Journal of Business Economics and Management
www.jbem.vgtu.lt
2010, 11(2): 227–242

COGNITION DRIVEN FRAMEWORK FOR IMPROVING COLLABORATIVE WORKING IN CONSTRUCTION PROJECTS: NEGOTIATION PERSPECTIVE

Xiaolong Xue[1], Yingbo Ji[2], Lin Li[3], Qiping Shen[4]

[1, 3]Department of Construction and Real Estate, School of Management,
Harbin Institute of Technology,
P. O. Box: 1251, No. 13, Fayuan Street, Harbin 150001, China
[2]School of Economics and Management, North China University of Technology,
Beijing 100041, China
[1, 4]Department of Building and Real Estate, Hong Kong Polytechnic University,
Hung Hom, Kowloon, Hong Kong, China
E-mails: [1]xlxue@hit.edu.cn; [2]yingboji@yahoo.com.cn;
[3]lilin5865566@163.com; [4]bsqpshen@polyu.edu.hk

Received 2 March 2009; accepted 26 February 2010

Abstract. Negotiation is the popular collaborative decision-making behavior in inter-organization systems, especially in the collaborative working in construction projects (CWCP). However, negotiation has long been recognized as a critical but time- and energy-consuming process. The lack of an effective framework to improve the efficiency (performance) of negotiation is a major problem for those seeking to enhance the efficiency and effectiveness of collaborative working in construction projects. This paper aims to develop a cognitive mapping-based application framework for improving collaborative working in construction project from negotiation perspective (CF-CWCP). This framework includes two-fold: (1) mapping negotiation process in construction projects using cognitive mapping technique; (2) developing CF-CWCP by integrating intelligent agent and cognitive mapping techniques. This research will benefit the partners in construction projects to improve construction negotiation performance. A prototype of CF-CWCP is developed.

Keywords: cognitive mapping, collaborative working, negotiation, construction project.

Reference to this paper should be made as follows: Xue, X.; Ji, Y.; Li, L.; Shen, Q. 2010. Cognition driven framework for improving collaborative working in construction projects: negotiation perspective, *Journal of Business Economics and Management* 11(2): 227–242.

1. Introduction

Due to the increasingly complicated processes, the changing business and technology environments, and the involvement of many partners (Schieg 2009), negotiation, as the most important feature of the collaborative decision-making process involving partners with different cultures and goals, becomes very complicated and time-consuming in CWCP (Xue *et al*. 2009). There are several major obstacles hampering efficient negotiation decision-making in CWCP, for example, all partners as rational economic man

ISSN 1611-1699 print/ISSN 2029-4433 online doi: 10.3846/jbem.2010.11

involved in CWCP, look to pursue their own benefits with conflicting goals (Raiffa *et al.* 2002), inadequate negotiation knowledge (Ren and Anumba 2002), adversarial collaborative relationships (Peña-Mora and Wang 1998), diversity of intellectual and intercultural background of negotiating partners (Cheng *et al.* 2006; Saee 2008), complex interactions (Choudhury *et al.* 2006), the uncertainty and dynamics of the business environment (Cheng *et al.* 2006) and asymmetric information between negotiating partners (Cheung *et al.* 2004).

The lack of an effective framework to improve the efficiency of negotiation decision-making is a major problem for those seeking to enhance the efficiency and effectiveness of CWCP (Cheng *et al.* 2006; Rau *et al.* 2006; Choudhury *et al.* 2006). Although previous research projects (Nwana 1996; Ren and Anumba 2004; Dzeng and Lin 2004; Eden and Ackermann 2004; Giordano *et al.* 2005) reveal the great potential of intelligent agent technology and cognitive mapping techniques in supporting negotiations, very little research has been done into attempts to integrate them into a systematic approach which would greatly enhance the efficiency of negotiations in CWCP. This research targets the development of a cognition driven framework for improving negotiation performance in CWCP through integrating intelligent agent technology and cognitive mapping techniques.

2. Theoretical background

2.1. Cognitive mapping technique and its application to facilitate negotiation

Cognitive mapping is based on "personal construct theory" (Kelly 1955) and has been developed following extensions to the use of "Repertory Grids", for the purpose of capturing a "personal construct system" (Eden 1988). The analyst using the technique of cognitive mapping seeks to elicit the beliefs, values and expertise of decision makers relevant to the issue in hand through interview or through the analysis and coding of documents. These are then captured as a model of the construct system represented as a cognitive map.

A cognitive map is composed of concept nodes of a target problem, signed directed arrows, and causality value between the nodes. Concept nodes represent concepts consisting of a given target problem, signed directed arrows, and causal relations between two concept nodes. Causality value means "+" and "–". The causality coefficient can be fuzzified into a real value between –1 and +1. Cognitive map with a causality coefficient "+" and "–" is sufficient for replicating human cognition, because decision makers typically do not use a more complicated set of relationships (Lee *et al.* 1992). Figure 1 presents an example of cognitive map of negotiator in construction claim (Li and Xue 2010). Cognitive map permits a rich representation of ideas, through the modelling of complex chains of argument as networks (Montibeller and Belton 2006).

Cognitive mapping has been found especially useful in solving unstructured problems, dealing with many variables and their causal relationships (Montibeller and Belton 2009).

Cognitive mapping have been used for distributed decision process modelling on the network, geographical information systems, the design of electronic commerce Web sites, knowledge management, decision analysis, business process redesign, complex war games, strategic planning problems (Noh *et al.* 2000). Using cognitive mapping is well known as a highly promising technique for capturing knowledge, especially tacit knowledge, as a means for constructing organizational memory, and is superior to common knowledge representation schemes such as rule and frame (Montibeller *et al*. 2008).

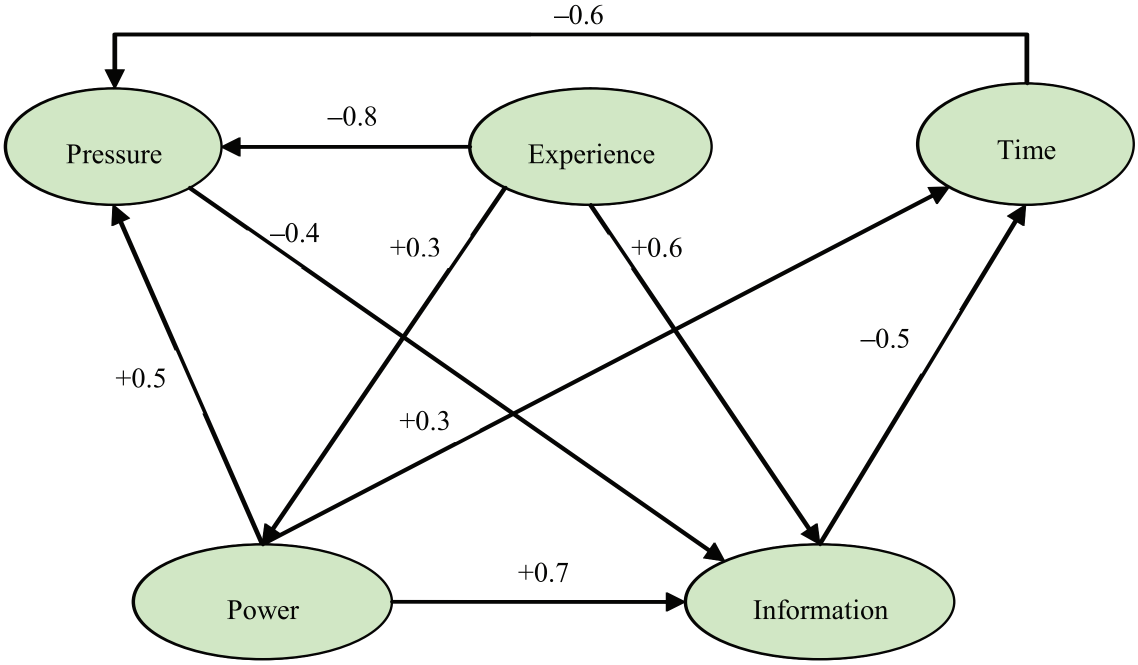

Fig. 1. An example of cognitive map of negotiator in construction claim

Cognitive mapping has been explored to facilitate negotiation (Eden and Ackermann 2004; Giordano *et al.* 2005). As Montibeller and Belton (2006) argued that the last stage of negotiation is to identify and agree to a set of potential strategic options. Using cognitive maps to evaluate the options and to understand their impacts on the goals could be helpful. Cognitive maps can be used to capture parts of the stakeholders' point of view and to enhance negotiation among individuals and organizations. Negotiators may find that cognitive mapping is a useful tool for helping them to prepare and engage in negotiation. At the pre-negotiation stage they can prepare for the talks by mapping out their own assumptions to explore the costs and benefits of alternative proposals, and they can construct cognitive maps of the other parties to the negotiation to anticipate their initial positions. Once the negotiations have begun, cognitive mapping can be used by negotiators to gain a better understanding of the statements and arguments of the other parties, as well as to provide a template for seeing how others comprehend their own position. Finally, the technique can be employed to help combine the positions of the various parties to the negotiation and create a package deal that can be described in a single text.

Although cognitive mapping has been investigated in negotiation in many initials, the most of them focus on public decision-making issues, such as water resources negotiation, international negotiation, B2B online negotiation, and policy analysis (Lee and Kwon 2006). It has not been applied for facilitating negotiation in construction projects. As Edkins *et al.* (2007) argued that projects are complex temporary entities. Less is known about the way that the management of a project is understood by those involved even though there are many systems and techniques used to progress project management. They initially explored a range of methodological approaches, drawn from the area of managerial and organizational cognition, employed to understand more fully and rigorously the broader attributes of the management of projects beyond the more execution orientated project management.

2.2. Alternative approaches to assisting negotiation in CWCP

Negotiation is a joint decision-making process of two or more parties working together to reach a mutually acceptable agreement over one or more issues (Cohen 2002; Saee 2008). In other words, it is a decision-making process where two or more participants jointly search for a consensus solution to the achievement of goals (Rosenschein and Zlotkin 1994). Negotiation can be classified into two broad categories: distributive negotiation, which usually results in a win-lose situation, and integrative negotiation, which results in a win-win situation (Raiffa *et al.* 2002). There are many factors impacting on the negotiation process and results, such as the knowledge and information about the issues negotiated, previous negotiation experience and cases, and communication skills and supporting tools (Li *et al.* 2007).

Negotiation is an important collaborative decision-making and coordination behavior in CWCP, which can take place at any stage and level of CWCP such as: resolving construction disputes and conflicts, making decision on construction materials and equipments procurement, developing collaborative planning or scheduling, obtaining consensus agreements, task and resource allocation, and deciding future collaborative strategy. Since negotiation in CWCP is so important, researchers have studied it from different perspectives of theory analysis and supporting tools. For examples, Peña-Mora and Wang (1998) developed a collaborative negotiation methodology to mediate the negotiation process of conflicts using Game Theory. Cheung *et al.* (2006) developed taxonomies of negotiation outcomes through a principal component factor analysis. Peña-Mora *et al.* (1993) developed a computer-supported conflict mitigation system. Cheung *et al.* (2004) developed a platform to improve communication between engineers to carry out negotiation task online.

Liou and Huang (2008) incorporated risk attributes of the BOT project into the formulation of a contractual-negotiation model. The proposed model allows the government and the sponsor to reach a consensus on the terms should the financial return as well as the risk of the project be determined. They suggested that the government and industry practitioners embody the risk attributes of the project in the automated contractual-negotiation model.

In addition, using intelligent agent or multi-agent system (MAS) technology to support negotiation in CWCP has attracted more attention. An agent is a self-contained program capable of controlling its own decision making and acting based on its perception of its environment, in order to one or more goals. An agent must possess any two of the following three behavioural attributes: autonomy, cooperation, and learning (Nwana 1996). MAS comprises a number of intelligent agents, which represents the real world decision makers and co-operate to reach the desired objectives. In MAS, each agent attempts to maximize its own utility meanwhile cooperates with other agents' to achieve their goals (Jennings *et al.* 1998). The main advantage of MAS is its responsibilities for acting various components of the engineering process or decision makers of the business process which is delegated to a number of agents. MAS are suitable for domains that involve interactions between different organizations with different objectives and proprietary information (Ren and Anumba 2004).

CWCP is one kind of typical MAS, which consists of general contractor agents, subcontractor agents, and supplier agents. MAS technology has been proved to be an effective tools to improve the performance of CWCP negotiations (Peña-Mora and Wang 1998; Ren and Anumba 2004; Dzeng and Lin 2004). Peña-Mora and Wang (1998) proposed a collaborative negotiation methodology and a computer agent named CONVINCER, which incorporates that methodology to mediate the negotiation of conflicts in large-scale civil engineering projects. Ren *et al.* (2003) developed a MAS facilitated system (MAS-COT) to tackle the very complex and dynamic construction claims negotiation. Kim and Paulson (2003) presented an agent-based compensatory negotiation methodology to facilitate the distributed coordination of project schedule changes wherein a project can be rescheduled dynamically through negotiation by all of the concerned subcontractors. Dzeng and Lin (2004) proposed an automated system that could evaluate bids, negotiate to finalize the bid and value the individual characteristics of negotiating parties which would be useful to both contractors and suppliers. They examined common negotiable issues and options for construction material procurement, and presented a web-based agent-based system that helps a contractor and suppliers to negotiate via the Internet. Genetic algorithm was used to find the most beneficial agreement for all parties.

2.3. Problems in the current negotiation in CWCP

Despite these early efforts, negotiation has not been studied very systematically in the project context, research lacks a common abstraction of the subject and there exists a serious gap in knowledge, for instance as to what frames of thought can assist project practitioners in crafting better agreements in CWCP (Murtoaro and Kujala 2007). Negotiation in CWCP is still a time- and energy-consuming process given the complex and dynamic nature of the CWCP and conflicting goals among all the partners involved (Cheng *et al.* 2006; Rau *et al.* 2006; Choudhury *et al.* 2006). In addition to the above economic rationality factors, there are various factors resulting inefficient negotiation, such as the diversity of the intellectual and intercultural background of the negotiating partners, complex interactions, inadequate negotiation knowledge of opponents (Ren and Anumba 2002), uncertainty, the dynamics of the business environment and asymmetric information between negotiating partners. The subjective behaviour in negotiation is also one of the crucial factors, which results in the complexity of negotiations in CWCP and also affects the efficiency of negotiations. As argued by Dzeng and Lin (2004), people often reach suboptimal agreements, thereby leaving money on the table in negotiation. Hence, the ability of partners to negotiate effectively is crucial for the success or failure of a project. The problem of how to effectively improve the efficiency of negotiations in CWCP remains unresolved in the current practice.

3. Cognition Driven Framework for Collaborative Working in Construction Projects

3.1. General Structure

The proposed CF-CWCP framework consists of three main stages, as shown in Fig. 2. Firstly, negotiation knowledge is formalized with the aid of cognitive mapping. In the second stage, the most appropriate cognitive map is retrieved by adaptation of the process of case-based reasoning (CBR) in the second stage. Finally, the cognitive map retrieved in the previous phase is applied to a new negotiation problem.

In our proposed framework, we adapt our previous multi-agent-based multi-attribute negotiation model (Xue *et al.* 2005) using fuzzy theory to find a compromised negotiation solution for a case with the aid of the negotiation cognitive map. Two newly proposed algorithm-retrieval and adaptation algorithms also need be developed. The retrieval algorithm can choose the most appropriate cognitive map for the negotiation from the case base, while the adaptation algorithm allows the cognitive map of negotiation to be properly updated to track the changes of negotiation environment to ensure the quality of negotiation cognitive map in CWCP.

CBR is a problem-solving paradigm in the field of artificial intelligent in which previous similar situations are retrieved and used to solve a new problem by reusing information and knowledge of that situation (Goh and Chua 2010). The typical problem–solving

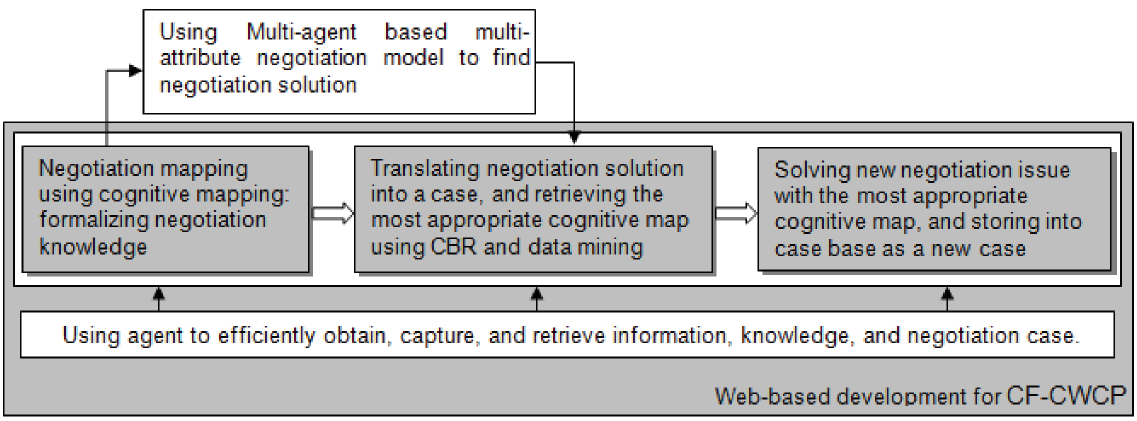

Fig. 2. The proposed structure of CF-CWCP

cycle of a CBR tool is based on five phases: retrieve, reuse, adaptation, review and storage. As described by Noh *et al.* (2000), CBR has many advantages for knowledge reuse as follows:

- It allows partners to propose solutions to problems quickly without need to derive those solutions from scratch. This provides organizational memory based intuition for a given problem, which can avoid any irregular or abnormal problem-solving process.
- It can provide a systematic mechanism for storing knowledge as cases and reusing them according to the characteristics of problems.
- Based on the past mistakes done by some partners in organization, CBR can alert partners to avoid repeating past mistakes.
- It can help partners point out what features of a problem are the important ones to remember during problem-solving.

Data mining can be broadly defined as the process of applying computer-based methodology, including new techniques for knowledge discovery, to data (Kantardzic 2003). It has been described as "the nontrivial extraction of implicit and potentially useful information from data" (Frawley *et al.* 1992).

Data mining is increasingly being used to extract information from the enormous data sets generated by modern technologies of computers, networks, video, camera, and sensors. Using data mining technique through design algorithms of information retrieve from formed cognitive maps, useful information or knowledge can be identified, and further as the concept nodes be added to the next cognitive map (as the new case) in CWCP.

3.2. Methodology

In order to achieve the specified research objectives, specific research methods will be adopted. Literature review and questionnaire survey will be a major approach to obtaining information on the negotiation process, attributes involved, causal relationships among the elements of the negotiation and tacit knowledge requirements. Focus group meetings will then be organised to verify the results of literature review and to further obtain valuable views about negotiation in CWCP from a group of carefully selected industry participants.

Action research will be used to iteratively develop and test the validity of the proposed framework in real negotiation in CWCP test bed. Action research is the process of systematically collecting research data on an ongoing system relative to some objective, goal, or need of that system; feeding these data back into the system based both on the data and on hypotheses; and evaluating the results of action by collecting more data (French and Bell 1999).

Action research is most appropriate for participants who recognize the existence of shortcomings in their activities and who would like to adopt some initial stance in regard to the problem, formulate a plan, carry out an intervention, evaluate the outcomes and develop further strategies in an iterative fashion (Gabel 1995). It is an approach where the researcher and industry partners collaborate in developing a diagnosis and solution to a problem.

It involves designing interventions in social processes and contributes to the stock of empirical knowledge from real-world situations (Fellows and Liu 2003).

Therefore, this method is very appropriate for examining the impact of using the proposed framework in negotiation process. Fig. 3 shows a conceptual framework of the use of these research methods, which is imbedded in the three tasks outlined in the framework of CF-CWCP, as described in the following sections.

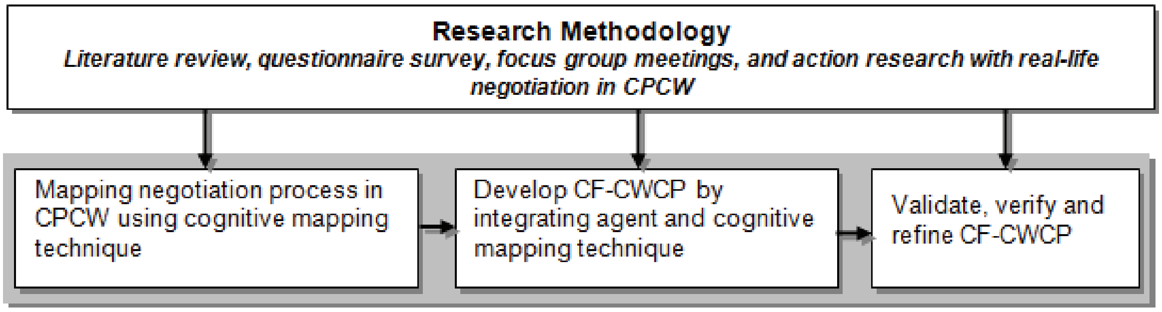

Fig. 3. Methodology for developing CF-CWCP

3.3. Mapping negotiation process

Mapping the negotiation process in CWCP aims to obtain the factors of the negotiation and the causal relationships among them. This mapping process covers the areas of the negotiation styles, negotiation attributes and factors, causal relationships among the negotiation factors, and negotiation flows. Questionnaires are issued to construction organizations, such as different scale construction enterprises, relevant departments of governments, consultants, and construction academic researches.

Focus group meetings with professionals in construction negotiation should also be conducted to obtain the above information, and to identify the key inhibitors and enablers in CWCP negotiations.

A standardized causal coefficient estimated in structural equation models (SEMs) will be employed to rationally and quantitatively retrieve the causal relationship among negotiation factors, especially subjective factors which affect the negotiation result, such as trust, emotion, pressure, culture, and to assist to create negotiation cognitive map in CWCP.

This task equips the knowledge of the latest developments and practices of negotiations in CWCP and with a good understanding of negotiation processes. Based on the above survey and review, the negotiators' requirements will be identified; and an illustrative cognitive map of negotiations in CWCP will be addressed by using cognitive mapping techniques. This map identifies negotiation flows, negotiation attributes and factors and the causal relationships among negotiation factors. Also, it will formalize knowledge about negotiations in CWCP.

3.4. Integrated method to develop CF-CWCP

Based on the negotiation cognitive map of CWCP in the previous phase, CF-CWCP will be developed using an agent-development toolkit, ZEUS, which should be capable of improving negotiation efficiency among partners in CWCP. ZEUS is an open-source advanced development toolkit for constructing distributed multi-agent applications (PLC BT 1999). For this purpose, CF-CWCP should have two basic functions.

One is identifying and representing the factors, flows, knowledge, concepts, and relationships in negotiation. The other is efficiently obtaining, capturing, saving and retrieving information and knowledge about negotiation and the negotiation process from previous negotiation experience. The first function of CF-CWCP can be met using cognitive mapping techniques.

The issue is how to meet the second function. In order to resolve this issue, we will employ intelligent agent technology to develop CF-CWCP based on the negotiation cognitive map obtained. The negotiation cognitive map compensates for the limited ability of the agent in dealing with the changing environments during negotiation (Ren and Anumba 2002; Cheng *et al.* 2006; Rau *et al.* 2006; Choudhury *et al.* 2006). Web-based development of CF-CWCP will also be used to improve negotiation efficiency. The details for how to develop CF-CWCP can be seen in section 3.1, as shown in Fig. 2.

3.5. Prototype of CF-CWCP

An initial prototype of CF-CWCP is developed by using cognitive mapping technique to meet the first function of representing the factors, flows, knowledge, concepts, and relationships in construction negotiation.

Assuming that there are five factors: pressure, experience (Fong and Kwok 2009), time, power (Singh 2009), and information (Schieg 2008), which affect the performance in construction negotiation. The cognitive map of relationships among these factors is shown in Fig. 1.

To get the information on factors' significance in negotiation) of five factors in construction negotiation, the cognitive map can be represented as an $n \times n$ (here, $n = 5$) adjacency matrix (denote matrix A), where n is the number of factors in cognitive map. The element of A, a_{ij} , is the value of the direct causal relationship from factor i to j. If there is no relationship, $a_{ij} = 0$. The relationship matrix is presented in Table 1.

Table 1. Relationship matrix of negotiation factors

ID (Factors)	1	2	3	4	5
1 Pressure	0	0	0	0	–0.4
2 Time	–0.6	0	0	0	0
3 Experience	–0.8	0	0	+0.3	+0.6
4 Power	+0.5	0	+0.3	0	+0.7
5 Information	0	–0.5	0	0	0

All direct and indirect relationships among factors can be calculated from the direct effects matrix by (Ülengin *et al*. 2010):

$$T=\sum_{k=1}^{n-1} A^k .$$

In the case of this research,

$$T=\begin{matrix} Pressure \\ Time \\ Experience \\ Power \\ Information \end{matrix}\begin{bmatrix} -0.12 & -0.35 & 0 & 0.2 & 0 \\ 0.3 & -0.12 & 0 & -0.44 & 0 \\ -0.36 & 1.02 & 0 & -0.45 & 0.3 \\ -0.53 & 0.24 & 0 & -0.12 & 0 \\ -0.47 & 0.49 & 0 & 0.01 & 0 \end{bmatrix}$$

In matrix T, sum of absolute value of numbers in row *i* indicates the significance of corresponding factor, denoting s_i :

$$s_i=\sum_{j=1}^{n-1} | t_{ij} | .$$

Then, the significance vector $s=(s_1,s_2...s_n)$ is driven. In this example, the significance vector of five factors is shown as s = (0.67, 0.86, 2.13, 0.89, 0.97). The results indicate that experience, which followed by information, plays the most important role in construction negotiation.

The order of significance of other factors is power, time, and pressure. The significance information of factors offers decision support to help negotiator focus on the most important matter in the process of negotiation. For example, in this case, the negotiator should pay more attention to use their experience and gather more information to improve negotiation performance.

Based on above analysis, the prototype system to meet the first function of CF-CWCP is developed, which is called cognitive map based negotiation decision support system. Figure 4 presents a snapshot of the prototype system.

This prototype system can help negotiator to form a cognitive map in construction negotiation through enter start node, end node, and their weight of relationship (interactive influence). Figure 5 presents the cognitive map of negotiation which is produced by the prototype system. The prototype system also integrates above reasoning method of cognitive map to help negotiator get factors' significance in construction negotiation, as shown in Figure 6.

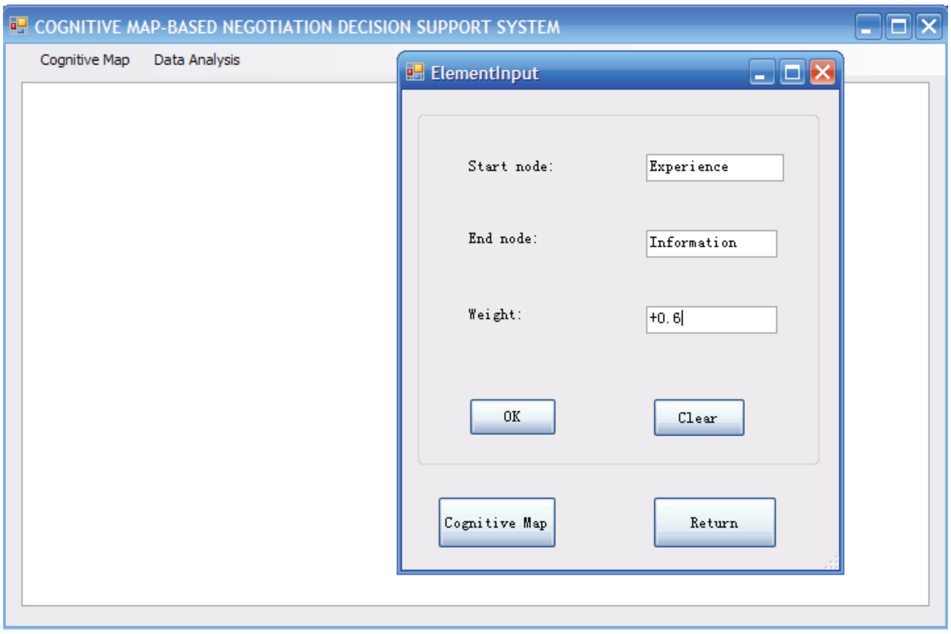

Fig. 4. Prototype system of CF-CWCP

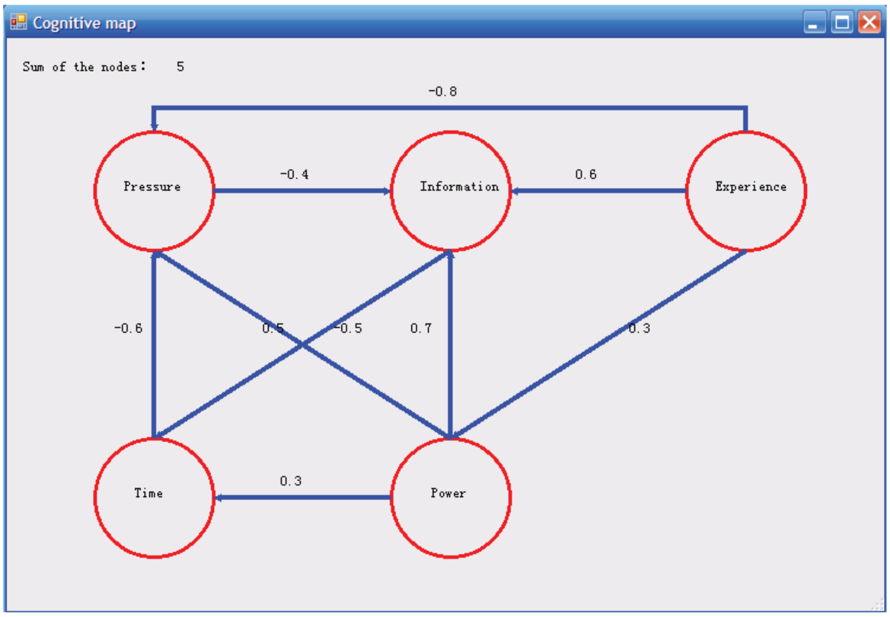

Fig. 5. A cognitive map produced by the prototype system

3.6. Validation of CF-CWCP

In order to validate, verify, and refine the proposed framework of CF-CWCP, we suggest selecting typical international construction projects and applying CF-CWCP to facilitate real-life negotiation issues. This is conducted in the form of participatory action research, to fully utilize this highly rigorous, yet reflective, approach (Berg 2001). Feedback and

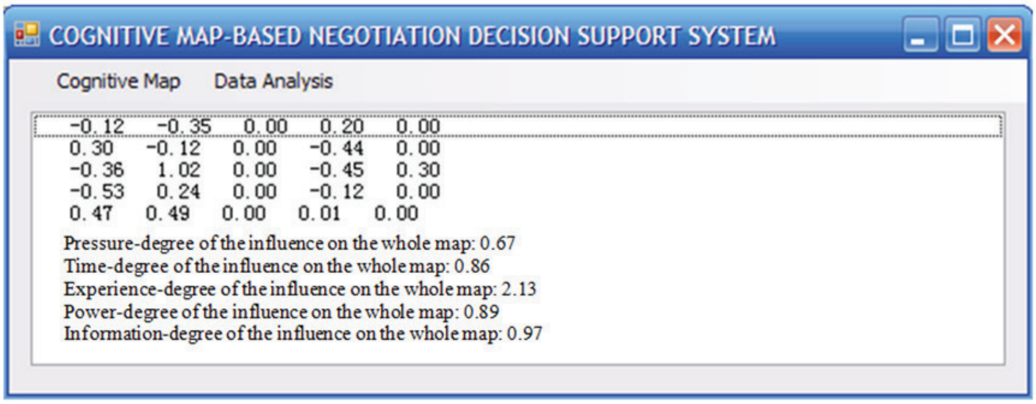

Fig. 6. Analysis results of the prototype system

comments on the usefulness, appropriateness and validity of the framework are collected from partners in the projects through focus group meetings, which are used to further develop and refine the framework. The validation is conducted in respect of a set of performance criteria, both quantitative (e.g., negotiation time, cost) and qualitative (e.g., satisfaction). The performance criteria are defined, the influencing factors on negotiation will be identified, and the relationship between these factors will be analyzed. The revised framework is presented through seminars and workshops to collect views from a wider audience and revisions are made accordingly to ensure the validity of the final framework. The validation focuses on both the process and outcomes of using the framework to support negotiation, including issues such as the efficiency of the negotiation process, the duration to obtain consensus on negotiation issues and resolve conflicts and the satisfaction with the final negotiated solution for improving the construction performance.

4. Conclusions

The novelty of the application framework proposed, CF-CWCP, lies in that it integrates the promising technologies – cognitive mapping and intelligent agents – to improve negotiation performance in CWCP, which, however, is not a simple combination of the two technologies, rather the seamless integration is based on a thorough analysis of the existing problems of negotiation in CWCP, the study of negotiation theories, and the use of the best of each technology.

It is expected that the proposed framework leads to new knowledge about negotiations in CWCP and to improve the negotiation performance. The framework also enables a better understanding of the factors, processes and knowledge requirements of negotiations in CWCP. More specifically, the developed framework could provide an effective approach to assist the negotiators efficiently find solution and resolve the major problems, such as conflicts, of negotiation in CWCP. This research develops an initial prototype to meet the first function of CF-CWCP. Further development for the other functions and implementation of CF-CWCP is valuable to be carried out.

Acknowledgement

This research was supported by the National Natural Science Foundation of China (NSFC) (Grant No. 70801023) and the foundation under the grant of htcsr06t05 from the National Center of Technology, Policy and Management, Harbin Institute of Technology. The work described in this paper was also funded by the Foundation of the Hong Kong Polytechnic University (1-ZV1V).

References

Berg, B. L. 2001. *Qualitative Research Methods for the Social Sciences*. Allyn and Bacon, Boston.

Cheng, C. B.; Chan, C. C. H.; Lin, K. C. 2006. Intelligent agents for e-marketplace negotiation with issue trade-offs by fuzzy inference systems, *Decision Support Systems* 42(2): 626–638. doi:10.1016/j.dss.2005.02.009

Cheung, S. O.; Yiu, T. W. Y.; Suen, H. 2004. Construction negotiation online, *Journal of Construction Engineering and Management* 130(6): 844–852. doi:10.1061/(ASCE)0733-9364(2004)130:6(844)

Cheung, S. O.; Yiu, T. W. Y.; Yeung, S. F. 2006. A study of styles and outcomes in construction dispute negotiation, *Journal of Construction Engineering and Management* 132(8): 805–814. doi:10.1061/(ASCE)0733-9364(2006)132:8(805)

Choudhury, A. K.; Shankar, R.; Tiwari, M. K. 2006. Consensus-based intelligent group decision-making model for the selection of advanced technology, *Decision Support Systems* 42: 1776–1799. doi:10.1016/j.dss.2005.05.001

Cohen, S. 2002. *Negotiating Skills for Managers*. New York: McGraw-Hill.

Dzeng, R. J.; Lin, Y. C. 2004. Intelligent agents for supporting construction procurement negotiation, *Expert Systems with Applications* 27(1): 107–119. doi:10.1016/j.eswa.2003.12.006

Eden, C. 1988. Cognitive mapping, *European Journal of Operational Research* 36(1): 1–13. doi:10.1016/0377-2217(88)90002-1

Eden, C.; Ackermann, F. 2004. Cognitive mapping expert views for policy analysis in the public sector, *European Journal of Operational Research* 152(3): 615–630. doi:10.1016/S0377-2217(03)00061-4

Edkins, A. J.; Jurul, E.; Maytorena-Sanchez, E.; Rintala, K. 2007. The application of cognitive mapping methodologies in project management research, *International Journal of Project Management* 25(8): 762–772. doi:10.1016/j.ijproman.2007.04.003

Fellows, R.; Liu, A. 2003. *Research Methods for Construction*. 2nd edition. Blackwell Publishing.

Fong, P. S. W.; Kwok, C. W. C. 2009. Organizational culture and knowledge management success at project and organizational levels in contracting firms, *ASCE Journal of Construction Engineering and Management* 135(12): 1348–1356. doi:10.1061/(ASCE)CO.1943-7862.0000106

Frawley, W.; Piatetsky-Shapiro, G.; Matheus, C. 1992. Knowledge discovery in databases: an overview, *AI Magazine* 13(3): 213–228.

French, W.; Bell, C. 1999. *Organization Development: Behavioral Science Interventions for Organization Improvement.* 6th ed. Prentice Hall, Upper Saddle River, NJ.

Gabel, D. 1995. *Presidential Address*. National Association for Research in Science Teaching (NARST), San Francisco.

Giordano, R.; Passarella, G.; Uricchio, V. F.; Vurro, M. 2005. Fuzzy cognitive maps for issue identification in a water resources conflict resolution system, *Physics and Chemistry of the Earth* 30(6–7): 463–469. doi:10.1016/j.pce.2005.06.012

Goh, Y. M.; Chua, D. K. H. 2010. Case-based reasoning approach to construction safety hazard identification: adaptation and utilization, *ASCE Journal of Construction Engineering and Management* 136(2): 170–178. doi:10.1061/(ASCE)CO.1943-7862.0000116

Jennings, N. R.; Sycara, K.; Woodridge, M. 1998. A roadmap of agent research and development, *Autonomous Agents and Multi-Agent Systems* 1(1): 7–38. doi:10.1023/A:1010090405266

Kantardzic, M. 2003. *Data Mining: Concepts, Models, Methods, and Algorithms*. John Wiley & Sons.

Kelly, G. A. 1955. *The Psychology of Personal Constructs*. New York: W. W. Norton.

Kim, K.; Paulson, B. C. 2003. An agent-based compensatory negotiation methodology to facilitate distributed coordination of project schedule changes, *ASCE Journal of Computing in Civil Engineering* 17(1): 10–18. doi:10.1061/(ASCE)0887-3801(2003)17:1(10)

Lee, K. C.; Kwon, S. J. 2006. The use of cognitive maps and case-based reasoning for B2B negotiation, *Journal of Management Information Systems* 22(4): 337–376. doi:10.2753/MIS0742-1222220412

Lee, S.; Courtney, J. F.; O'Keefe, R. M. 1992. A system for organizational learning using cognitive maps, *Omega – The International Journal of Management Science* 20(1): 23–36. doi:10.1016/0305-0483(92)90053-A

Li, L.; Xue, X. L. 2010. Cognitive map based negotiation decision support system for improving construction project management, in *The Proceedings of 2nd International Postgraduate Conference on Infrastructure and Environment,* 11–12 June, 2010, Hong Kong, China (Accepted).

Li, M.; Tost, L. P.; Wade-Benzoni, K. 2007. The dynamic interaction of context and negotiator effects: A review and commentary on current and emerging areas in negotiation, *International Journal of Conflict Management* 18(3): 222–259. doi:10.1108/10444060710825981

Liou, F. M.; Huang, C. P. 2008. Automated approach to negotiations of BOT contracts with the consideration of project risk, *ASCE Journal of Construction Engineering and Management* 134(1): 18–24. doi:10.1061/(ASCE)0733-9364(2008)134:1(18)

Montibeller, G.; Belton, V. 2009. Qualitative operators for reasoning maps: Evaluating multi-criteria options with networks of reasons, *European Journal of Operational Research* 195(3): 829–840. doi:10.1016/j.ejor.2007.11.015

Montibeller, G.; Belton, V. 2006. Causal maps and the evaluation of decision options – a review, *Journal of the Operational Research Society* 57(7): 779–791. doi:10.1057/palgrave.jors.2602214

Montibeller, G.; Belton, V.; Ackermann, F.; Ensslin, L. 2008. Reasoning maps for decision aid: an integrated approach for problem-structuring and multi-criteria evaluation, *Journal of Operational Research Society* 59(5): 575–589. doi:10.1057/palgrave.jors.2602347

Murtoaro, J.; Kujala, J. 2007. Project negotiation analysis, *International Journal of Project Management* 25: 722–733. doi:10.1016/j.ijproman.2007.03.002

Noh, J. B.; Lee, K. C.; Kim, J. K.; Lee, J. K.; Kim, S. H. 2000. A case-based reasoning approach to cognitive map-driven tacitknowledge management, *Expert Systems with Applications* 19: 249–259. doi:10.1016/S0957-4174(00)00037-3

Nwana, H. S. 1996. Software agents: an overview, *Knowledge Engineering Review* 11(3): 205–244. doi:10.1017/S026988890000789X

Peña-Mora, F.; Wang, C. Y. 1998. Computer-supported collaborative negotiation methodology, *ASCE Journal of Computing in Civil Engineering* 12(2): 64–81. doi:10.1061/(ASCE)0887-3801(1998)12:2(64)

Peña-Mora, F.; Sriram, D.; Logcher, R. 1993. Design rationale for computer-supported conflict mitigation, *ASCE Journal of Computing in Civil Engineering* 9(1): 57–72. doi:10.1061/(ASCE)0887-3801(1995)9:1(57)

PLC BT. 1999. *The ZEUS Agent Building Toolkit Methodology Documentations*.

Raiffa, H.; Richardson, J.; Metcalfe, D. 2002. *Negotiation Analysis: The Science and Art of Collaborative Decision Making*. Cambridge: The Belknap Press of Harvard University Press.

Rau, H.; Tsai, M. H.; Chen, C. W.; Shiang, W. J. 2006. Learning-based automated negotiation between shipper and forwarder, *Computers and Industrial Engineering* 51: 464–481. doi:10.1016/j.cie.2006.08.008

Ren, Z.; Anumba, C. J. 2002. Learning in multi-agent systems: a case study of construction claims negotiation, *Advanced Engineering Informatics* 16(4): 265–275. doi:10.1016/S1474-0346(03)00015-6

Ren, Z.; Anumba, C. J. 2004. Multi-agent systems in construction-state of the art and prospects, *Automation in Construction* 13(3): 421–434. doi:10.1016/j.autcon.2003.12.002

Ren, Z.; Anumba, C. J.; Ugwu, O. O. 2003. The development of a multi-agent system for construction claims negotiation, *Advances in Engineering Software* 34(11–12): 683–696. doi:10.1016/S0965-9978(03)00107-8

Rosenschein, J. S.; Zlotkin, G. 1994. *Rules of Encounter: Designing Conventions for Automated Negotiation among Computers*. The MIT Press, Cambridge, MA.

Saee, J. 2008. Best practice in global negotiation strategies for leaders and managers in the 21st century, *Journal of Business Economics and Management* 9(4): 309–318. doi:10.3846/1611-1699.2008.9.309-318

Schieg, M. 2009. Model for integrated project management, *Journal of Business Economics and Management* 10(2): 149–160. doi:10.3846/1611-1699.2009.10.149-160

Schieg, M. 2008. Strategies for avoiding asymmetric information in construction project management, *Journal of Business Economics and Management* 9(1): 47–51. doi:10.3846/1611-1699.2008.9.47-51

Singh, A. 2009. Organizational power in perspective, *Leadership and Management in Engineering* 9(4): 165–176. doi:10.1061/(ASCE)LM.1943-5630.0000018

Ülengin, F.; Kabak, Ö.; Önsel, Ş.; Ülengin, B.; Aktaş, E. 2010. A problem-structuring model for analyzing transportation-environment relationships, *European Journal of Operational Research* 200(3): 844–859. doi:10.1016/j.ejor.2009.01.023

Xue, X. L.; Li, X. L.; Shen, Q. P.; Wang, Y. W. 2005. An agent-based framework for supply chain coordination in construction, *Automation in Construction* 14(3): 413–430. doi:10.1016/j.autcon.2004.08.010

Xue, X. L.; Shen, Q. P.; O'Brien, W.; Ren, Z. M. 2009. Improving agent-based negotiation efficiency in construction supply chains: A relative entropy method, *Automation in Construction* 18(7): 975–982. doi:10.1016/j.autcon.2009.05.002

PAŽINIMU GRĮSTAS MODELIS BENDRAVIMUI GERINTI STATYBOS PROJEKTUOSE: DERYBŲ ASPEKTAS

X. Xue, Y. Ji, L. Li, Q. Shen

Santrauka

Derybos yra populiarus bendradarbiavimu grįstas tarimasis tarp organizacinių sistemų priimti sprendimus, ypač vykdant statybų projektus. Derybos jau seniai suvokiamos kaip vertingas, tačiau daug laiko ir energijos atimantis procesas. Veiksmingos sistemos, galinčios padėti pagerinti derybų efektyvumą, trūkumas yra viena iš pagrindinių problemų siekiantiems padidinti bendradarbiavimo veiksmingumą vykdant statybos projektus.

Pagrindinis šio straipsnio tikslas – išplėtoti pažinimo kartografija paremtos sistemos, kuri pagerintų bendradarbiavimą vykdant statybos projektus, taikymą atsižvelgiant į derybų perspektyvas. Šią sistemą sudaro dvi dalys: 1) kartografinis derybų procesas vykdant statybos projektus, pagrįstas pažinimo kartografijos technologija; 2) pažinimo sistemos, gerinančios bendradarbiavimą vykdant statybos projektus, plėtojimas integruojant intelektinius agentus ir pažinimo kartografijos technologiją. Šis tyrimas padės statybų projektų dalyviams pagerinti derybų efektyvumą, be to, išplėtotas pažinimo sistemos prototipas.

Reikšminiai žodžiai: pažinimo kartografija, bendradarbiavimas, derybos, statybos projektai.

Xiaolong XUE is an Associate Professor of Construction Engineering and Management in the Department of Construction and Real Estate, School of Management at Harbin Institute of Technology, Harbin, China. He received the Ph.D. in Construction Engineering and Management from Harbin Institute of Technology in 2006. Dr Xue is an active researcher in construction management. His research interests include improving construction management employing cognitive science, collaborative working, performance measurement, and application of information technology in construction. He has published more than 20 papers in international journals and conference proceedings.

Yingbo JI is a lecturer of Construction Engineering and Management in the Department of Management, School of Economics and Management at North China University of Technology, Beijing, China. She obtained the Ph.D. in Construction Engineering and Management from Tianjin University. Dr Ji is an active researcher in construction management. Her research interests include construction industrialization, sustainable construction, and performance measurement.

Lin LI is a master student in the Department of Construction and Real Estate, School of Management at Harbin Institute of Technology, Harbin, China. She received the Bachelor of Management in Information Management and Information System from the School of Computer at Henan University in 2009.

Qiping SHEN is a Chair Professor of construction management in the Department of Building and Real Estate, Hong Kong Polytechnic University, Hong Kong, China. Prof. Shen is an active researcher in collaborative working in construction, supported by information technology. He has managed a large number of research and high-level consultancy projects with total funding over HK$15 million, and has published extensively in both academic and professional journals and international conferences. He teaches in these fields mainly at the postgraduate level, and has successfully supervised a large number of PhD, MPhil, MSc, and BSc students. Professionally, he is the President of the Hong Kong Institute of Value Management (HKIVM) and member of the Institute of Value Management (IVM) in the UK. As a Certified Value Specialist (CVS) and Value Management Facilitator (VMF) recognized by the Hong Kong SAR Government, he has professionally facilitated a large number of value management and partnering workshops for a variety of large client organizations in both the public and private sectors.