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A Model for Bidding Markup Decisions Making based-on Agent Learning

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***Abstract*—**Bidding is a very important business function to find latent contractors of construction projects. Moreover, bid markup is one of the most important decisions for a bidder to gain a reasonable profit. Since the bidding system is a complex adaptive system, bidding agent need a learning process to get more valuable knowledge for a bid, especially from past public bidding information. In this paper, we proposed an iterative agent leaning model for bidders to make markup decisions. A classifier for public bidding information named PIBS is developed to make full use of history data for classifying new bidding information. The simulation and experimental study is performed to show the validity of the proposed classifier. Some factors that affect the validity of PIBS are also analyzed at the end of this work.

***Keywords*—**bidding markup, decision making, agent learning, information similarity.

I. INTRODUCTION

BIDDING is an important function performed by construction contractors which involves two crucial decisions. Those are the decisions of whether or not to bid for a project and bid markup. Once a contractor decides to bid on a project, she/he needs to decide on bidding price based on her/his estimation of construction cost and profit. Each contractor attempts to offer a price that maximizes the chance of winning the project with a reasonable profit. Winning project contracts is the starting point for contractors to gain profit. Although the profit contained in bidding price is an unrealized profit, it is the base of future actual profit. Therefore, bidding markup decision is very important to contractors.

So far, quite a few strategy models for bid markup decision have been proposed [1]-[5]. However, most of these models ignore the complexity and adaptation of bidding decisions. Moreover, bidding activities are not considered as a system in these works. Based upon theories of complex and adaptive bidding system, the paper proposed a new model focusing on the effect of adaptation of bidder on bidding markup decisions.

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II. ANALYSIS OF BIDDING SYSTEM BASED ON CAS

Complex Adaptive System (CAS) [6], which is the outcome of thinking the discipline of system evolutionary process, was first put forward formally by Holland in the 10th anniversary of the Santa Fe Institute. According to CAS, the members in a system are adaptive agents, and every agent is interactive with environment and other agents, during which agents are continually learning and gaining experience which is the basis for agents to change their behavior and structure. The most significant character of CAS is adaptation which is the source of system complexity. That is also explained as “adaptation builds complexity”.

Contractor’s bidding system is a CAS. The two decisions involved in the tendering process are considered complex, which roots in uncertainty of consequences of each alternatives due to too much risks during construction process and the large number of factors affecting these decisions which is supported by many research results. Ahmad and Minkarah presented 31 factors affecting the bid decision by conducting a questionnaire survey among general contractors from top 400 general contractors in the United States [1]. Shash identified 55 factors characterizing the bid decision-making process through a questionnaire survey in the United Kingdom [7]. A competitive bidding strategy model proposed by Fayek presented more than 90 factors that may influence the choice of margin size [8]. In addition, bidding process is also complex. Generally, bidding construction projects has to follow certain procedures, including,

(1) getting bidding documents,
(2) analyzing the documents,
(3) field surveying the bidding project,
(4) making decision of bidding price,
(5) determining bidding strategy,
(6) preparing for tender materials, and,
(7) submitting a tender.

It is not a linear process as it seems to be. As shown in Fig. 1, the bidding price often needs to be adjusted according to experience, newly learned information about competitors or owners, and price change by negotiating with subcontractors and suppliers. Even before the final successful bidder is determined, the seller may negotiate with several potential winning bidders about price or other related problems. And the bidder has to readjust price based on newest information. Therefore, the bidding process is a non-linear process full of

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feedback and interaction.

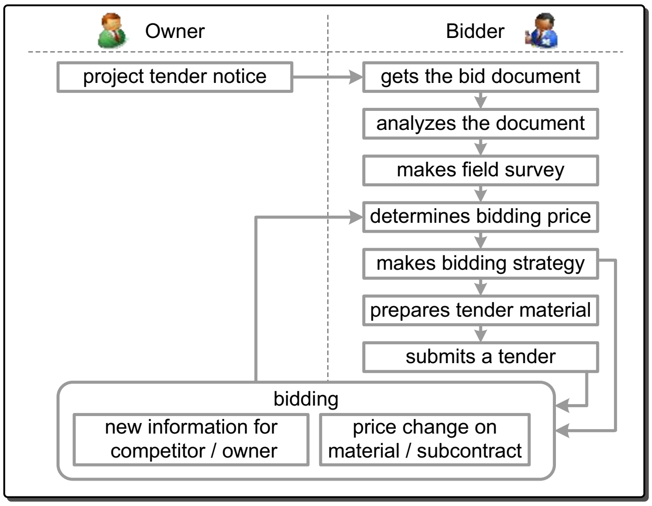

Fig.1 Iterative process of bidding on project

Meanwhile, the bidding system is adaptive. As a subsystem of the whole organization system, bidding system needs to continually adjust itself to adapt to the change of other units within the organization. For example, it adapts to leaving or joining of a critical person or crew carrying out by personnel resource unit. Also bidding system needs to adjust its estimate for project cost when project management unit increase productivity. Simultaneously, bidding system is adaptive to external environment, including market competition and collaboration with other organizations. Therefore, bidding system is considered as a complex and adaptive system.

III. Bid Pricing Model with Auction Theory

A first-price sealed-bid auction is a form of auction where bidders submit one bid in a concealed fashion. The submitted bids are then compared and the person with the highest bid wins the award, and pays the amount of his/her bid to the seller. Whether a bidder wins the object for sale depends on his/her own bid price and other bidders' price. Construction project bidders also submit their sealed bid to seller who compare all of bids and award the contract to lowest bid. So the process of construction project auction is reverse form of a first-price sealed-bid auction.

Auctions have traditionally been divided into two categories, namely, private value auctions and common value auctions. In private value auctions, bidders know their own value for the commodity with certainty but are unsure about others' valuations. In contrast, common value auctions pertain to situations in which the object for sale is worth the same to everyone, but bidders have different private information about its true value. Most real-world auctions, however, are not exclusively common value or private value.

During the process of construction project auction, the seller release common information by providing project documents and field survey. The bidders estimate the common cost component V according to this information. At the same time, construction plan, state of technology level and productivity which are different in different construction organizations are related factors to estimate cost. Bidders get private cost component ci based on this private information. Therefore, the estimated project cost C consists of two parts: private cost and common cost $C=V+c_i$. There are n ($n\geq 3$) risk neutral bidders who compete for a construction contract. Each one of the n bidders has an unbiased estimate v_i of the true common cost. The common cost component is modeled here as the average of the bidders' estimates, i.e.,

$$V=\sum_{i=1}^{n}\frac{v_i}{n} \tag{1}$$

The private and common cost estimates are identically and independently distributed across bidders.

A bidder who is awarded a contract at a bid of b_i receives a net profit of $p=b_i-c_i-V$. Assumption that price of bidder i is his/her cost increasing function $b_i=B(c_i)$, which is consistent with the real world because each rational bidder will raise his/her bid price when his/her estimate cost increase. When price of bidder i is lower than other n-1 bidders, bidder i is a successful bidder. To simplicity, we assume that there is only one lowest bid price. $S_i(b^{-1}(b_i))$ is the probability of bidder i who is winning the contract.

$$\begin{aligned} S_i(b^{-1}(b_i)) &= \prod_{j\neq k}\mathrm{prob}[C_k > b^{-1}(b_i)] \\ &= \prod_{j\neq i}\left[1-\mathrm{prob}[C_k < b^{-1}(b_i)]\right] \\ &= \left[1-b^{-1}(b_i)\right]^{n-1} \\ &= \left[1-F\left(\frac{C_i-C_L}{C_H-C_L}\right)\right]^{n-1} \end{aligned} \tag{2}$$

Optimal bidding pricing strategy of bidder i is maximize his/her expected profit.

$$\mathrm{Max}\,\pi_i=\left(b_i-c_i-\sum_{i=1}^{n}\frac{v_i}{n}\right)\left[1-F\left(\frac{C_i-C_L}{C_H-C_L}\right)\right]^{n-1} \tag{3}$$

IV. The Learning Mechanism of Bidder Agent

Every bidder is an adaptive agent in bidding system, which means that the behavior of each agent is adaptive to system objective and change of system resources and environment. Learning is the basic capability of agent and the foundation of adaptation. The result of learning acts on the structure and behavior of system and adaptation is realized. As illustration above, common cost component and private cost component are relatively fixed. The profit, difference between bidding price and estimate cost, is the key of bidding decision, which learning of agent focuses on.

Generalized learning is a complex process including information retrieval, knowledge discovery, and/or decision

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making. Basically, the learning model of a bid agent includes a series of features/functions, such as classifying, storing, analyzing and optimizing, as illustrated in Fig. 2.

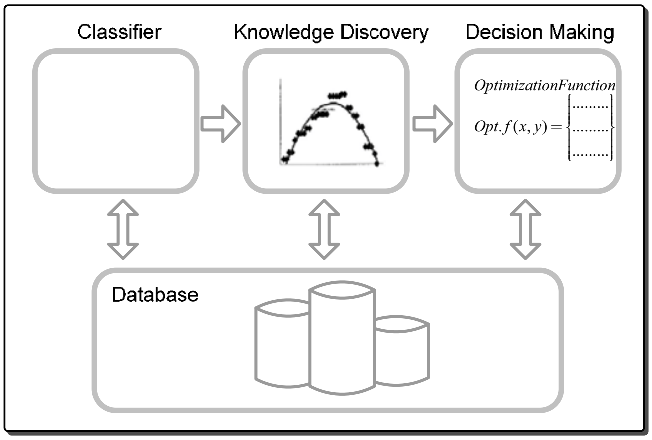

Fig. 2 Main features of the learning process

Firstly learning is started with classifying the information into different groups according to specific criterion, with the aids of a classifying function. And the classified information is stored in a particular form secondly. When a decision needs to be made, the stored information is analyzed and new knowledge is formed to support the decision.

Agent of a bidding system can optimize the bid markup decision through such a learning process. Agent needs to collect history bidding information and then classify this information according to its attributes, and store it into the database. Next agent finds the characteristic of bid price of each group through carefully analysis. When agent faces a new markup decision, she/he needs to search the right group whose attributes is most similar to the new bidding. Based on the characteristic of bid price of the compared group, the new markup decision can be improved. As a result, the learning process is also iterative.

In the next section a kind of information similarity classifier is introduced, which can accurately find the group possessing the most similar information attributes to a new bidding.

V. Classifier of Information Similarity

Suggest $\boldsymbol{X}$ is the set of attributes of bids on building projects, i.e., $X=(x_1, x_2, \dots, x_m)$ is a space with m dimensions. Meanwhile, $\boldsymbol{V}$ is a vector with values on these dimensions indicating to public information of a bid, namely, $\boldsymbol{V}=(v_1, v_2, \dots, v_m)$. To be noted that each value of $\boldsymbol{V}$ is in uniform distribution on the interval [-b, +b].

As mentioned above, the bidding agent should analyze the bidding information of a building project within the learning process. Only for the current bidding information has same attributes with history bidding information, is the learning process executed properly and valuably. Within the history information, two bids are called relational if the two bidding information have same values on same attributes. The relational attributes and values of bidding information are called partial information of the data set.

Similarity is one of the key statistical factors to measure the relativity of variables. For relational bidding information, if the two bids have more similarity on public attributes and values, they have more interdependency on reference and probability of a same category.

Based on above analysis, an algorithm is proposed in this work for classifying Partial Information of Bids with their Similarities, namely, PIBS.

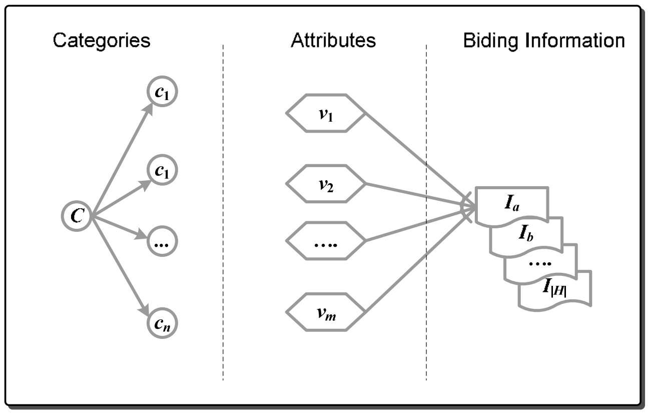

Fig. 3 The physical description of variables in PIBS

Firstly, the similarity of information for two bids is figured out by the cosine similarity function, i.e.,

$$sim(I_a, I_b)=\sum_{j=1}^{m} v_{aj} v_{bj} \Big/ \sqrt{\sum_{j=1}^{m} (v_{aj})^2 \sum_{j=1}^{m} (v_{bj})^2} \qquad (4)$$

where I_a and I_b indicate two bids that have relational bidding information; v_{aj} and v_{bj} are the values of j^{th} attributes for the two bids a and b respectively; $j=(1,2,\dots m)$, m is the amount of disclosed attributes of bids.

It can be drawn from formula (4) that the two bids are more similar if the two vectors (I_a, I_b) are more close to each other.

Secondly, a new bidding information can be categorized with and into the classified data set. However, the data set should be well established with an initialized process for classifying history information.

Suggest $\boldsymbol{H}$ is the data set of disclosed historical information and is initially classified into n categories, i.e., $C=(c_1, c_2, \dots, c_n)$. Traverse the categories of data set $\boldsymbol{H}$ to find a most relative set c_k $(1 \le k \le n)$ for the to-be-classified information I. This task can be accomplished with the probability function $P(h_k|I)$, i.e., the probability of bidding information I being categorized into c_k, as shown in (5).

$$P(c_k \mid I)=\frac{1}{|c_k|}\sum_{j=1}^{|c_k|} sim(I, I_j) \qquad (5)$$

where I_j is the history bidding information classified into the category c_k, and $|c_k|$ is the amount of bidding information which is classified into c_k.

The probability function $P(c_k|I)$ shows the average similarities of the to-be-classified information I and all bidding

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information I_j within the category c_k. The category for I can be get when traversing c_k to find the maximum $P(c_k|I)$.

Finally, the PIBS algorithm is developed by calling above two functions shown in (4) and (5), as follows.

```
// PIBS Algorithm
Input:    History bidding information, (H)
          Initialized categories, (C)
          New biding information, (I);
Output:   Category of I, (c(I));
     initialize Probability List L;
     initialize Dataset D;
     for j=1, j<=|H|, j++ {
       if corre(I,I[j]) then I[j]→D;
     }
     for l=1, l<=|D|, l++ {
       calculate sim(I,I[k]) with (4);
     }
     for k=1, k<=|C|, k++ {
       calculate P(c[k]|I) with (5);
       P(c[k]|I)→L[k];
     }
     sort L
     c(I)=c[x] where L[x]=max{L};
     end of PIBS
```

The bidding agent may find valuable references with PIBS to figure out pricing strategies of the new bid from his/her history bidding information. Due to the limitation of space, the optimization process of bidding markup decision is out of the scope of the paper.

VI. Simulations and Results

In this work, we reference Liu and Ling's most important attributes affecting markup estimation proposed in [4] to generate the data set for simulations and experimental study. The 52 attributes of bidding information were organized into seven classes, i.e., Project characteristics, Project documents, Company characteristics, Bidding situation, Client characteristics, and Consultant characteristic.

Seven data sets of bidding information are generated with different amount of category, attribute, and data record. The values of all public attribute for bidding information are normalized, i.e., they are in uniform distribution on the interval [0, 1]. The data sets used for simulation are summarized in Table I.

TABLE I
Summary of Original Date Sets Used for Simulation

Data Set	Amount of Attribute	Amount of Category	Amount of History Records	Amount of To-be-Classified Samples
1	8	4	60	20
2	12	6	120	20
3	18	8	260	20
4	18	12	300	40
5	24	16	360	40
6	36	20	450	80
7	52	24	550	80

In the process of simulating, the original data sets in Table I are filtered to several series of date sets with linearly increasing Amount of Attribute (m) and Amount of Category (n) respectively. The simulation is performed by Matlab v7 on Windows platform. The simulating result is shown in Fig. 4.

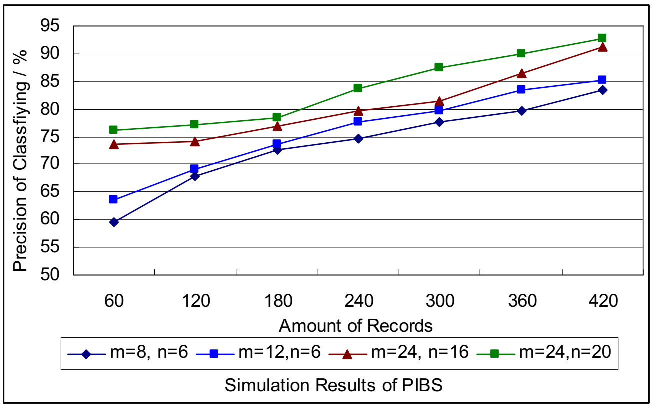

Fig. 4 Validity of PIBS with different amount of data record, attributes and categories.

It can be seen from Fig. 4 that the Amount of Attributes in bidding information is the primary factor for the validity of PIBS, and the Amount of Category is secondary factor. Meanwhile, the average amount of information in each category is also a factor should being taken into account.

VII. Conclusion

In the paper we proposed an agent learning model for bidding markup decision. The model is based upon iterative process that includes features as classifier, data storing, knowledge discovery and decision making. We developed a classifier named PIBS for analyze bidding information to manifest markup decision making in the proposed model. The simulation work is performed to show the validity of PIBS with some factors. In our future work, the optimizing model for pricing on bidding will be further explored, as well as new knowledge discovery method applying on this domain.

Acknowledgement

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References

[1] I. Ahmad, and I. Minkarah, "Optimum mark-up for bidding: a preference-uncertainty trade-off approach," Civ. Eng. Syst, vol. 4, pp.170-174, 1987.
[2] I. Carr, "General bidding model," J. Construct. Div., vol.108, pp.639-650, 1982.
[3] K. Mochtar, and D. Arditi, "Pricing strategy in the U.S. construction industry," Construct. Manag. Econ., vol. 19, pp. 405-15, 2001.
[4] M. Liu, and Y. Ling, "Modeling a contractor's markup estimation," J. Civ. Eng. Manag., vol. 131, pp. 391-399, 2005.
[5] M. Skitmore, and J. Pemberton, "A multivariate approach to construction contract bidding markup strategies," J. Oper. Res. Soc., vol. 45, pp. 1263-1272, 1994.
[6] J. Holland, "Complex adaptive systems," Daedalus, vol. 121: pp. 17-30, 1992.
[7] A. Shash, "Factors considered in tending decisions by top UK contractors," Construct. Manag. Econ., vol. 11, pp. 111-118, 1993.
[8] A. Fayek, "Competitive bidding strategy model and software system for bid preparation," J. Constr. Engrg. Mgmt., vol. 124, pp. 1-10, 1998.