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Machine learning for negotiating agents

Learning a Latent Representation of the Opponent in Automated Negotiation

TU Delft

CSE3000 Research Project

01. Background

- Machine learning methods are becoming more popular in the field of automated negotiation
- PPO [1] is a SOTA, sample efficient reinforcement learning algorithm
- A latent representation (opponent model) contains information about different aspects of the opponent
  - Acceptance strategy
  - Reservation value
  - Preferences
  - Bidding strategy

02. Research question

- Can we learn a latent representation of an opponent and use it to improve our strategy?

03. Methodology

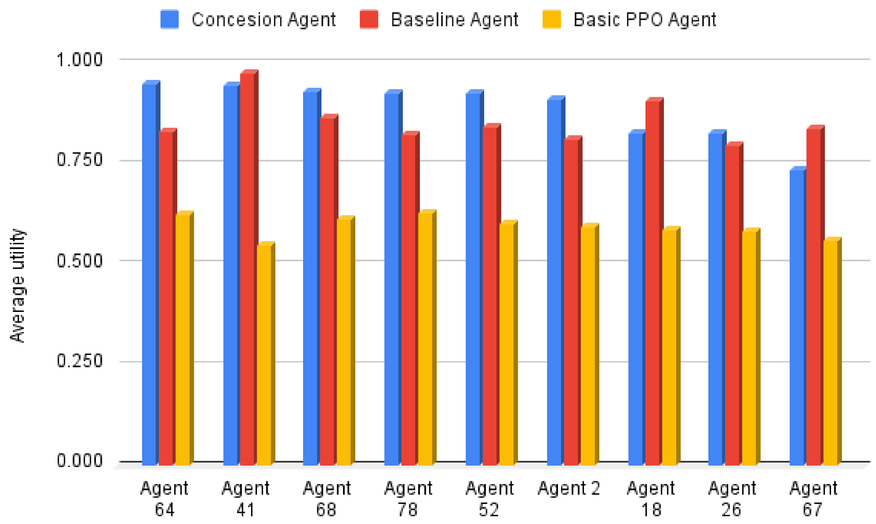
- Bilateral negotiation using the Alternating Offers protocol
- Learning how the opponent concedes and extracting a value [2]
- Input state:
  - Concession Balance
  - Opponent concession parameter
  - Progress [0,1]
- Trained by negotiating against CSE3210 opponents, over a range of 50 domains
- Tested by running 50 sessions against each opponent from the test set

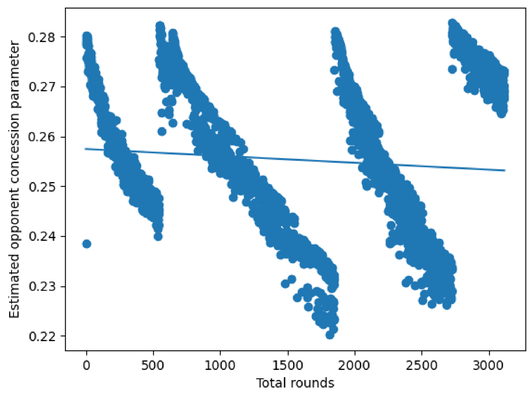
$$Balance = \sum(Concession_{own} - Concession_{opp})$$

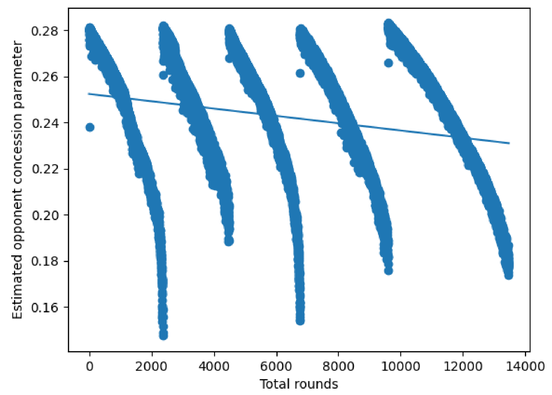
$$Concession_{own} = U_{own}(\omega_{previous}) - U_{own}(\omega_{latest})$$

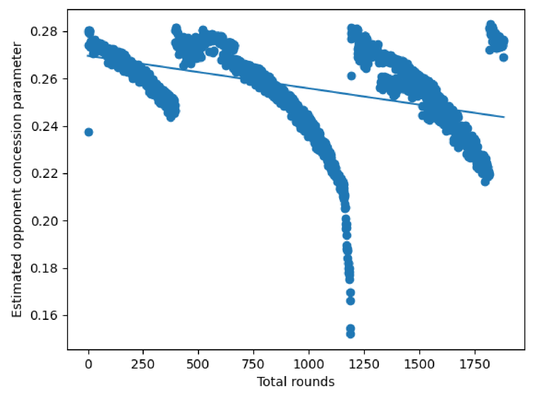
$$Concession_{opp} = U_{opp}(\omega_{previous}) - U_{opp}(\omega_{latest})$$

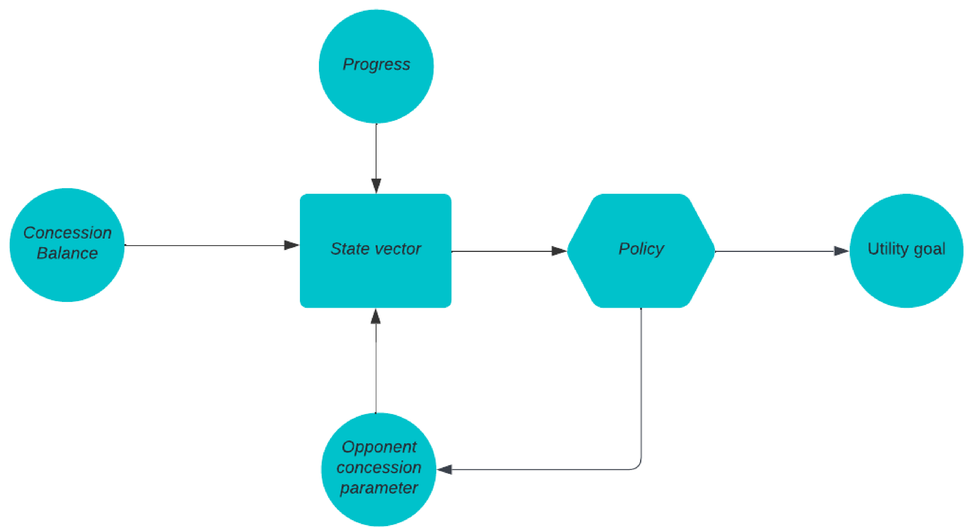
04. Results











05. Analysis

- Concession Agent outperforms the baseline against 6 out 9 agents
- Performance does not improve after repeated negotiation sessions against the same opponent
- Sensitive to the concession balance, it will concede by a small margin when the opponent begins to concede, while still retaining high utility
- The opponent concession parameter decreases as the session progresses
- The state vector is dependent on the accuracy of the opponent model

References

- [1] Schulman, J., Wolski, F., Dhariwal, P., Radford, A., & Klimov, O. (2017). Proximal Policy Optimization Algorithms.
- [2] Yasumura, Y., Kamiryo, T., Yoshikawa, S., & Uehara, K. (2009). Acquisition of a concession strategy in multi-issue negotiation. Web Intelligence and Agent Systems, 7(2). doi: 10.3233/WIA-2009-0160