Topics in Computational Game Theory

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1 Description

The "Computational Game Theory" is an umbrella title for a course that briefly introduces several research areas, all in some way related to computation and algorithms. These range from applied algorithmic techniques to more philosophical models. On one hand, the topics include mechanism design and game theory problems that are too difficult to solve on paper and therefore require a computer solver (the field of algorithmic mechanism design). On the other hand, we will also cover ways to predict the outcomes of learning and evolutionary processes, and problems where agents have restricted computational abilities or are themselves machines with open source code.

2 Prerequisities

Some familiarity with basic (undergraduate level) game theory and microeconomics, e.g: what a game and a Nash equilibrium is, how to solve simple microconomics optimization problems etc.

I am very happy to provide references and work out the missing parts if necessary.

Coding experience is not required.

3 Evalutation

There will be a few short assignments to motivate discussion. For example, submitting a strategy for a version of Axelrod tournament or finding what the strategies converge to. Given participation in class, I would not expect preparation to take more than 30-60 minutes per week.

4 Topics / Plan

Part I: Game design

1. **Algorithmic mechanism design. Classic games.**

   Automated mechanism design (Sandholm, 2003). Selfish routing, combinatorial auctions, bidding languages, network formation (Nisan et al., 2007).

2. **Mechanism design without money.** When taking turns paying for coffee at VLF cafeteria optimal?

   Matching problems. Chore allocation problem. (Miller, 2012)

Part II: Game is given

3. **Evolutionary game theory.**

   Axelrod's tournaments and extensions (Axelrod, 1980), Moran process, evolutionary stable strategies, etc.

4. **Reinforcement learning.** "Ai economist" (Zheng et al., 2020), learning optimal tax schedules for non-convex environments in a black box. "Uncoupled" dynamics.

5. **Convergence and stochastic stability.** Two simple algorithms learn to play each other for a long time, what is the outcome?

   Complexity of finding Nash equilibria. Potential games. Weak acyclicity, spanning trees, perturbed dynamics (Foster and Young, 1990), Q-learning in Bertrand (Calvano et al., 2020) and medium/long-term dynamics in Levine and Modica (2016) model of a rise of communism in China.

6. **Revealed strategies.** Can we learn what people/algorithms intend to do in repeated games by only observing their actions?

   Finite histories, automata, empirical methods (Dal Bó and Fréchette, 2018; Dal Bó and Fréchette, 2019; Camera et al., 2012), etc.

7. **Advanced and extra topics.** Algorithmic information design, game theory with known source code, possibly other applied topics TBD with the group.

(Some) References

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