GentleS

Takumu Shimizu

Tokyo University of Agriculture and Technology

shimizu@katfuji.lab.tuat.ac.jp

1 Negotiation Management

GentleS inherits *LearningAgent* and negotiates with opponents independently. In addition, GentleS is the agent improved from Gentle which got second place in SCML2021. We don't set utility function and the decision of GentleS is mainly based on the unit price. The following shows the trading information for the basis of the decision.

i : simulation step

j : negotiation step,

t^{nego} : negotiation time

$n_{offer}^{contract}$: number of agreements by Gentle's offer

$n_{accept}^{contract}$: number of agreements by Gentle's accept

p^{max} : maximum unit price of the negotiation

p^{min} : minimum unit price of the negotiation

$p^{best\_contract}$: the best unit price of the agreements with the opponent

$p^{worst\_contract}$: the worst unit price of the agreements with the opponent

$p_{i,j}^{opp\_offer}$: offer price of the opponent on day i, step j

$q_{i,j}^{opp\_offer}$: offer quantity of the opponent on day i, step j

$$p_i^{best\_selling} = \max\left(p_{i,0}^{opp\_offer}, p_{i,1}^{opp\_offer}, \ldots, p_{i,j}^{opp\_offer}\right)$$

$$p_i^{best\_buying} = \min\left(p_{i,0}^{opp\_offer}, p_{i,1}^{opp\_offer}, \ldots, p_{i,j}^{opp\_offer}\right)$$

1.1 Offering Strategy

GentleS determines the offer unit price p^{offer} and the offer quantity q^{offer} based on some trading information. In that case, we divided the negotiation into two parts and determine the offer price based on each strategy. The first part of the negotiation is $0 \leq j \leq 18$, the final part of the negotiation is $j \geq 19$.

Determine price

In the first part of the negotiation, GentleS doesn't have to concede because the acceptable standards of other agents are usually high. Therefore, GentleS determine the offer price by the following formula.

$$p^{offer} = \begin{cases} p^{max} & \text{if selling} \\ p^{min} & \text{if buying} \end{cases}$$

In the final part of the negotiation, it is necessary to determine the appropriate price to agree certainly. The symbols $\prec$ and $\succeq$ are defined as the symbols that indicate whether the price is good or not for Gentle. In the cases, $5 \prec 10$ is true for the seller agent, and $5 \succeq 10$ is also true for the buyer agent. s^{offer} is a slack variable related to the offer, and the larger this value, the more bullish the offer. We set a threshold τ that is the criterion for determining whether a given

price is bad for GentleS or not. Using these, GentleS determine the offer price by the following formula.

$$p^{offer} = \begin{cases} \mathrm{tp}(i) \times (1 + \mathrm{type} \times s_{offer}) & \text{if } n_{accept}^{contract} + n_{offer}^{contract} = 0 \\ p^{worst\_contract} & \text{if } n_{accept}^{contract} \geq 1 \text{ and } p^{worst\_contract} \succeq \mathrm{tp}(i) \\ & \text{or } n_{accept}^{contract} < 1 \text{ and } n_{offer}^{contract} \geq 1 \\ p^{worst\_contract} \times (1 + \mathrm{type} \times 0.1) & \text{if } n_{accept}^{contract} \geq 1 \text{ and } p^{worst\_contract} \prec \mathrm{tp}(i) \end{cases}$$

$$\mathrm{type} = \begin{cases} 1 & \text{if selling} \\ -1 & \text{if buying} \end{cases}$$

$$s_{offer} = 0.1 - 0.4 \times \min\left(\frac{t^{nego}}{0.3}, 1\right)$$

$\mathrm{tp}(i)$: the trading price in the day i

Determine quantity

GentleS considers the quantity of the previous offer and its need q^{need} to make the offer that is more acceptable for the opponent. It's because almost all agents refuse the offer whose quantity is more than their demand. q^{need} is the quantity of external contracts minus that of agreements for the day. Therefore, GentleS determine the offer quantity by the following formula.

$$q^{offer} = \min(q^{need}, q_{i,j-1}^{opp\_offer})$$

1.2 Acceptance Strategy

GentleS determines the acceptable unit price p^{offer} based on some trading information. The quantity is not taken into account, and GentleS continues to negotiate with all opponents until its needs q^{need} are fulfilled. s^{accept} in the equation is a slack variable related to acceptance, and the larger this value, the more concessional acceptance. We set a variable r that is the ratio of the change in the opponent's concession rate.

$$p^{accept} = \begin{cases} \max\left(p_i^{best\_selling}, p^{best\_contract} \times (1 - s_{accept})\right) & \text{if it is a seller} \\ \min\left(p_i^{best\_buying}, p^{best\_contract} \times (1 + s_{accept})\right) & \text{if it is a buyer} \end{cases}$$

$$s_{accept} = \begin{cases} 0.2 & \text{if } r \geq 3 \\ 0 & \text{if } r < 3 \end{cases}$$

$$r = \frac{p_{i,j}^{opp\_offer} - p_{i,j-1}^{opp\_offer}}{p_{i,j-1}^{opp\_offer} - p_{i,j-2}^{opp\_offer}}$$

2 Risk Management

When deciding whether to accept the opponent's offer, GentleS checks if the minimum requirements are fulfilled. The minimum requirements are that accepting the offer is less loss than not accepting and being penalized. Therefore, GentleS checks the following formula is true.

$$\begin{aligned} c^{product} - p_{i,j}^{opp\_offer} &< c^{disposal} && \text{if selling} \\ p_{i,j}^{opp\_offer} + c^{product} - p^{ex} &< c^{shortfall} && \text{if buying} \end{aligned}$$

$c^{product}$: production cost
$c^{disposal}$: disposal cost
p^{ex} : price of exogenous contracts
$c^{shortfall}$: shortfall penalty

3 Evaluation

We tested GentleS in simulations against *LearningAgent* and *AdaptiveAgent*. The results are shown in Table 1.

Table 1: The test results of Gentle

Agent	score	min	Q1	median	Q3	max
GentleS	1.044116	0.960640	1.015330	1.070021	1.085855	1.101688
LearningAgent	1.023410	0.935890	0.998555	1.061219	1.067170	1.073121
AdaptiveAgent	0.835217	0.660423	0.782248	0.904074	0.922614	0.941154

The results show that GentleS is equal to or better than the other agents in all scores. Therefore, GentleS outperforms other agents in many cases. The reason for these results is that GentleS takes into account $p^{worst\_contract}$. $p^{worst\_contract}$ is the price that the opponents use as a criterion to determine whether or not to accept the offer. Hence, offering a price close to $p^{worst\_contract}$ makes it easier for the opponents' agreements.