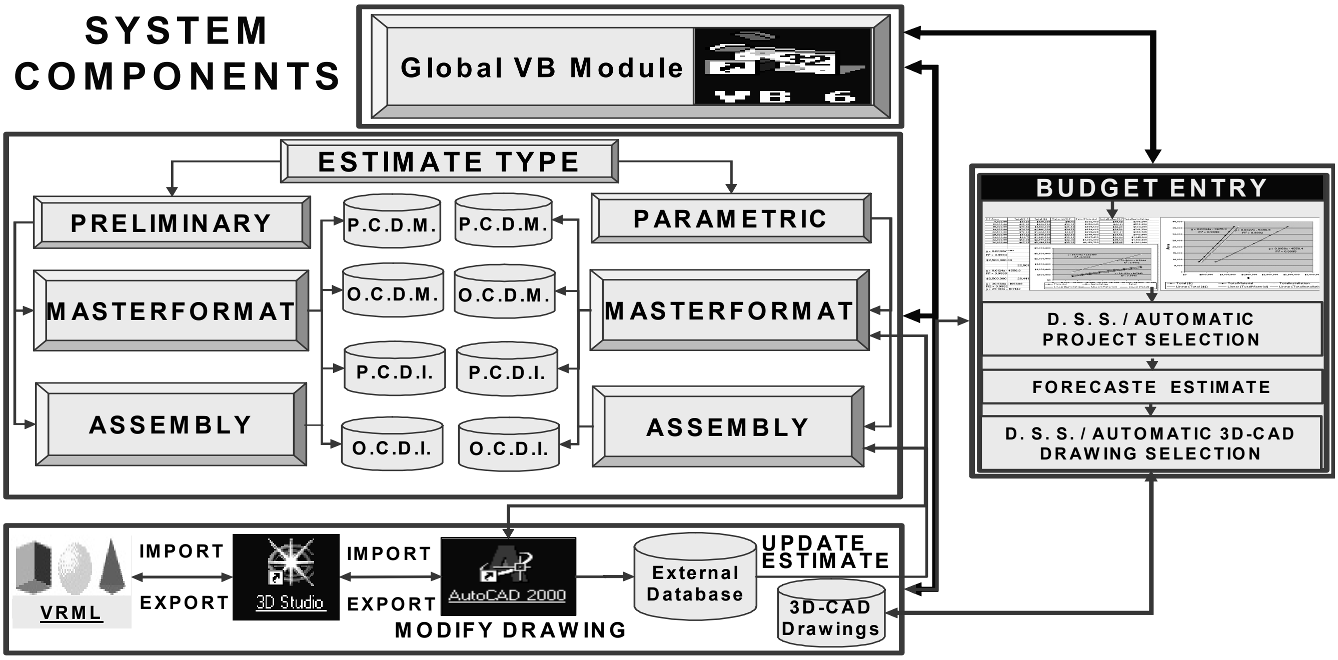

Figure 1. System Components

2.1 *System components*

The system consists of components designed in a modular format, incorporating a global Visual Basic module, which is considered as the gateway to access all other three modules and links four cost databases. These databases are managed by a database management system, which in this case is Microsoft Access. The system components are developed through four steps described in the following paragraphs. Figure 1 exemplifies the system components.

2.1.1 *Step one*

In this step all the pertained databases are designed and implemented in order to store cost data of previously constructed projects and from R.S. Means publications. In addition one 3D-CAD drawings database is developed so it is accessed by the DSS to select the closest drawing for the proposed project. Figure 2 shows the graphical illustration of the system's database development process. This process is divided into two parts: Conceptual Modeling and Data Model Implementation.

2.1.2 *Step two*

This step comprises the development of AutoCAD internal modules in order to automate the process of reading and writing the retrieved parameters from the 3D drawings. Moreover, a direct link between AutoCAD and an external database is established to accelerate the storing process of the extracted parameters. Finally, two additional drops down menus are added to the AutoCAD menu to make the procedures that are carried out by the internal modules easier. Figure 3 illustrates the AutoCAD modules and components.

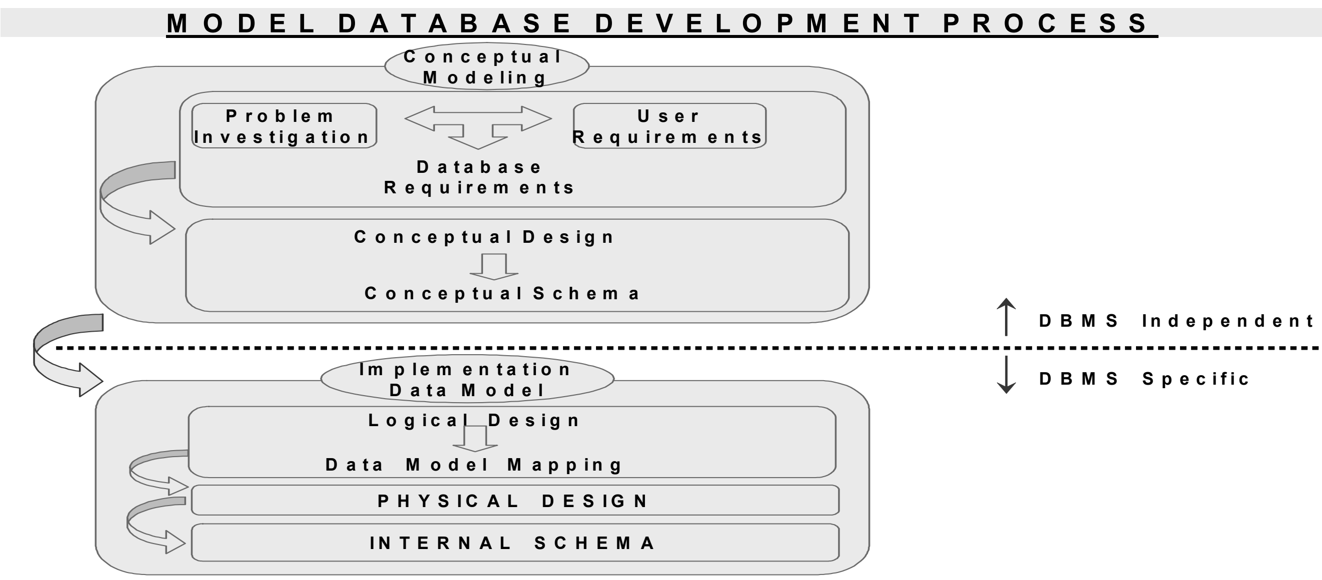

Figure 2. System's databases development process

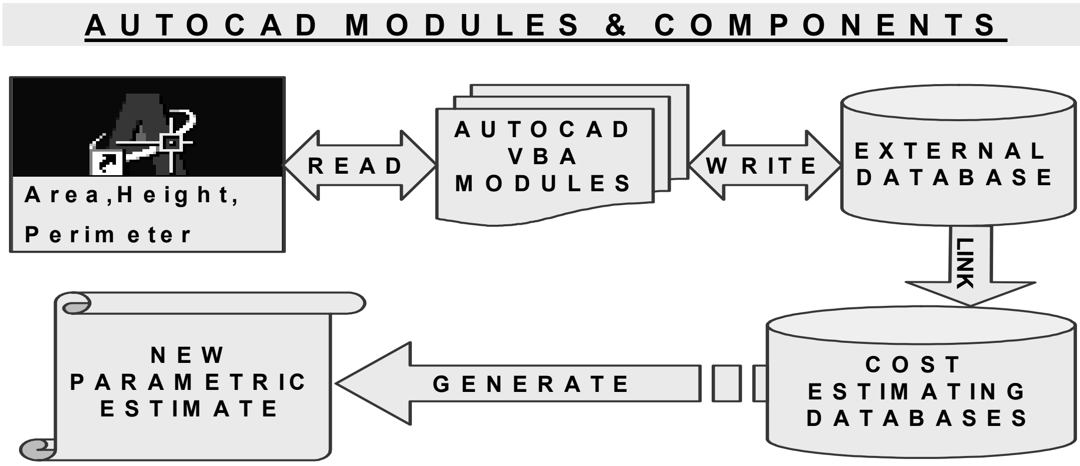

Figure 3. AutoCAD modules and components

2.1.3 *Step three*

This step covers the design and implementation of the global Visual Basic module. As shown in Figure 1, this module is considered the entryway for all other modules. Furthermore, this module executes all required calculations and cost adjustments needed after modifying the 3D-CAD drawing associated with the selected project. Figure 4 shows a screen printout for a sample form of all the calculations and adjustments carried out by this module based on the new parameters from the drawing.

2.1.4 *Step four*

In this step a decision support system is designed and implemented so that it provides the user with the best project and associated 3D-CAD drawing based on the budget entry. For this purpose, a rule base system has been developed containing a total of 80 rules related to the system functionality. These rules are divided into the following three groups:

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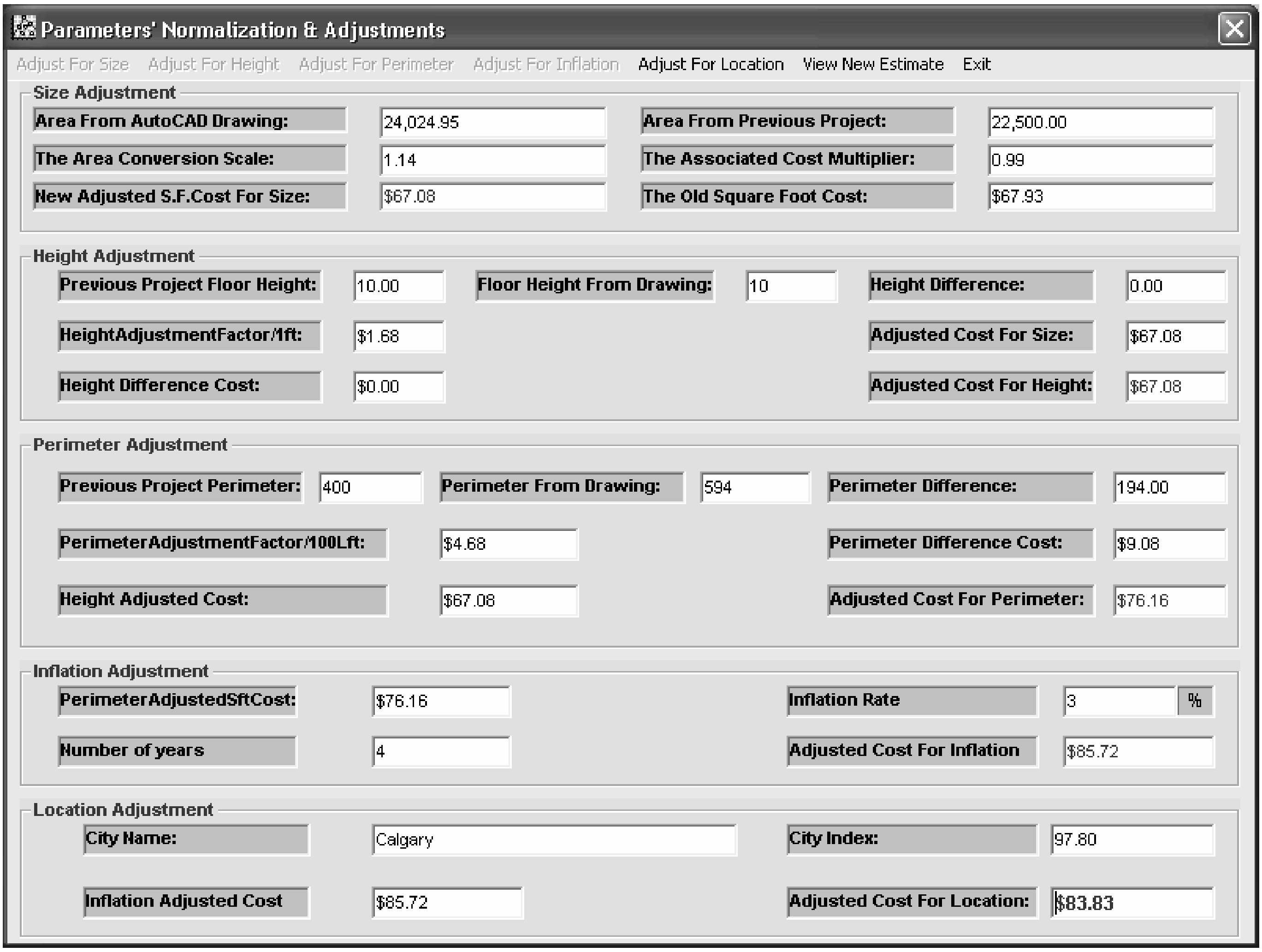

Figure 3. AutoCAD modules and components

on the budget entry. For this purpose, a rule base system has been developed containing a total of 80 rules related to the system functionality. These rules are divided into the following three groups:

1 Wide, containing 25 rules
2 Intermediate, containing 25 rules
3 Narrow, containing 30 rules.

Figures 5 and 6 show the Rule Based Reasoning workflow process and the Rule Base structure respectively.

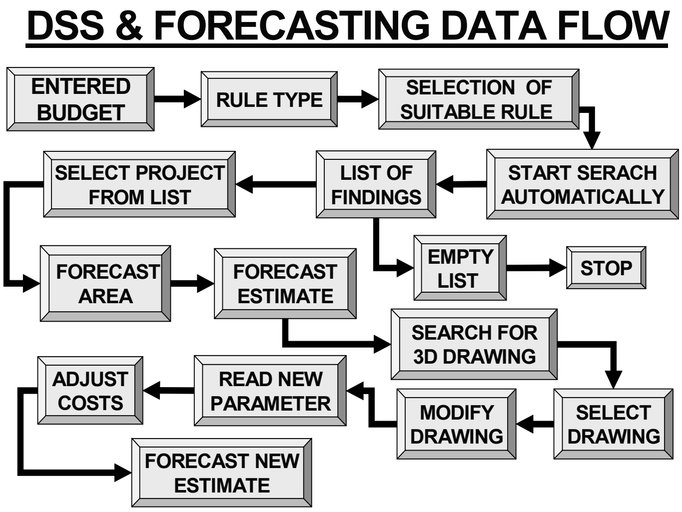

Figure 5. Rule based reasoning workflow process

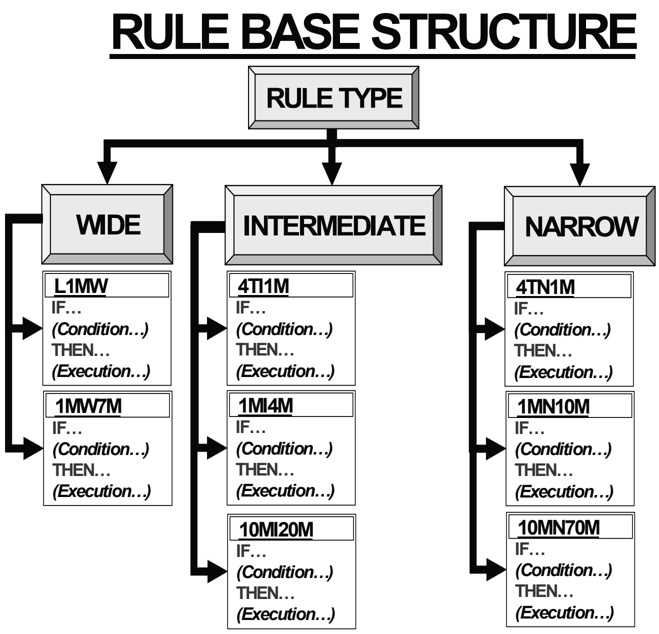

Figure 6. Rule base structure

Once the user accepts the project selected by the DSS, its area and related conceptual estimates are immediately forecasted using sets of linear regression equations derived for that purpose. Thereafter, the DSS selects a suitable 3D-CAD drawing from the specified database and makes it available for the user to animate and modify. Once the drawing is modified, the new parameters are read and accordingly a new estimate is generated.

3 CONCLUSION

A methodology to automate the process of preparing conceptual estimate has been presented. A decision support system that helps users in selecting a project and 3D-CAD drawing that meets the allocated budget and accordingly forecast its gross area and cost estimate is introduced. This system assists owners, architects, and cost engineers during the course of conducting feasibility studies for proposed projects. Besides its simplicity, flexibility, user-friendly and ability to allow the user to visualize a preliminary shape of the proposed project in 3D mode and to carry out any essential modifications in the sense of extracting floor areas or adding more floors. The development process is carried out using software applications known to the industry such as AutoCAD, MS Access, and Visual Basic.

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