A Strategy of Re-negotiation with Case-Based Reasoning

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Abstract
It is widely existed in real life that there are many transactions between buyer and seller. Which factors are used to contact the transaction history so that current negotiations can reach a consensus faster and better has become a hot research spot. This paper proposes a method of repeated negotiation with case-based reasoning. The target case will be matched with the most similar source case by similarity function. The transaction value in the most similar case is used as the new offer of the target case, which can make the negotiation agent complete repeated bilateral multi-issue negotiation more effectively under the incomplete and uncertain information, and the presence of deadline. Finally, the feasibility and effectiveness of the case-based reasoning re-negotiation proposed in this paper are verified by simulation experiments.

Key words: Degree of Similarity; Case-based Reasoning; Re-negotiation; Utility Evaluation

1. INTRODUCTION

E Negotiation is the process by which a group of agents communicate with one another to try to reach agreements on some matter of common interest; it is a process of mutual recognition, common interests and interaction between hearts. Automated negotiation refers to a group of autonomous agents coordinate the process of reaching a consensus on one or some of the issues of interest (Baarslag and Hindriks, 2013). From the proposal of automated negotiation up to now, automated negotiation has experienced the process of the negotiation issues from single to multiple, participates in negotiations from unilateral to bilateral to multilateral, negotiation process by a bid to cycle times to re-negotiation (Cao and Luo, 2014). Many scholars at home and abroad have done a lot of research in this area, and have achieved some success in the set negotiation environment.

The work discussed in this paper is a repeated negotiation between the agents from two sides. That is: agents from two sides for multiple issues after negotiations, due to demand, negotiate once again, which is common in reality. In order to solve the problem better, we prescribe that in the process of repeated negotiations, the issue of each negotiation and the weight of each issue are the same. In repeated negotiations, as the negotiators will pay attention to the negotiation history, so we will put successful agent negotiation cases in the backstage database and record the expected value of each successful negotiation and transaction value. When the agent receives a new negotiation proposal, it will use similar method to match expected values of the target case and history case (source case) and find out the most similar case. We will use the transactions values of the most similar case as we make a new offer.

2. RECOGNITION REASONING MECHANISM BASED ON SIMILARITY CASE

2.1. Definition of Similarity

Similarity refers to the degree of similarity between the two proposals in this paper. In this paper, the calculation of the similarity adopts the calculation model of the similarity function proposed by Faratin et al. (Minyi, 2013). But the calculation model is simplified, and the relevant parameters are redefined. The similarity calculation formula in this paper is described as formula 1 (Junhao, 2014).

$$Sim(x, y) = \sum_{i \in I} w_i \cdot Sim_i(x_i, y_i)$$  \hspace{1cm} (1)

In the above formula, x and y represent the two proposals in the given issue set I. w_i represents the set weight of the proposal i by negotiator and it satisfies the equation $\sum_{i \in I} w_i = 1$. x_i and y_i represent the two proposals’ values of the negotiation proposal i. The similarity calculation between them can be represented by the following equation 2.

$$Sim_i(x_i, y_i) = 1 - \frac{|x_i - y_i|}{k_i}$$  \hspace{1cm} (2)

k_i represents the range of values for the issue i.
In the above formula, the greater the value of $Sim(x, y)$, the more similar the two issues; and vice versa. In this paper, the author uses the theory to find the most similar cases in the case base, and uses similar cases’ transaction offer to form a new offer in the negotiation process.

### 2.2. Case-Based Reasoning Technology Based on Agent

Case-based reasoning technology is the research direction in recent years (SR and A, 2015). It is an important reasoning method to obtain the current problem (target case) solution by accessing the solution of the same kind of problem (source case base) in the past. It can effectively solve the problems in the field which is difficult to express or unable to express by knowledge (Lei and Cunlu, 2016). And it can fully imitate the human way of thinking to solve the specific problems with high speed and precise analysis, which is very suitable for the situation of drawing lessons from past experience fully and partially. Agent application case-based reasoning method can be used to determine the current method of the new offer based on the negotiation history case (Zhang and Li, 2016). It can be seen that we have theoretical basis for the use of case-based reasoning in repeated negotiations. In the course of repeated negotiation, agent can solve the current problem well through the previous negotiation cases, so it is absolutely necessary to introduce the case-based reasoning method in the negotiation process. The process of case-based reasoning based on agent is shown in Figure 1.

![Figure 1. The process of case-based reasoning based on agent](image)

The first step is the case retrieval. By case retrieval, the cases set similar to the target case can be obtained; and then by using similarity function, the target case can be matched with the source case and the most similar case can be selected. In this step, the matching function of the case determines the effect of an inference system. In this paper, the similarity function is selected as the matching function; agent will evaluate and revise the obtained case and apply its solution to the current case; finally, the last step is to save the new solution to the source case base.

### 2.3. Case-Based Reasoning Based on Similarity

In the evaluation of the overall similarity, we use the similarity function defined above to compare the target case and the source case so as to find the most similar case. Set case set (cases base)$C = \{c_1, c_2, \ldots, c_i, \ldots, c_m\}$, and the expected value of the attribute set for the case $i$ is $\{c_i^1, c_i^2, \ldots, c_i^n\}$, then the similarity between the expected value of the target case $c_r$ and the expected value of the source case $c_i$ is $Sim(x, y) = \sum_{j=1}^{n} w_j \cdot Sim_j(c_r^j, c_i^j)$. In the above formula, $n$ represents the number of case attributes and $w_j \in [0, 1]$ is the weight value of the attribute $j$ with $\sum_{j=1}^{n} w_j = 1$. $Sim_j(c_r^j, c_i^j) \in [0, 1]$ represents the attribute $j$’s similarity between the target case $c_r$’s expected value and the source case $c_i$’s expected value. Its definition is $Sim_j(c_r^j, c_i^j) = 1 - \frac{|c_r^j - c_i^j|}{k_j}$, $k_j$ represents the range values of the feature $j$. Then we can find the most similar case for using.

### 3. REPEATED NEGOTIATION BASED ON CASE-BASED REASONING

#### 3.1. Frame Structure of Agent in Negotiation

The agents of both sides are using the following defined mode for negotiation to increase the degree of intelligence and automation of our negotiation system (Sun and Zhao, 2015). The negotiation agent has the
following steps to do: 1) In order to get a full understanding of the target case, agents from two sides interact with each other through the negotiation interface before the negotiation, which lays the foundation for the problem solving. 2) The assessment is made according to the previous understanding of the problem by the scheme evaluation mechanism. The inference engine from the information layer obtains necessary data and case knowledge, and obtains the best matching case and gives offer by using case-based reasoning technology and similarity function. 3) After the successful completion of the negotiation, the results of the negotiation will be stored in the data base as a source case for future use of similar problems. While storing the results, the source case that is not matched with the target case for the longest period of time will be deleted. Data layer, network, agent internal modules constitute our entire negotiation system. In summary, the logical structure of the agent is shown in Figure 2.

![Figure 2. The logical structure of the agent](image)

**Figure 2.** The logical structure of the agent

Decision and control module will play an important role in some important aspects. Such as, decision and submission of the proposal, the control of the negotiation process, the judgment and processing of the deadlock situation, etc. In the situation of one’s own side refusing to accept the other side’s offer and requiring new negotiation scheme, the source case most similar to the case will be searched out for the reasoning mechanism to process and the reasoning mechanism will give feedback. In the case evaluation module, there is a set of weighted scoring rules, which is mainly to evaluate the proposal by the other side. It calculates the weighted score of the proposed scheme in accordance with the scheme set in this paper, and estimates the gap between this scheme and the target threshold to assist the correct judgment of the decision module mentioned before. Negotiation interface is used for receiving the other party agent’s proposal, sending their own proposals, and interacting with each other to accept its control information. Finding out the best similar case is the key link of the negotiation. And the use of similarity function to seek the most similar case algorithm is given as follows:

S1: obtain the negotiation history cases;
S2: Record the value span k[j] of attribute j of the obtained case;
S3: Calculate the similarity of each case (In order to improve the matching speed, we only match the latest 20 cases in this algorithm);
S4: Find the best matching case.

### 3.2. Repeated Negotiation Process Based on Reasoning Mechanism

From the above experimental results, the conditional random field model is used to achieve the good. The previous successful negotiation cases are stored in negotiation agent’s database (MA and MS, 2015). When the Agent receives a proposal, first, it will use the utility evaluation function to judge whether the proposal satisfies the set threshold. If it satisfies the set threshold, the proposal will be accepted; otherwise, the most similar case in the cases base will be matched. After obtaining the most similar case, it will determine whether the case reaches the negotiation deadline. If it reaches the deadline, then the negotiation fails; otherwise, the transaction value obtained in the most similar case is used for proposing a new offer. This is repeated until the end of the negotiation. The whole negotiation process is shown in Figure 3.
The threshold of agent is set for the total effect of negotiation (Jiang and Pang, 2014). The calculation formula of the negotiation total effect adopted in this paper is shown in formula 3:

$$U_j^t = \sum w_i \times V_{i}^{j,t}$$ (3)

where $w_i$ represents the weight accounted by issue $i$ with $\sum_i w_i = 1$; $t$ represents the negotiation issue; $j$ represents agent; $V_{i}^{j,t}$ represents the value evaluation value made by $t$ times of agent $j$ in issue $i$; the greater the value of $U_j^t$, the higher effect the agent obtains, and vice versa.

Based on the characteristics of the negotiation issues, we divide the issues into two categories:

1. The issue value is in proportion to its effectiveness, that is, the higher the value of the issue, the higher its effectiveness. At this point, the calculation formula of $V_{i}^{j,t}$ is shown in formula 4. For example, the supplier’s
demand for price issues, the higher the price, the greater the effect for the supplier itself; on the contrary, the lower the price, the smaller the effect for the supplier.

\[ V_{i,j}^{t} = \frac{x_{i,j}^{t} - I_{i}^{j}_{\text{min}}}{I_{i}^{j}_{\text{max}} - I_{i}^{j}_{\text{min}}} \]  

(4)

(2) The issue value is in inversely proportion to its effectiveness, that is, the higher the value of the issue, the lower its effectiveness. At this point, the calculation formula of \( V_{i,j}^{t} \) is shown in formula 5. For example, the supplier’s demands for the issue of payment date. the longer the payment date, the smaller the effect for the supplier; conversely, the shorter the payment date, the greater the effect for the supplier.

\[ V_{i,j}^{t} = 1 - \frac{x_{i,j}^{t} - I_{i}^{j}_{\text{min}}}{I_{i}^{j}_{\text{max}} - I_{i}^{j}_{\text{min}}} \]  

(5)

\( x_{i,j}^{t} \) represents a value in the acceptable range of issue \( i \) for the \( t \) times agent program \( j \) of the other side’s proposal. \( I_{i}^{j}_{\text{min}} \) represents the minimum acceptable degree of one’s proposal on the issue \( i \). \( I_{i}^{j}_{\text{max}} \) represents the maximum acceptable degree of one’s proposal on the issue \( i \).

Agent will set a threshold for the total effectiveness before each negotiation. When the received offer from his rival is more than or reaches the threshold, it will accept the offer; otherwise, it will offer counter proposal until the close of negotiation.

The previous expected value and transaction value of successful negotiation will be stored in source case. When finding the best similar case, negotiation agent will be based on the last transaction value of the most similar case as a new proposal to send to the negotiation opponent.

4. SIMULATION AND ANALYSIS

Experiment uses Java language. The case-based reasoning repeated negotiation system was tested based on JADE (Agent Development Environment Java) of the multi-agent system platform. Background database management system uses SERVER SQL. Different number of source cases is set in each negotiation agent database (previous negotiation successful cases). The issue for each negotiation is: price (P), delivery time (D), payment time (T). Then the Offer submitted between the Agents is formalized as: (P, D, T). The experiment is carried out in repeated negotiations. Therefore, in the process of each negotiation, the requirements and preferences are roughly the same. We set different source cases to carry out a number of experiments. The negotiation structure is as follows.

The number for issue exchanges required by reaching an agreement by negotiators under certain preferences and issues in the case base of different similarity cases is shown in Fig. 4. It can be seen through this figure that with the increase in the number of cases in the case base of high degree of similarity, the number of issue exchanges required to achieve consensus is reduced.

![Figure 4. The number of issue required by transaction with the similarity degree of cases](image)

The effectiveness obtained with the increasing times of negotiations in certain cases in the case base is shown in Figure 5. It can be seen that with the increase in the number of negotiations, the effectiveness obtained
by the negotiators will tend to be close to a balance. The psychological trend of the negotiators is more likely to trade with a traded seller, which makes the whole transaction activities more smoothly.

Figure 5. The buyers’ transaction effectiveness with the increasing number of repeated negotiations

6. CONCLUSIONS

In this paper, case-based reasoning repeated negotiation strategy, using similarity function to obtain the best matching case, using the best practices to deal the most value for the formation of a new round of proposed, in a certain extent simplifies the negotiation process and improves the efficiency of the negotiation under the set agent negotiation threshold. But we still have a lot of work to do: find better matching functions between the source case and the target case to obtain the best similar case; in the process of Agent learning, in addition to the application of case-based reasoning technology mentioned in this paper to increase the agent’s experience, try introducing some other learning methods to understand the negotiation opponent’s preferences and habits, be familiar with more negotiation background and rules to further improve the efficiency and effectiveness of automatic negotiation. All of these are to be considered further in the future.

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