Cost Estimation and Negotiation Agent for Home Construction

Yamin Htet
University of Computer, Monywa, Myanmar
yaminhtet07@gmail.com

Abstract

A cost estimate establishes the base line of the project cost at different stages of development of the project. At a given stage of project development, this represents a prediction provided by the cost engineer or estimator on the basis of available data. The negotiation between the budgeted amount of homeowner and the estimation of the system is also the important stage of the construction project. This paper intends to support the engineer and contractor of home construction as the Decision Support System (DSS). Technically, the software is the desktop, single-user DSS which support the cost estimation and cost negotiation of home construction with the help of agent technology. This paper supports the engineers with fast and easy calculations in cost estimation. This system also applies the human negotiation style in agent technology with user friendly interface. Application domain of this paper is the home construction with relevant civil engineering techniques, such as Plinth Area Estimate (P.A.E) method and Cubical Content Estimate (C.C.E) method. The proposed system is implemented by C# programming language with Microsoft Visual Studio 2008 environment.

Keywords: P.A.E, C.C.E, Human-Like Negotiation

1. Introduction

Today's homeowners are very actively involved with the design of their homes insisting on looking over scores of house plans and having their architects modify everything specifically. Construction process needs resources input. Construction inputs exist in the form of men, materials, machinery and memory. The construction works can be executed through the client's own organization, that is, departmentally, or through contractors, or through a combination of both. Building construction estimating is the determination of probable construction costs of any given projects. A cost estimate establishes the base line of the project cost at different stages of development of the project. Building construction estimating is the determination of probable construction costs of any given project. There are many items that influence and contribute to the cost of project the estimate is prepared before the actual construction of a project, a great deal of study must be put into the construction documents, and this makes estimating one of the most important phases of any contractor business. Since the estimate is prepared from the working drawings and specification of a building, the ability of the estimate to visualize all of the different phases of construction becomes a prime ingredient An estimate is computation or calculation of the quantities required and expenses likely to be incurred in the construction of work. The main objective of the estimate is to known before hand the cost of the work.

This estimate is an accurate one based on the plan and sections of the building. The quantities of items under sub-head of work are calculated from the dimensions taken from drawing and total cost is worked out in the form called abstract of cost. The rates of different items of works are taken as per analysis of rates for finished item of work. Detailed estimate is calculated in detailed measurement form. To determine the rate of particular item of work from the quantities of materials and labours required and their cost is known as Analysis of Rates.

The rates of materials and labours are fluctuating from place to place and therefore the rates of different items work also vary from place to place. The system supports the decision making for the engineer to estimate the construction project with the help of civil engineering technique and to negotiate the construction cost by means of agency. Plinth Area Estimate method and Cubical Content Estimate method are implemented in this software. Detailed cost estimations are also applied in the cost estimation. For negotiation, the human-like negotiation ideas are used in this system.

2. Decision support system

Decision Support Systems are a specific class of computerized information systems that supports business and organizational decision-making activities. A properly-designed DSS is an interactive software-based system intended to help decision

makers compile useful information from raw data, documents, personal knowledge, and/or business models to identify and solve problems and make decisions. Using scope as the criterion, Power [4] differentiates enterprise-wide DS*S* and desktop DSS. An enterprise-wide DSS is linked to large data warehouses and serves many managers in the company. A desktop, single-user DSS is a small system that runs on an individual manager's PC. There are three fundamentals of a DSS architecture are: the database (or knowledge base), the model (i.e., the decision context and user criteria), and the user interface. The users themselves are also important components of the architecture. DSS which perform selected cognitive decision-making functions and are based on artificial intelligence or intelligent agents technologies are called Intelligent Decision Support Systems (IDSS)[3].Decision support systems allow managers to consider various courses of future action and see projected results in order to plan future activities.

3. Construction project

The major construction projects can be grouped into "Building Construction", "Infrastructure Construction", "Industrial Construction" and "Special-purpose Projects". Works include residential and commercial complexes, educational and recreational facilities, hospitals and hotels, warehouse and marketing facilities. 'Buildings' constitute the largest segment of construction business. The building business serves mankind by providing shelter and services for its habitation, educational, recreational social and commercial needs. The building works are mostly designed by the Architect Engineering firms, and are financed by public and private sector and individuals.

4. Methods of estimating

The two types of estimating are preliminary estimating (or) approximate estimating and detailed estimating [1].

4.1. Preliminary estimating

These methods are used by architects engineering for first construction with clients and contractors to guide their thinking in the first approach to a probable cost of a building.

The project is decomposed into major structural systems or production equipment items, e.g. the entire floor of a building or a cooling system for a processing plant.

- P.A.E (Plinth Area Estimate) or Floor Area
- Estimate method
- C.C.E (Cubical Content Estimate) method
- Footrun Estimate method
- Lumpsum Estimate method

4.1.1. Plinth area estimate (P.A.E) method

The plinth area means the built up covered area measured at floor level of the basement. The roughly estimate cost of a proposed building can be achieved by multiplying the total plinth area with P.A.E rate.

Estimated Cost = Total Plinth Area x P.A.E rate

P.A.E rate =Total cost / Total Plinth Area

P.A.E rate is cost per sq-m (or) sq-ft of a similar building in that region (locality)

4.1.2. Cubical content estimate (C.C.E) method

This estimate is also approximate and is prepared on the basis of cubical content various buildings. The cubical content of a storey, can by worked out by multiplying the floor area of the storey by the Height. Cubic content rate is deduced from the cost of such building in the locality. This estimate is considered more accurate than that of plinth area estimate as the height of the building is also taken into account. This is rough cost estimate based on cubic contents. Rate per cubic meter should also be mentioned.

Estimated Cost = Total Cubical Content x C.C.E rate

C.C.E rate = Total cost / Total Cubical Content

Cubical content = Floor area x Height

4.1.3. Footrun estimate method

It is calculated on the total length of work and finding the cost by multiplying the total length of work by the rate per foot run.

Estimate Cost = Rate x Total length

4.1.4. Lumpsum estimate method

It is calculated on the basic of a lumpsum of work or a unit number.

Estimate Cost=Number of posts x Rate\

5. Agent based DSS

Most information systems in today’s organizations are built around the information technologies of computers and telecommunications, i.e., computer-based information system. On the

other hand, the information systems can be strongly provided by the advent of the agent technology which is a new paradigm for developing software applications in today's IT world.

Agent technology takes inspiration from such diverse areas as economic, philosophy, logic, ecology, and the social sciences. It enables efficient operations of a small business or a large corporation; it makes possible effective management; and it supports the search for competitive advantages in the marketplace. Economic growth, that is, growing productivity of resources, is based on moving to newer and more advanced technologies. Management support systems assist the various levels of management in controlling their business units. Through management reporting systems, managers are able to obtain summary reports on part, current and projected activity within their areas of responsibility.

Agent-based systems are one of the most vibrant and important areas of research and development to have emerged in information technology in the 1990s. Put at its simplest, an agent is a computer system that is capable of flexible autonomous action in dynamic, unpredictable, typically multi-agent domains. Many observers believe that agents represent the most important new paradigm for software development since object-orientation. The basic idea of agent-based information system is to support the user (manager) in problem solving, learning, planning and other daily functions effectively and efficiently.

Simple reflex agents act only on the basis of the current percept. The agent function is based on the condition-action rule (if condition then action rule). This agent function only succeeds when the environment is fully observable. Some reflex agents can also contain information on their current state which allows them to disregard condition whose actuators are already triggered. According to their attributes, agents could be classified as showing weak or strong notions of agency. The weak notion of agency, which comes from DC and DAI, sees agents as a paradigm of network based cooperative automation. The strong notion of agency, from Artificial Intelligence (AI), leads toward an anthropomorphic view where agents are seen as conscious, cognitive entities that have feelings, perceptions and emotions just like humans [5]. Agents are computer systems with two important capabilities. First, they are at least to some extent capable of autonomous action – of deciding for themselves what they need to do in order to satisfy their design objectives. Second, they are capable of interacting with other agents as well as human beings – not simply by exchanging data, but by engaging in analogous of the kind of social activity that we all engage in every day of our lives: cooperation, coordination, negotiation and the like [6]. The definition of agent processing can be approached from two interrelated directions:

- internal state processing and ontologies for representing knowledge
- interaction protocols - standards for specifying communication of tasks

Agent systems are used to model real world systems with concurrency or parallel processing.

- Agent Machinery - Engines of various kinds, which support the varying degrees of intelligence
- Agent Content - Data employed by the machinery in Reasoning and Learning
- Agent Access - Methods to enable the machinery to perceive content and perform actions as outcomes of Reasoning
- Agent Security - Concerns related to distributed computing, augmented by a few special concerns related to agents

The agent may decide to take an action based on the new content; for example, to notify the user that an important event has occurred. This action is verified by a security function and then given the authority of the user. The agent makes use of a user-access method to deliver that message to the user. If the user confirms that the event is important by acting quickly on the notification, the agent may also employ its learning machinery to increase its weighting for this kind of event.

6. Negotiation

After the estimation of a particular home construction, the system provides the cost negotiation between the owner's budgeted amount of the construction and the system's calculated estimation.

6.1. Negotiation Agent

Accept the owner's budgeted amount
Accept the system's estimated amount
Calculate the difference between the amounts
Repeat
If difference > 10% of the system's estimated amount then
Ask for the owner to increase the amount
Until the difference < 10% of the system's estimated amount (or) the owner refuse the increment of his budget
If the new budgeted amount < the estimated amount then
Repeat

Reduce the material cost by 2%
Calculate the new estimation of construction
Until the new estimation < the budgeted amount

7. Basic knowledge of home construction

The estimation is based on the cost material, cost of labour and other cost such as engineer cost. To calculate the estimation, the basic standard rate of material usage, the basic labour rate and the percentage of other cost are also applied in this system. Another important aspect is the particulars of the home construction which means the basic activities of the home construction.

The examples of particulars are

- Earthwork excavation for foundation
- 9" thick (1:3:6) cement concrete for foundation
- Brick work in (1:3) cement motor for reinitiating wall in foundation
- 4.5\" thick brickwork in (1:3) cement motor for brick wall
- C.G.I sheet roofing
- Brick laid flat in flooring in cement motor (1:3)
- (1/2)" thick (1:3) cement concrete floor

The examples of basic standard rate of material usages for home construction are

- The 100 cubical feet of the particular – 9" thick (1:3:6) cement concrete for foundation – requires 13 bags of cement, 0.5 suds of sand and 1 suds of aggregate.
- The 100 cubical feet of the particular – Brick work in (1:3) cement motor for reinitiating wall in foundation – requires 550 numbers of brick, 3 bags of cement and 0.1 suds of sand.
- The 100 cubical feet of the particular – 4.5\" thick brickwork in (1:3) cement motor for brick wall – requires 350 numbers of brick, 3 bags of cement and 0.1 suds of sand.
- The 100 cubical feet of the particular – Brick laid flat in flooring in cement motor (1:3) – requires 345 numbers of brick, 7 bags of cement and 1.5 suds of sand.

The estimation cost of home construction is calculated the current rates of materials in accordance with the above standard rates. For example, let the current rate of a bags of cement is 7000 kyats. The cubic content of foundation (5x60x0.75) is 225 cu-ft. This means one side of the foundation.

The basic standard rate for that foundation is 13 bags per 100 cu-ft. The number of bags requirement will be nearly 30 bags of cement. Therefore, the estimate cost of cement only for that foundation will be 210,000 kyats. All of the material requirements for the project need to be calculated items by items.

The next consideration is the labour resource. There are also some basic standard rates of labour in home construction. This type of cost mainly depends on the current rates of labour.

The other costs for home construction includes the engineer cost , five percent of the total of material and labour cost, the supervisor cost, three percent of the total of material and labour cost and the security cost for project area, two percent of total of material and labour cost.

8. Related work

X.Zhang and V.Lesser solved the problem of negotiation in a complex organizational context. An integrative negotiation mechanism was introduced, which enables agents to dynamically select a negotiation attitude based on the degree of external directedness. Experimental work explored the question of whether it always improves the organization's social welfare to have an agent be completely externally-directed when negotiating and making choices. Results showed that there were situations in which it was better for the organization if agents were partially externally directed in their negotiations with other agents rather than completely externally-directed. They discussed the driving factors behind this unexpected result. They introduced an integrative negotiation mechanism that enables agents to interact over a spectrum of negotiation attitudes from completely self-directed to completely externally directed in a uniform reasoning framework. The agent could not only choose to be self-directed or externally-directed, but also could choose how externally directed it wants to be. Introducing this mechanism in the agent framework also strengthens the capability of multiagent systems to model human societies. Multi-agent systems were important tools for developing and analyzing models and theories of interactivity in human societies. There were many complicated organizational relationships in human society, and every person plays a number of different roles and was involved in different organizations. A multi-agent system with that integrative negotiation mechanism was an ideal testbed to model human society and to study negotiation and organization theories [7].

Negotiation is commonly required to reach a final contractual agreement in construction material procurement. However, even simple negotiations often result in suboptimal agreements, thus 'leaving money on the table.' An automated system that could evaluate bids, negotiate to finalize the bid, and value the individual characteristics of negotiating parties would be useful to both contractors and

suppliers. They studied examines common negotiable issues and options for construction material procurement, and presented an agent-based system, named C-Negotiators, that helps a contractor and suppliers to negotiate via the Internet. Genetic algorithm was used to find the most beneficial agreement for all parties, and web-based implemented was used to improve negotiation efficiency. Experiments also were conducted and demonstrated that C-Negotiators improved negotiation efficiency by saving negotiation time and cost, and improved negotiation effectiveness by suggesting a better agreement with higher joint payoff. The application of the system was mainly limited by its symmetric optimization, while procurement negotiations in the construction industry were biased towards the contractor, and also by user comfort with their preferences and negotiations being monitored by the system [2].

9. System Design

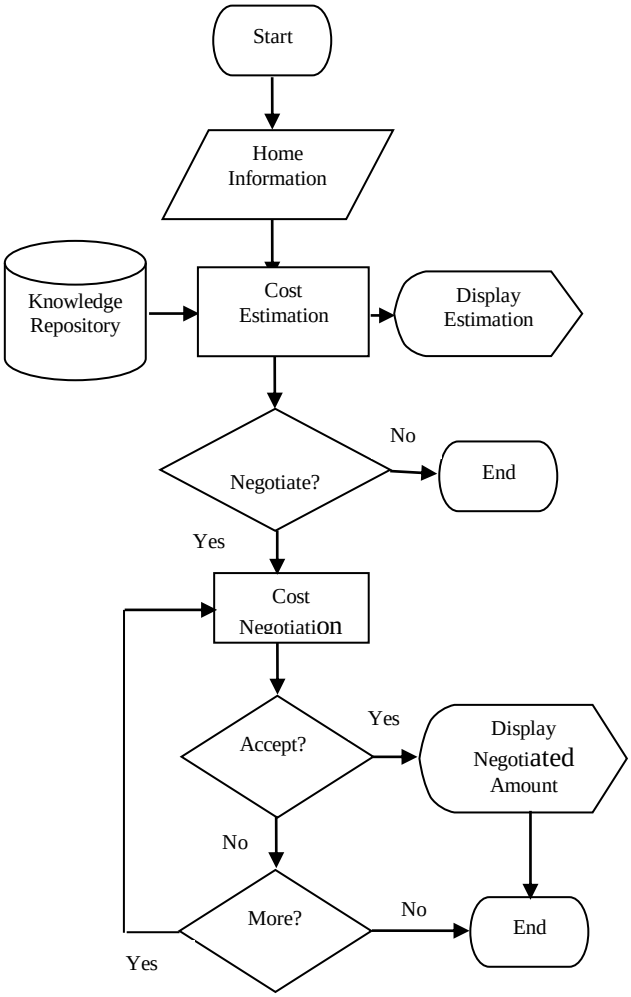

Figure 1. System flow diagram

10. Implementation of the system

The implementation of the system can be divided into three main portions: File, Estimation and Negotiation.

10.1. File menu

The "File" menu implements the essential requirements of home construction.

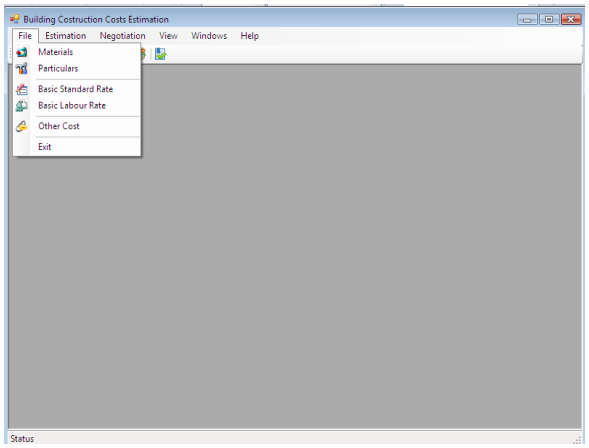

Figure 2. File Menu of the cost estimation and negotiation system

10.2. Estimate menu

The "Estimation" menu accepts the user inputs of home construction, such as the owner name, address, detailed measurements of the home and so on. Then the system calculates the estimation of the construction based on the above input data using the civil engineering techniques.

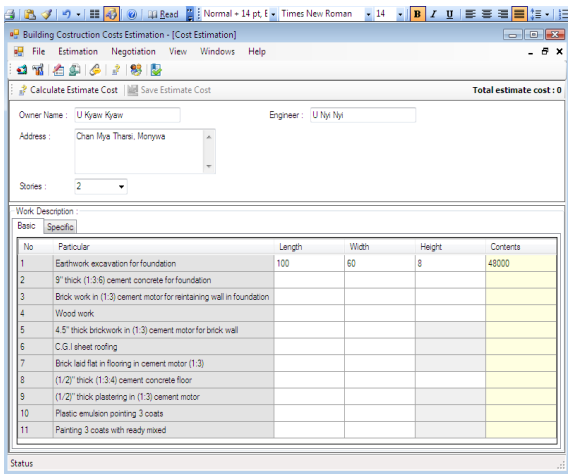

Figure 3. Calculate Estimate Cost of the cost estimation and negotiation system

10.3 Negotiation menu

If the owner would like to negotiate the estimation cost of his home construction, the engineer, or the contractor, can execute the "Negotiation" menu under some constraint of the system.

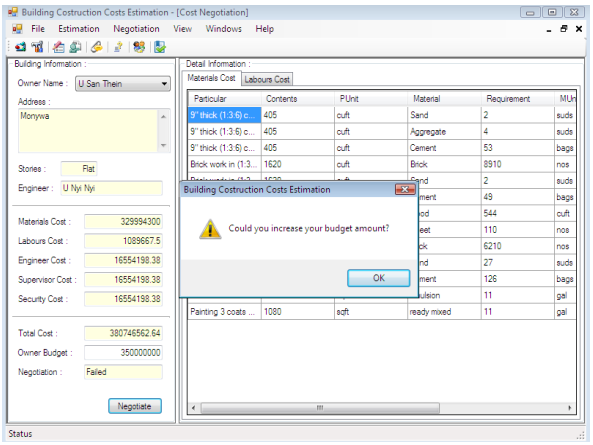

Figure 4. Negotiation process of the system

11. Conclusion

This paper studies a simple and efficient decision support system based on the civil engineering techniques and the software agent technology. This system is easy to implement, acquiring the basic home construction knowledge and the help of civil engineer. This system allows the users to assist the calculation of cost estimation and the negotiation with the person who would like to build a home. As a computer-based software system, the advent of agent technology supports as a type of simple reflex agent. The system also runs the agent capabilities of reactivity and social ability by implementing the cost negotiation with the homeowner. This is also an interactive system by means of iterative negotiation. Using this system, the engineer can be easily calculated the cost estimates of the Home structure. This system can avoid the errors that can have saved by using manual operation. Then, the result of cost estimate can be retrieved quickly by using this system. So, this system is flexible computer and user for construction estimation.

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