Automated Strategy Adaptation for Multi-times Bilateral Closed Negotiations

(Extended Abstract)

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ABSTRACT

Bilateral multi-issue closed negotiation is an important class for real-life negotiations. Usually, negotiation problems have constraints such as a complex and unknown opponent's utility in real time, or time discounting. In the class of negotiation with some constraints, the effective automated negotiation agents can adjust their behavior depending on the characteristics of their opponents and negotiation scenarios. Recently, the attention of this study has focused on the interleaving learning with negotiation strategies from the past negotiation sessions. In this paper, we propose an automated agent that estimates the opponent's strategies based on the past negotiation sessions. Our agent tries to compromise to the estimated maximum utility of the opponent by the end of the negotiation. In addition, our agent can adjust the speed of compromise by judging the opponent's Thomas-Kilmann Conflict Mode using past negotiation sessions. In the experiments, we demonstrate that the proposed agent has better outcomes than existing agents.

Categories and Subject Descriptors

I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence - Multi-agent System

Keywords

Automated Multi-issue Negotiation; Agreement Technology

1. INTRODUCTION

Motivated by the challenges of bilateral negotiations between automated agents, the automated negotiating agents competition (ANAC) was organized[1]. The purpose of the competition is to facilitate research in the area of bilateral multi-issue closed negotiation. Recently, the attention of this study has focused on the interleaving learning with negotiation strategies from the past negotiation sessions.

In this paper, we propose an adaptive strategy based on the past negotiation sessions by adjusting the speed of compromising depending on the opponent's strategy, automatically. For judging the opponent's strategy, we need to characterize the opponents in terms of some global style, such as negotiation styles or a known conflict-handling style. One important style is the Thomas-Kilmann Conflict Mode Instrument (TKI)[3]. The TKI is designed to measure a person's behavior in a conflict situation based on the concerns of two people appearing to be incompatible. The proposed agent tries to compromise speedily when the opponent is cooperative and passive. In the experiments, we demonstrate that the proposed agent outperforms the other agents that participated in the qualifying round of ANAC-2013.

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2. NEGOTIATION ENVIRONMENTS

The interaction between negotiating parties is regulated by a negotiation protocol that defines the rules of how and when proposals can be exchanged. The competition used the alternating-offers protocol for bilateral negotiation as proposed in [4], in which the negotiating parties exchange offers in turns.

The parties negotiate over *issues*, and every issue has an associated range of alternatives or *values*. A negotiation outcome consists of a mapping of every issue to a value, and the set Ω of all possible outcomes is called the negotiation *domain*. Both parties have certain preferences prescribed by a *preference profile*, which can be modeled by a utility function U that maps a possible outcome $\omega \in \Omega$ to a real-valued number in the range $[0, 1]$. In contrast to the domain, the preference profile of the players is private information. A bid is a set of chosen values $v_1 \dots v_N$ for each of the N issues (I). Each of these values has been assigned an evaluation value $eval(v_i)$ in the utility space. Each issue has been assigned the normalized weight w_i ($\sum_{i \in I} w_i = 1$) in the utility space. The utility is the weighted sum of the normalized evaluation values. The utility function of the bid($\vec{v} = (v_1, \dots, v_N)$) is defined as $U(\vec{v}) = \sum_{i=1}^{N} w_i \cdot eval(v_i)$. A negotiation lasts a predefined time in seconds (*deadline*). We compute the discounted utility U_D^t of an outcome ω from the undiscounted utility function U: $U_D^t(\omega) = U(\omega) \cdot d^t$($d$:discount factor).

3. COMPROMISE ADAPTATION STRATEGY

3.1 Basic Compromise Strategy

Our agent estimates the alternatives the opponent will offer in the future based on the opponent's offers. Our behavior is decided based on the following equations: $emax(t) = \mu(t) + (1 - \mu(t))d(t)$, $target(t) = 1 - (1 - emax(t))t^{\alpha}$. ($\mu(t)$: the mean of the opponent's offers in our utility space, $d(t)$: the deviation of the opponent's offers in our utility space when the timeline is t, α: a coefficient for adjusting the speed of compromise.) Our agent searches for alternatives whose

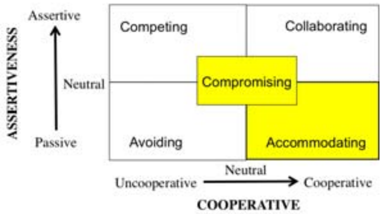

Figure 1: Overview of Thomas-Kilmann Conflict Mode Instrument (TKI)

Table 1: Estimation of Cooperativeness and Assertiveness based on Past Negotiation Sessions

Condition	Cooperativeness
$u(bid_t) > \mu_h$	Uncooperative
$u(bid_t) = \mu_h$	Neutral
$u(bid_t) < \mu_h$	Cooperative

Condition	Assertiveness
$\sigma^2(t) > \sigma_h^2$	Passive
$\sigma^2(t) = \sigma_h^2$	Neutral
$\sigma^2(t) < \sigma_h^2$	Assertive

utility is $target(t)$ by changing the starting points randomly by iteratively deepening the depth-first search method. Our agent judges whether to accept it based on $target(t)$ and the mean of the opponent's offers using the probability of acceptance: $P = \frac{t^5}{5} + (U(\omega) - emax(t)) + (U(\omega) - target(t))$. ($U(\omega)$:our utility of the opponent's offered bid)[2].

3.2 Strategy Adaptation using Past Sessions

An opponent's strategy is predictable based on earlier encounters or an experience profile, and can be characterized in terms of some global style. Thomas-Kilmann Conflict Mode Instrument (TKI)[3] is designed to measure a person's behavior in conflict situations. "Conflict situations" are those in which the concerns of two people appear to be incompatible. In this situation, an individual's behavior has two dimensions: (1) *assertiveness*, the extent to which the person attempts to satisfy his own concerns, and (2) *cooperativeness*, the extent to which the person attempts to satisfy the other person's concerns. These two basic dimensions of behavior define five different modes for responding to conflict situations: Competing, Accommodating, Avoiding, Collaborating, and Compromising as Figure 1 shows.

The left side of Table 1 shows the relationships between the condition and cooperativeness, and the right side of table 1 shows the relationship between the condition and assertiveness. Our agent tries to compromise more and more when the opponent is cooperative and passive, which means the opponent is "accommodating" or "compromising" in the TKI. For judging the opponent's TKI, we employ the past negotiation sessions. The speed of compromising is decided by α in $target(t)$. α is set as a higher value at the first stage, and α is decreased when the opponent is "accommodating" or "compromising."

4. EXPERIMENTAL ANALYSIS

The performance of our proposed agent is evaluated with GENIUS[1], which is also used as a competition platform for ANAC. Nineteen agents were submitted to the competition. The 11 domains were selected from archives submitted by the participants of ANAC-2013. For each pair of agents, under each utility function, we ran a total of 20 negotiations (including the exchange of preference profiles). In other words, 75,240 sessions are run in the qualifying round. The maximum negotiation time of each negotiation session is set to 3 minutes and normalized into the range of $[0, 1]$. Table 2 shows mean scores and variances of all agents.

Table 2: Results of Every Combination among ANAC-2013 Agents

	Agent	Rank	Mean	Variance
1	**Our Agent**	**1**	**0.562**	**0.00019**
2	Agent Slinkhard	2-3	0.522	0.00132
3	TMFAgent	2-4	0.516	0.00163
4	MetaAgent	3-4	0.495	0.00252
5	GAgent	5-8	0.457	0.00241
6	InoxAgent	5-8	0.455	0.00235
7	SlavaAgent	5-11	0.447	0.00018
8	VAStockMarketAgent	5-11	0.446	0.0052
9	RoOAgent	7-11	0.432	0.00313
10	AgentTalex	7-11	0.431	0.00285
11	AgentMRK2	7-11	0.43	0.00344
12	Elizabeth	12-14	0.387	0.00443
13	ReuthLiron	12-15	0.374	0.00416
14	BOAconstrictorAgent	12-15	0.373	0.00141
15	Pelican	13-18	0.359	0.00434
16	Oriel_Einat_Agent	15-18	0.35	0.00534
17	MasterQiao	15-18	0.345	0.00214
18	Eagent	15-18	0.338	0.00707
19	ClearAgent	19	0.315	0.00109

As Table 2 shows, our agent has won by a big margin in the qualifying round of ANAC-2013. Considering the variance among the domains, our agent had advantages compared with other agents. The main reason of it is that our agent tries to improve the speed of making agreements by adjusting $emax(t)$. In addition, our agent tries to compromise positively when the opponent is cooperative. Agents couldn't learn from the past negotiation sessions in the past ANAC; therefore, they tried to find effective agreements by eliciting the opponent's utility in the negotiation session.

5. CONCLUSION

This paper focused on bilateral multi-issue closed negotiation, which is an important class of real-life negotiations. This paper proposed a novel agent that estimates the alternatives the opponent offers based on past negotiation sessions. In addition, our agent could adjust the speed of compromising using the past negotiation sessions. We demonstrated that the proposed method results are good outcomes.

6. REFERENCES

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