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University of Ruse “Angel Kanchev”

MULTIAGENT SYSTEM WITH ARTIFICIAL INTELLIGENCE

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08,2022

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LECTURE 5

Decisions in solving distributed tasks

1. Game theory in negotiation
2. Nash equilibrium
3. Prisoners’ dilemma
4. Bargain
5. Voting
6. Auctions
7. Heuristic-based negotiation

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Negotiation

Part of negotiations are:

- language for communication
- negotiation protocol
- decision process by which an agent decides upon its position, concessions, criteria for agreement, etc.

Single party **or** multi-party negotiation: one to many or many to many

May incorporate a single shot message by each party or discussion with a few messages going back and forth

Negotiation techniques are:

- Game theoretic negotiation
- Heuristic-based negotiation
- Argument-based negotiation

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Evaluation

Criteria to evaluate negotiation protocols among self-interested agents

Agents are supposed to behave rationally

Rational behavior = an agent prefers a greater utility (payoff) over a smaller one

Payoff maximization: individual payoffs, group payoffs, or social welfare

Social welfare

- The sum of agents' utilities (payoffs) in a given solution.
- Measures the global good of the agents
- Problem: how to compare utilities

Pareto efficiency

- Measures global good, does not require utility comparison

Individual rationality (IR)

Stability

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Nash equilibrium

It is a game theory concept

- determines the optimal solution in a non-cooperative game in which each player lacks any incentive to change his/her initial strategy;
- a player does not gain anything from deviating from their initially chosen strategy, assuming the other players also keep their strategies unchanged.

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The Prisoner's Dilemma

- The title comes from Albert Tucker who, whereas instructing at Stanford College, brought the diversion to life. He told of two burglars captured by police close the scene of a burglary. The two were taken absent and set in several meet rooms. Each suspect was examined and told they must carefully select whether to confess and involve the other.
- Without confessions, the police seem as it were charge them with minor guns charges coming about in a one-year jail sentence. Ought to both burglars confess and involve the other, they would each serve 10 a long time behind bars. Be that as it may, in case one burglar confesses and ensnares the other, whereas the other doesn’t, at that point the one who collaborated with police would go free whereas the assistant would serve 20 a long time in jail.

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The Prisoner's Dilemma

- Two men are collectively charged with a crime and held in separate cells. They have no way of communicating with each other or making any kind of agreement. The two men are told that:
  - if one of them confesses to the crime and the other does not, the confessor will be freed, and the other will be jailed for three years;

  and

  - if both confess to the crime, then each will be jailed for two years.

Both prisoners know that if neither confesses, then they will each be jailed for one year.

Prisoner 1 (columns) / *Prisoner 2* (rows)

Prisoners	Don't confess	Confess
Don't confess	Win/Win	Lose Much / Win much
Confess	Win Much / Lose much	Lose/Lose

The Prisoner's Dilemma

The 'standard' approach to this problem could be to put yourself in the place of a prisoner, and reason as follows.

- Suppose I cooperate. Then if **j** cooperates, we will both get a payoff of 3. But if **j** defects, then I will get a payoff of 0. So the best payoff I can be guaranteed to get if I cooperate is 0.
- Suppose I defect. Then if j cooperates, then I get a payoff of 5, whereas if j defects, then I will get a payoff of 2. So the best payoff I can be guaranteed to get if I defect is 2.

So, if I cooperate, the worst case is I will get a payoff of 0, whereas if I defect, the worst case is that I will get 2.

I would prefer a guaranteed payoff of 2 to a guaranteed payoff of 0, so I should defect.

Since the scenario is symmetric (i.e. both reason the same way), then the outcome that will emerge - if both agents reason 'rationally' - is that both agents will defect, giving them each a payoff off 2.

Bargain

- In a transaction when the seller and the buyer value a product differently, a surplus is created. A bargaining solution is then a way in which buyers and sellers agree to divide the surplus.
- For Example: A – car 15000, B – car 25000
- Trade leads to the generation of a surplus that should not occur
- A negotiated settlement provides an acceptable way to divide the surplus between the two parties.

Voting

- Truthful voters - Rank feasible social outcomes based on agents' individual ranking of those outcomes
- Social choice rule
- Binary protocols
- Pluralist protocols

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Auctions

- The auctioneer wants to sell an item at the highest possible payment and the bidders want to acquire the item at the lowest possible price
- A centralized protocol, includes one auctioneer and multiple bidders
- The auctioneer announces a good for sale. In some cases, the good may be a combination of other goods, or a good with multiple attributes
- The bidders make offers. This may be repeated for several times, depending on the auction type
- The auctioneer determines the winner

Auction characteristics:

- Simple protocols
- Centralized
- Allows collusion “behind the scenes”
- May favor the auctioneer

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Auctions

- Auction settings
    - Private value auctions: the value of a good to a bidder agent depends only on its private preferences. Assumed to be known exactly
    - Common value auctions: the good's value depends entirely on other agents' valuation
    - Correlated value auctions: the good's value depends on internal and external valuations

- Auction protocols

English (first-price open cry) auction - each bidder announces openly its bid; when no bidder is willing to raise anymore, the auction ends. The highest bidder wins the item at the price of its bid.

Strategy:

In private value auctions the dominant strategy is to always bid a small amount more than the current highest bid and stop when the private value is reached.

In correlated value auctions the bidder increases the price at a constant rate or at a rate it thinks appropriate

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Auctions

- Auction protocols

First-price sealed-bid auction - each bidder submits one bid without knowing the other's bids. The highest bidder wins the item and pays the amount of his bid.

Strategy:

No dominant strategy

Bid less than its true valuation but it is dependent on other agents bids which are not known

Dutch (descending) auction - the auctioneer continuously lowers the price until one of the bidders takes the item at the current price.

Strategy:

Strategically equivalent to the first-price sealed-bid auction

Efficient for real time

Auctions

- Auction protocols

Vickery (second-price sealed-bid) auction - each bidder submits one bid without knowing the other's bids. The highest bid wins but at the price of the second highest bid

Strategy:

The bidder dominant strategy is to bid its true valuation

All-pay auctions - each participating bidder has to pay the amount of his bid (or some other amount) to the auctioneer

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Auctions

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Heuristic-based negotiation

- Creates a good rather than an optimal solution
- Heuristic-based negotiation:
  - Computational approximations of game theory techniques
  - Informal negotiation patterns
- There is no central intermediary
- Speeches are private between negotiating agents
- The protocol does not prescribe an optimal course of action
- A central concern: the agent's heuristic decision-making during negotiation

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Argumentation-based negotiation

- Arguments used to persuade the party to accept a negotiation proposal
- Different types of arguments
- Each argument type defines preconditions for its usage. If the preconditions are met, then the agent may use the argument.
- The agent needs a strategy to decide which argument to use
- Most of the times assumes a BDI model

Appeal to past promise - the negotiator *A* reminds agent *B* of a past promise regarding the NO, i.e., agent *B* has promised to the agent A to perform or offer NO in a previous negotiation.

Preconditions: *A* must check if a promise of NO (future reward) was received in the past in a successfully concluded negotiation.

Argumentation-based negotiation

Promise of a future reward - the negotiator A promises to do a NO for the other agent A at a future time.

Preconditions: A must find one desire of agent B for a future time interval, if possible a desire which can be satisfied through an action (service) that A can perform while B can not

Appeal to self interest - the agent *A* believes that concluding the contract for NO is in the best interest of *B* and tries to persuade *B* of this fact.

Preconditions: *A* must find (or infer) one of *B* desires which is satisfied if *B* has NO or, alternatively, *A* must find another negotiation object NO' that is previously offered on the market and it believes NO is better than NO'.

Threat - the negotiator makes the threat of refusing doing/offering something to *B* or threatens that it will do something to contradict *B*'s desires.

Preconditions: *A* must find one of *B*'s desires directly fulfilled by a NO that *A* can offer or *A* must find an action that is contradictory to what it believes is one of *B*'s desires.

References

1. Adnan, Muhamad Hariz Muhamad; Hassan, Mohd Fadzil; Aziz, Izzatdin; Paputungan, Irving V, "Protocols for agent-based autonomous negotiations: A review". 2016 3rd International Conference on Computer and Information Sciences (ICCOINS). Kuala Lumpur, Malaysia: IEEE: 622–626. doi:10.1109/ICCOINS.2016.7783287.
2. Durfee, Edmund. (2001). Distributed Problem Solving and Planning.. 118-149.
3. Michael Wooldridge, An Introduction to Multiagent Systems, 2009
4. Russel, S. and Norvig, P. Artificial Intelligence: A Modern Approach, fourth edition, Pearson, 2022
5. Smith, "The Contract Net Protocol: High-Level Communication and Control in a Distributed Problem Solver," in IEEE Transactions on Computers, vol. C-29, no. 12, pp. 1104-1113, Dec. 1980, doi: 10.1109/TC.1980.1675516.
6. Davis, R. and Smith, R. Negotiation as a Metaphor for Distributed Problem Solving Artificial Intelligence 20, pp. 63-109, 1983. Winner of the 2006 Influential Paper Award
7. A. M. Mohamed and M. N. Huhns, "Benevolent agents in multiagent systems," Proceedings Fourth International Conference on MultiAgent Systems, 2000, pp. 419-420, doi: 10.1109/ICMAS.2000.858504.
8. David Poole, Alan Mackworth, Artificial Intelligence: Foundations of Computational Agents, second edition, Cambridge University Press 2017 (Available at https://artint.info/index.html)

References

9. T.W. Sandholm. Distributed rational decision making. In Multiagent Systems - A Modern Approach to Distributed Artificial Intelligence, G. Weiss (Ed.), The MIT Press, 2001, p.201-258.

10. J.S. Rosenschein, G. Zlotkin. Designing conventions for automated negotiation. In Readings in Agents, M. Huhns & M. Singh (Eds.), Morgan Kaufmann, 1998, p.253-370.

11. M.P. Wellman. A market-oriented programming environment and its applications to distributed multicommodity flow problems. Journal of Artificial Intelligence Research, 1, 1993, p.1-23.

12. N.R. Jennings, e.a., Automated negotiation: prospects, methods, and challenges, Journal of Group Decision and Negotiation, 2000.

13. S. Kraus, K. Sycara, A. Evenchik, Reaching agreements through arumentation: a logical model and implementation, Artificial Intelligence, Elsevier Science, 104, 1998, p. 1-69.

14. A. Florea, B. Panghe. Achieving Cooperation of Self-interested Agents Based on Cost”, In Proceedings of the 15th European Meeting on Cybernetics and System Research, Session: From Agent Theories to Agent Implementation, Vienna, 2000, p.591-596

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