CS 451
Group Number: 10
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Assignment

1. PREPARATION: ANALYZE NEGOTIATION DOMAIN

a) The main goal of this question is to determine the Nash Point for a holiday negotiation scenario between Agent A and Agent B, based on their preferences for the location, duration, and hotel quality. A result that meets specific negotiating axioms and may be considered a "fair outcome" that is acceptable to both sides is called a Nash solution.

The preferences of Agent A and Agent B were provided. For each issue there are weights and evaluation values.

Utility Function Formula : $u(i1,i2,i3,i4) = w1 \cdot u(i1)+w2 \cdot u(i2)+w3 \cdot u(i3)+w4 \cdot u(i4)$
Given : Antalya, Barcelona, Milan;
1 Week, 2 Weeks;
Hostel, 3 star, 5 star;
Outcomes : 18 Possible Outcomes

1. Antalya, 1 Week, Hostel => (A)= 5.6 ; (B) = 3.4;
2. Antalya, 1 Week, 3 star => (A)= 3.2 ; (B) = 3.4;
3. Antalya, 1 Week, 5 star => (A)= 3.5 ; (B) = 4.1;
4. Antalya, 2 Weeks, Hostel => (A)= 7 ; (B) = 5.8;
5. Antalya, 2 Weeks, 3 star => (A)= 4.6 ; (B) = 5.8;
6. Antalya, 2 Weeks, 5 star => (A)= 4.9 ; (B) = 3.4;
7. Barcelona, 1 Week, Hostel => (A)= 8.6 ; (B) = 2.9;
8. Barcelona, 1 Week, 3 star => (A)= 6.2 ; (B) = 2.9;
9. Barcelona, 1 Week, 5 star => (A)= 6.5 ; (B) = 3.6;
10. Barcelona, 2 Weeks, Hostel => (A)= 10 ; (B) = 5.3;
11. Barcelona, 2 Weeks, 3 star => (A)= 7.6 ; (B) = 5.3;
12. Barcelona, 2 Weeks, 5 star => (A)= 7.9 ; (B) = 6;
13. Milan, 1 Week, Hostel => (A)= 4.6 ; (B) = 6.9;
14. Milan, 1 Week, 3 star => (A)= 2.2 ; (B) = 6.9;
15. Milan, 1 Week, 5 star => (A)= 2.5 ; (B) = 7.6;
16. Milan, 2 Weeks, Hostel => (A)= 6 ; (B) = 9.3;
17. Milan, 2 Weeks, 3 star => (A)= 3.6 ; (B) = 9.3;
18. Milan, 2 Weeks, 5 star => (A)= 3.9 ; (B) = 10;

The Nash Point was found to be the holiday package with a stay in 'Milan' for '2 weeks' at a 'Hostel':Agent A's Utility: 6.0Agent B's Utility: 9.3. Number 16.

b) For this part, we started by running the negotiation without adding any reservation values to the agent's utility function. Next, we tried adding a reservation value of 0.5 just for agent A. That made agent A act differently compared to before. The graph for agent A showed less of a drop and stayed more stable. This suggests that agent A became more rigid and less likely to give in because of the reservation value. After that, we switched agent A back to its original settings and gave agent B a reservation value of 0.2. That made agent B become more insistent, so agent A ended up conceding more than before. Lastly, we gave both agents the same reservation values. The output looked like a mix of the previous situations. The graphs were less curvy, similar to when only agent A had a reservation value, but the drop wasn't as big, as when only agent B had a reservation value. So, it's clear that reservation values make agents more stubborn and less likely to give in.

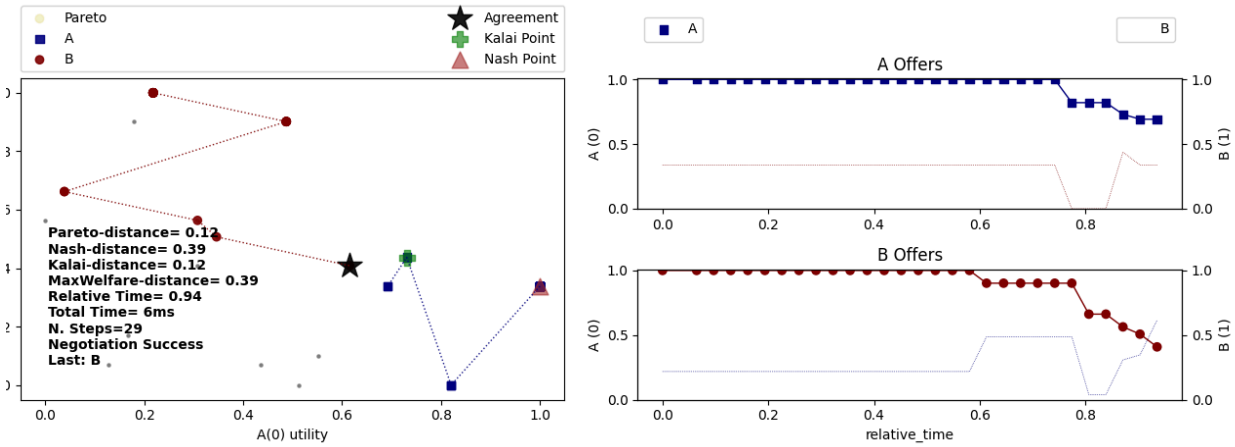

Fig. 1. Reservation value added to both(A=0.5, B=0.2)

2. DESIGN A NEGOTIATION STRATEGY

a) For this project, we are going to combine “A Tit for Tat Negotiation Strategy” with “HardHeaded”. In that strategy, we define a threshold utility value that cannot be passed under and the acceptance value. First, our agent tracks the initial moves. For the first moves, our agent follows a tit-for-tat strategy; however, when the opponent starts to make consecutive moves, it goes with the hardheaded strategy. Our agents get the idea of the opponent with those moves. For instance, if the opponent keeps trying to decrease our utility, our agent will understand that the opponent is trying to exploit us by going aggressive. On the other hand, if it keeps increasing our utility value, our agent infers that the opponent can be exploited. In both cases, our agent won’t concede like in the hardheaded strategy. In the end, our agent increases the bid no matter what to create time pressure and accepts the offer in the last move if it is equal to or more than the acceptance value. Here is the PEAS description for our agent:

- Performance measure: To measure our performance, total gained utility from negotiation is our priority. Our agent tries to get as much possible utility from the negotiation by exploiting conceding opponents and standing its ground when facing an aggressive opponent. Also, it will try to exploit other strategies to gain more utility in the end. For instance, some strategies concede more to reach an agreement when the deadline is near for agreement. Our agent also will try to exploit that by going more aggressive in the end. By the last move, if it exceeds the acceptance value, it will accept the offer with the possible maximum utility.

- Environment: First of all, our agent will have a threshold utility value that it cannot bid under. Also to time constraints, our agent will not tend to concede but becomes more rigid when the negotiation reaches the end. It will do that to get more utility by exploiting well-known time-restrained strategies. To test that, we will run it against a time-conceding opponent to see how it will be effective against such agents. Also, we plan to run a negotiation with Boulware strategy using agent to see how resilient our agent is against an aggressive opponent.

- Actuators: For our actions, first, we will mimic the opponent to get an idea. If it is not making the same consecutive moves, our agent keeps mimicking. When the deadline of the negotiation is near, our agent goes aggressive no matter what to get more value. On the other hand, if the opponent makes the same consecutive moves, it will increase the bid no matter what. Accepts the offer if it is more or equal to the acceptance value. Otherwise, reject it.

- Sensors: For sensors, our agent will track the opponent's moves by making the same moves(increases bid if opponent increases, decreases bid if opponent decreases). If it makes a specific number of consecutive actions, the type of our opponent will be decided. If it keeps increasing the bid, it will be known as an aggressive opponent; however, if it keeps decreasing the bid, our agent will decide that our opponent can be exploitable.

b) The BOA framework divides negotiation strategies into these three main components : Bidding Strategy, Opponent Model, and Acceptance Strategy. Our goal in this project is to create a negotiating agent that competently combines the aggressiveness of the "HardHeaded" method with the adaptability of a "Tit for Tat" strategy. This hybrid strategy is carefully designed to maneuver through a variety of negotiating situations by constantly modifying its approach in response to the opponent's actions. The foundation of our approach is the definition of an acceptable utility value, an unassailable minimum that protects our agent's interests while allowing for mutually advantageous agreements.
In order to obtain important information about the opponent's approach, our agent starts the negotiation by imitating their first movements. It takes a "HardHeaded" approach to opponents that try to reduce our utility, maintaining competition and concentrating on optimizing results. Conversely, the agent detects opportunities for exploitation and modifies its approach when the opponent seems to be boosting our utility.

In order to get advantageous conditions, our agent grows more forceful as the negotiation draws closer to its deadline. In order to maximize the outcome of the negotiation without sacrificing usefulness, it is intended to accept proposals that either meet or surpass an initial acceptance value in the final seconds.
BOA Framework :

- Bidding Strategy
    - The bidding method used by our agent takes a double approach. It mimics the opponent's movements at first to figure out their tactics and preferences. Establishing baseline expectations and equal responsiveness are crucial during this phase. When the negotiation goes on, the agent becomes more aggressive if it senses the other side is trying to minimize our value. This strategic adaptability prioritizes maximizing our utility by enabling adaptive response based on the opponent's actions.

- Opponent Model
    - Using machine learning and statistical methodologies, we analyze the opponent's bid history in detail in order to determine their strategic goals and preferences, which is then used to model their reservation value. This analysis is essential for optimizing our agent's bid and acceptance tactics, guaranteeing a comprehensive and deep understanding of the other party's negotiation strategy.

- Acceptance Strategy
    - Our agent's acceptance method involves evaluating the opponent's offer's utility in relation to a dynamic threshold, taking into account both the offer's current usefulness and the possible utility of future offers. In order to make sure that our acceptance choices are in line with our overall negotiating objectives, this strategic review is based on decision-making frameworks that evaluate the expected value of holding out for better offers.

Evaluation : Our evaluation includes a methodical testing against agents with different tactics, evaluating our bidding strategy's efficacy, our opponent model's correctness, and how well our acceptance approach uses negotiation dynamics. These tests verify our agent's durability and flexibility.

Lessons and Suggestions : Our experience on this project made us realize that for a project like this we need more detailed research and more sophisticated machine learning techniques for a better understanding of our opponents and modify our plans by that/them.

Conclusion : This project showed us a negotiation agent using a hybrid strategy within the BOA framework may be successfully designed and in future implemented. Our research shows agent's capacity to provide better negotiation results and provide important information for the creation of flexible negotiating tactics
Reference : https://link.springer.com/chapter/10.1007/978-3-642-30737-9_18
https://link.springer.com/chapter/10.1007/978-3-642-30737-9_17