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E-Commerce Oriented Human-Computer Negotiation Strategy Model

Mukun Cao
School of Management, XiamenUniversity, China, mkcao@xmu.edu.cn

Hong Hong
School of Management, XiamenUniversity, China, honggirl@126.com

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Mukun Cao[1],*Hong Hong*[1*]
[1]School of Management, XiamenUniversity, China

Abstract: Human-computer negotiation plays an important role in B2C e-commerce. There is a paucity of further scientific investigation and a pressing need on designing the software agent that can deal with the human's random and dynamic offer, which is crucially useful in human-computer negotiation to achieve better online negotiation outcomes. The lack of such studies has decelerated the process of applying automated negotiation to real world applications. To address the critical issue, this paper develops a strategy concession model.The theoretical model and algorithm of the combined strategy were developed. To demonstrate the effectiveness of this model, we implement a prototype and conduct human-computer negotiations over 121 subjects. The experimental analysis not only confirms our model's effect but also reveals some insights into future work about human-computer negotiation systems.

Keywords: automated negotiation, negotiating agent, negotiation strategy

1. INTRODUCTION

Negotiation is a communication process among a group of parties with conflicting interests or preferences in order to reach an agreement or compromise [1, 2]. E-commerce oriented negotiation is increasingly assuming a pivotal role in many organizations, and a number of prominent negotiation models have been developed over the past decades[3].The human-computer negotiation plays a paramount role in the e-commerce oriented applications, especially in the B2C context where software agents act as business provider [4]. Comparing with the traditional online sales mode where customers view the basic product or service information on the website and often need to negotiate with human salespeople through a "contact us" link, the human-computer automated negotiation system can help business organizations to reduce the labor cost for negotiation and greatly increase the transaction efficiency to the optimum extent.

Prior studies have been conducted to design the human-computer negotiation agent [5, 6], whichdemonstrate that a softwareagent can proficiently negotiate with and even outperform people. Here we illustrate some typical examples, such as the Diplomat agent[7], the AutONA agent[8], the Cliff-Edge Agent[9], the Colored-Trails agent [10], the Guessing Heuristic agent [11], the QOAgent[12], the Virtual Human agent [13], and the LaptopOnDemand.com [14]. Among all of these negotiating agents, only the LaptopOnDemand.com is an e-commerce oriented application. Owing to the randomness of the human's behavior, the e-commerce human-computer negotiation context is assumedly more complicated. The human-computer negotiation system accordingly needs much smarter software agents to negotiate with the human negotiators effectively. The agent is expected to try different strategies to obtain a better negotiation outcome. The ability to quickly and autonomously combine appropriate strategies among the candidates to cope with the negotiation situation is a very important perspective for evaluating the designed agent's intelligence level.

The main objective of this study is to construct and validate a generic and robust concession model in an effort to support various strategies combination during the human-computer negotiation in e-commerce. From our perspective, human-computer negotiation is essentially a behavioral game process [15], in which single strategy can hardly process all the possible complicated situation generated by the human's random and dynamic negotiation behavior. Our aim of this paper is designing a negotiation strategy that combines various strategies,

* Corresponding author.Email: mkcao@xmu.edu.cn(Mukun Cao), honggirl@126.com (Hong Hong)

which enable the agent to deal with as much complex negotiation context as possible to satisfy the practical application environment of e-commerce.

2. THE STRATEGY MODEL

This section presents our method for strategy integration. The simplest negotiation model is a bilateral negotiation with a single attribute. In most cases, however, the negotiators have to process several attributes of the product at the same time [1, 16]. Before making concession, the negotiator would trade off among the different attributes. When they cannot trade off a satisfied result, they might concede according to the predefined concession strategies, evolving to a similar process with the single attribute negotiation. As a result, we just consider the price in our model.

2.1 The Time Dependent Negotiation Strategy

Our strategy selection model is based on Faratin's time-dependent concession model, which indicates that an agent is likely to concede more rapidly if it needs to reach an agreement by a deadline [17]. As depicted in Figure 1, there is actually a family of concession curves, which can be defined simply by varying the value of parameter β determining the convexity degree of the curve. The shape of the each concession curve represents a human's negotiation behavior. As there are infinite proposal curves (corresponding to infinite values of β, one for each curve) included in the solution space, theoretically speaking, the model covers the entire possible proposal curves the human being might choose during the process of the negotiation. The task of our multi-strategy selection model is to select among all of these proposal curves dynamically to deal with the ever changing opponent's negotiation behavior, rather than fixing on one proposal curve from the beginning to the end of the negotiation as the prior studies did.

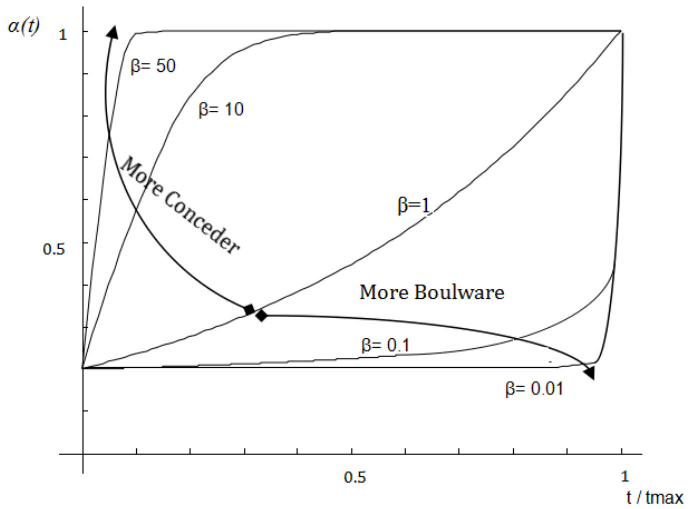

Figure 1.The exponential functions for the computation of $\alpha(t)$. Time is presented as relative to t^{a}_{max} [17]

There are two different patterns of behavior: (1) the Boulware, discriminated by $\beta < 1$, maintains the offered value until the time is almost exhausted, whereupon they concede up to the reservation value; and (2) the Conceder, discriminated by $\beta > 1$, leads the agent to go quickly towards its reservation value. The curve with $\beta = 1$ represents the intermediate state between Boulware and Conceder.

The family of the proposal curves can be defined by function $\alpha(t)$ as follows:

$$\alpha^{a}_{j}(t) = \exp^{(1-\frac{\min(t,t^{a}_{\max})}{t^{a}_{\max}})^{\beta}\ln K^{a}_{j}} \tag{1}$$

where a is the agent's name, j denotes the negotiation issue, t is a predominant time factor used to decide which value to offer in the next round, t^a_{max} is the time by which agent a must have completed the negotiation, and K^a_j is a constant that when multiplied by the size of the interval, determines the value of issue j to be offered in the first proposal by agent a. So, we have $\alpha^a_j(0) = K^a_j$ and $\alpha^a_j(t^a_{max}) = 1$.

2.2 The Selection Strategy

There has been a lot of work using the fixed time dependent strategy to negotiate (i.e., the agent keeps the same strategy from the beginning to the end of the negotiation). We conducted fixed strategy computer-computer negotiation experiment to test the success rate with the result just 31%, which cannot be accepted in most real applications. However, in the real life negotiation, the negotiator often changes negotiation strategy during the process of negotiation. Our expectation is enable the agent switch among the different time dependent tactics, boulware or conceder, to form a strategy selection mechanism. To do so, the agent can cope with the human's ever-changing offers, rather than fixes at one negotiation strategy in the whole process of the negotiation. So the agent needs to keep learning its counterpart's negotiation behaviors and then adjusts its current strategy to a proper one at a proper time to respond the opponent's possible price changes.

The agent needs a criterion for strategy changing. Through a lots of negotiation experiences, we find that there is close relationship between the human's negotiation behavior and their concession mode. It is commonsense that the negotiator suddenly increases or decreases concession drastically, comparing with the former concession just made, often means that the negotiator is now changing its strategy. On the contrary, if the negotiator keeps a steady concession (i.e., makes the same or similar concession at two neighboring offer and keeps this style in a certain period), that often means the negotiator intends to keep current strategy unchanged in the coming rounds. The increase and decrease of concession can be described by the concession rate, denoted as θ, which is the ratio between the two neighboring concessions. The θ can be expressed formally from the seller's perspective as follows from the human buyer's perspective:

$$\theta = \frac{x^t_{b\to s} - x^{t-1}_{b\to s}}{x^{t-1}_{b\to s} - x^{t-2}_{b\to s}} \tag{3}$$

where $x^t_{b\to s}$ is the price offered by buyer b to seller s at time t, thus the difference between the agent's two neighboring offer prices,$x^t_{b\to s} - x^{t-1}_{b\to s}$ is a concession. So we have the following three cases:

(1) When the human buyer accelerates concession to approach its deadline (i.e., $\theta > 1$), in order to reach an agreement surely, the agent seller has to adjust its strategy to cater to the buyer. With the opaque of both negotiators' strategies, the agent can only conjecture, imitate and adjust through the prices that the human just offer. As to the imitation, we do not simply have the agent imitate the opponent's concession, but imitate the opponent's concession rate. Namely, the seller agent imitates the human buyer's concession rate θ, where the agent can calculate its next offer through formula (), and deduce its new strategy function.

$$x^t_{s\to b} = (1+\theta)\, x^{t-1}_{s\to b} - \theta x^{t-2}_{s\to b} \tag{A.2}$$

where $x^t_{s\to b}$ denotes the seller agent's offer to human buyer at time t.

(2) When the human buyer decelerates concession (i.e., $\theta < 1$), according to the time dependent tactic model in section 3.2, this kind of situation takes place when the negotiator makes big concession at the beginning of the negotiation. After that the agent gradually decreases concession to approach the reservation price, and finally terminates at the deadline. In this circumstance, the seller agent will take $1/\theta$ as its concession rate, from which the seller agent calculates its next offer through formula (), and deduces the new strategy function. The reason why the agent takes $1/\theta$ instead of θ is because $1/\theta > 1$, by which the agent can develop more Conceder strategy to cater to the seller's fast concession and reach an agreement quickly. This can be proved by the following experiments.

$$x_{s\to b}^{t} = (1+\frac{1}{\theta})\, x_{s\to b}^{t-1} - \frac{1}{\theta} x_{s\to b}^{t-2} \qquad \text{(A.2)}$$

Based on the new offer obtained from the above formula () and (), a new strategy function can be deduced as the following equation shows:

$$x_{s\to b} = min^{\,s} + (1 - exp^{(1-\frac{\min(t, t_{max}^{S})}{t_{max}^{S}})^{\beta} lnK^{s}})(max^{s} - min^{s}), \qquad \text{(A.9)}$$

where t is independent time variable and $x_{s\to b}$ is the dependent offer price (seller to buyer) variable. Through this function, the seller agent's finds new strategy and negotiate along with it.

(3) When the human buyer keeps a steady concession rate (i.e., $\theta = 1$), making the same concessions between the last two neighboring offers, the agent seller will simply keep the current strategy unchanged, and will find a new point along the current strategy function curve to make the next offer.

The typical situations of the experiments are shown in Figure2, from which we can see there would not have been an agreement point between the two initial strategy of the buyer and seller, but due to the seller's strategy selection ability, after several rounds of offer exchanges, the seller adjusted its strategy according to the buyer's concession change to finally find a deal point between them.

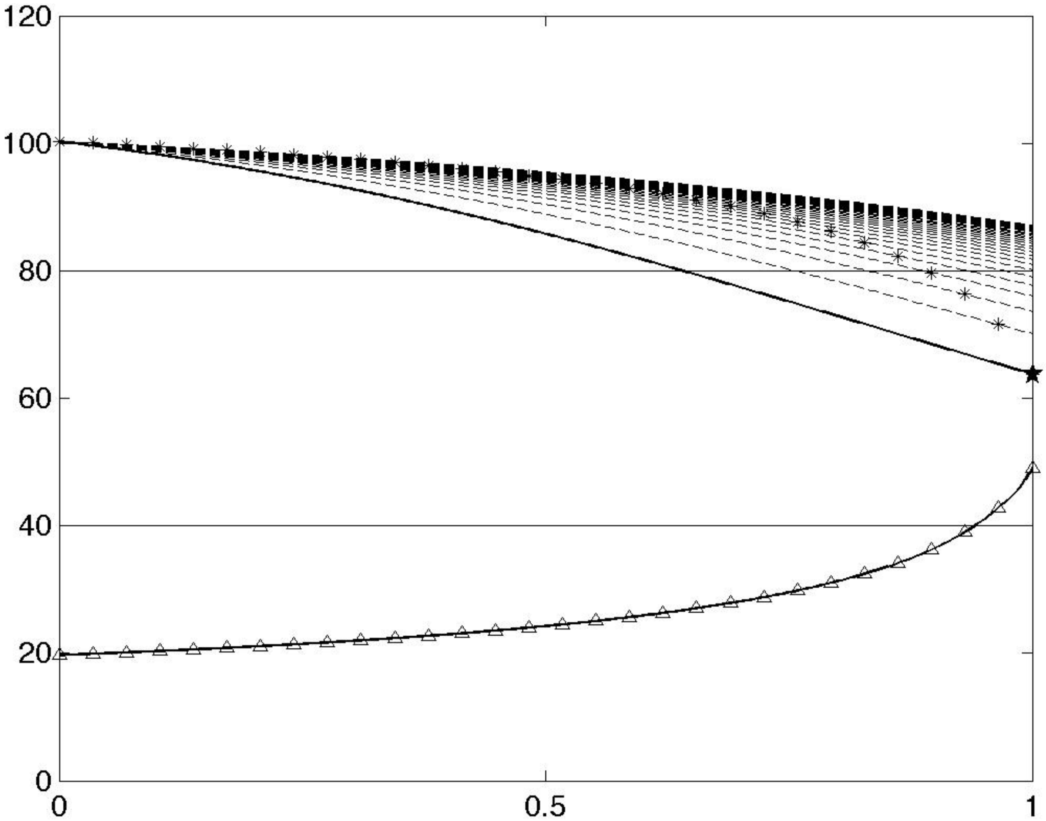

Figure 2. Computer-computer negotiation experiment comparison

3. EXPERIMENT EVALUATION

This section will conduct lots of experiments to evaluate the effectiveness of our combined strategy concession model, which will practically benefit real human-computer negotiation system development.

3.1 Experimental Design

To empirically validate the design hypotheses and the combined strategy concession model, we conducted a between-subject experiment. 121 human subjects played the role of buyers negotiating purchases with same amount of agent sellers, and were randomly assigned to negotiate with one of the three kinds of seller agent via a human-computer interaction interface, through which the human can input their offer, see the computer's offer, accept or reject the computer's offer. The three kinds seller agent adopts different strategies: Boulware, Conceder and Combined Strategy. Through comparing the different negotiation result, we can justify the validity of the newly designed combined strategy concession model. Table 1 depicts the experiment design.

Table 1.The experiment design

Experiment Groups	Single Fixed Strategy		Combined Strategy
	Boulware	Conceder	
Subject Number	40	42	39

The negotiation topic is about a transaction on a rechargeable battery for mobile phones. The merchant's price for this 20000mha capacity portable battery is 107RMB. As there are many different similar type of brand products in the online market with the price interval from 40RMB to 120RMB, the subjects are asked to achieve the goal that trying their best to let the computer opponent to make concession as large as possible from the original price 107RMB, and finally deals at a relative lower price to increase the buyer's own utility as much as possible. In order to facilitate the comparison study, all the negotiations are set under a same standard scenario. (1) The human's reservation price for this product is 80RMB, which means exceeding this price cannot be accepted due to a negative utility. (2) For the seller agent side, the reservation price is set to 40RMB, under which is non-acceptable. (3) In order to get a wide negotiation interval, the human buyer's initial price is set to ￥20RMB. Therefore, subjects can make offer between 20 and 80 during the process of negotiation. What needs further explanation is that the reason we set such a low initial price, which would not be understood in real-life negotiation because it might irritate the opponent or be misunderstood as a noncooperation posture. In human-computer negotiation, however, we consider the situation would be different with the human-human dyads, as the computer is not easy to be irritated, on the contrary, setting a lower initial price will be benefit for the negotiator to get a wider negotiation space.

3.2 Subjects

Before the main experiment, we conducted a pilot study involving 50 participants who were students and teachers. The experimental procedure and questionnaire items were fine-tuned based on their feedback. Subjects for the main experiment were recruited from classes (including MBA, postgraduate and undergraduate) in September 2014. The subject recruitment was announced via multiple channels including the distribution of flyers, the placement of posters and mass email. The announcement included a description about the nature of the experiment and reward structure. The subject recruitment was also announced via researchers' verbal description about the experiment and direct invitation to the students after class.

In total, 121 subjects completed the experiment procedure and made 121 agent-human dyads for the analysis of the main experiment. Table 1 summarizes the demographic information of the subjects. There are more male subjects (63.6%) in terms of gender distribution and the majority of respondents are between 18 and 30 years of age (71.1%). With respect to education, about half of them hold master degree, 46.3% hold bachelor degree and 3.3% hold doctoral degree. Furthermore, 61.2% of subjects are employees, and 38.8% are students. As for employee subjects, most have worked for 5 to 10 years, and their industry is dispersive.

3.3 Hypotheses

The ensuing section elaborates on the hypotheses for the experiments.

Hypothesis 1 (H1): The human-computer dyad is more likely to reach an agreement (i.e., can achieve a higher deal rate of the negotiation) when the agent makes combined strategy offers than when it makes single fixed strategy offers, i.e., Boulwar strategy (H1a) or Conceder strategy (H1b).

Hypothesis 2 (H2): An agent that uses the combined strategy is more likely to outperform the human than the one that uses the single fixed strategy (i.e., boulware or conceder).

Hypothesis 3 (H3): The agent that makes combined strategy offers is more likely to reach an agreement with human in shorter time than when it adopts single fixed boulware strategy, but longer than when it adopts single fixed conceder strategy.

Hypothesis 4 (H4): A human counterpart is more likely to obtain a worse intrinsic utility after negotiating with an agent that implement combined strategy than with one that implements single fixed strategy.

Hypothesis 5 (H5): An agent that implements combined strategy is more likely to obtain a better intrinsic utility than the one that implements single fixed strategy after negotiating with a human counterpart.

Hypothesis 6 (H6): The human-computer dyad is more likely to obtain a better joint outcome (i.e., larger utility product and smaller utility difference) when the agent implements the combined strategy than when it implements the single fixed strategy.

4. DATA ANALYSIS, RESULTS AND DISCUSSION

This section experimentally compares the effects of combined strategy mechanism and the classical fixed strategy mechanism in the human-computer negotiation.

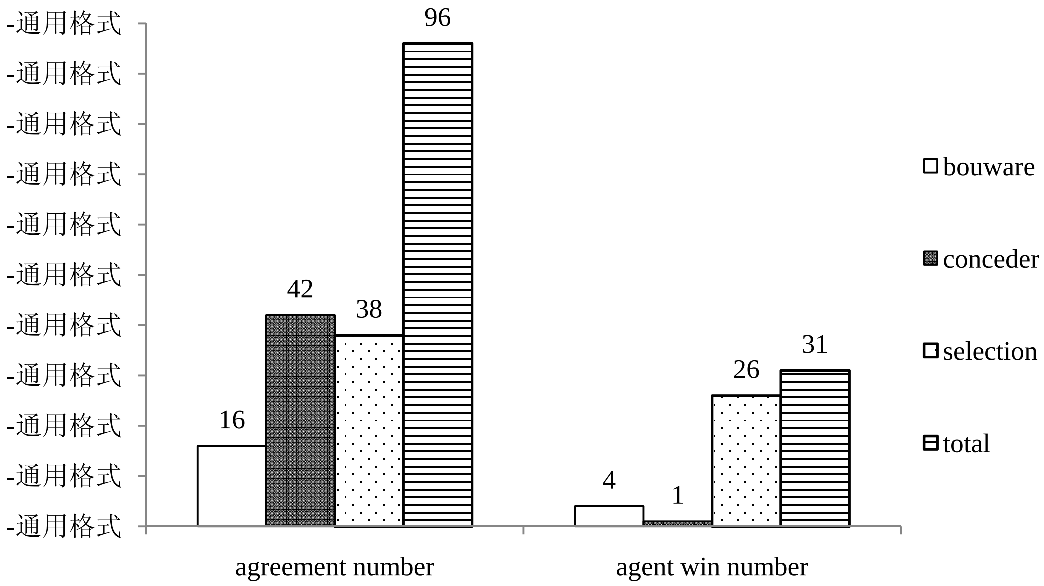

Figure 3. Experiment result for different strategy groups

According to the data in figure 3, overall, among the 121 agent-human dyads, 96 dyads obtained agreement and 25 dyads ended up with no agreement. Among 96 agreed dyads, 32 dyads are agents accept humans' offer, and 64 are humans accept agents' offers. By the "final offer" rule enforced in the experiment, non-agreement cases only occurred when subjects reject the agent's final offer, or a counteroffer fell into the agent's rejection region.

Success rate depends on the different strategy the agents employ. Among the 40 boulware agents, only 40% made deals with the human. Towards the 42 conceder agents, almost all can reach agreements with human (100%). The reason for so high success rate is due to the feature of the conceder strategy, which represents the kind of negotiator who eagers to make a deal as soon as possible. Synthesizing the result of boulware and conceder, the agents that adopt single fixed strategy could make 70.7% deals, which is lower than the ratio when the agent adopts our combined strategy (97.4%). As to the total effect for employing agent to negotiated with human, nearly 79.3% negotiation succeeded, which implies the feasibility for using negotiating agent in e-commerce negotiation.

All the hypotheses are supported, with the exception of H1b, but not affecting the overall judgment on H1, as it is supported when we compare combined strategy to single fixed strategy, which is actually the combination of the competitive and collaborative strategy. The logistic regression testing has been discussed above. A summary of the outcomes of hypotheses testing is presented in Table 2.

Table 2. Hypotheses testing results

Hypotheses	Dependent Variable	Relationships	Sig.	Results
H1	Success rate			Partially Supported
H1a		Selection>Bouware	**0.000**	**Supported**
H1b		Selection>Conceder	0.998	Not supported
H2	Agent win ratio			Fully Supported
H2a		Selection>Bouware	**0.015**	**Supported**
H2b		Selection>Conceder	**0.000**	**Supported**
H3	Final time			Fully Supported
H3a		Selection<Bouware	**0.000**	**Supported**
H3b		Selection>Conceder	**0.042**	**Supported**
H4	Buyer utility			Fully Supported
H4a		Selection<Bouware	**0.034**	**Supported**
H4b		Selection<Conceder	**0.000**	**Supported**
H5	Seller utility			Fully Supported
H5a		Selection>Bouware	**0.034**	**Supported**
H5b		Selection>Conceder	**0.000**	**Supported**
H6	Utility product			Fully Supported
H6a		Selection>Bouware	**0.000**	**Supported**
H6b		Selection>Conceder	**0.000**	**Supported**
	Utility difference			
H6c		Selection<Bouware	**0.000**	**Supported**
H6d		Selection<Conceder	**0.000**	**Supported**

5. CONCLUSIONS

This research proposes a strategy model for automated negotiation system, and experimentally evaluates its effects in the human-computer negotiation. The strategy model is a novel idea for the current automated negotiation research, and should be considered as a requisite strategy to enable the agent dynamically respond the human’s ever-changing offer and get agreement successfully. Experimental results confirmed that, compared with the conventional single fixed strategy, the proposed multi-strategy selection mechanism leads to a higher agreement ratio, better individual utility and joint utility. The contribution of this study leads to further valuable empirical experiences for utilizing agent technology in a human-computer negotiation system, thus expected to bridge the gap between the theoretical and practical aspects of the negotiation system.

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