Computational Game theory

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1 Course description

Non-cooperative game theory is a branch of game theory for the resolution of conflicts among players (agents), each behaving selfishly to optimize one's own well- being subject to resource limitations and potentially other restrictions coming from rival's actions. While being a standard modelling technique in economics, the Nash paradigm recently received further attention in connection with adversarial machine learning and multi-agent reinforcment learning, as well as challenging problems in distributed optimal control. The quest for efficient numerical algorithms and the analysis of their complexity thus became an important question in the modern theory of computational game theory. In this course we will introduce the basic tools of these modern techniques.

2 Course timeline

Dates	Topic	Time
9.12.2026	Introduction to Normal form games	9:00-12:00
10.12.2026	LP Formulation for Zero-Sum games	10:00-12:00
16.12.2026	Elements of Mathematical Programming	10:00-12:00
17.12.2026	Potential and congestion games.	10:00-12:00
18.12.2026	Finite-Dimensional Variational Inequalities	10:00-12:00
21.12.2027	Online learning and regret minimization in games.	10:00-12:00
11.01.2027	Online learning and regret minimization in games.	10:00-12:00
13.01.2027	Learning dynamics and equilibrium selection	10:00-12:00
19.01.2027	Markov decision processes	10:00-12:00
20.01.2027	Stochastic games and multi-agent reinforcement learning	10:00-12:00
25.01.2027	Stochastic games and multi-agent reinforcement learning	9:00-12:00

3 Assessment

In order to successfully pass the course, the following assessement criteria need to be satisfied:

1. Handing in take home assignments (20 points)
2. Presentation (20 points)
3. Oral exam (60 points)

In total students can reach 100 points.

The grading of the course follows the scheme below: Genügend ≥ 50 , Befriedigend ≥ 60, Gut ≥ 70, Sehr gut ab ≥ 80.

4 Design of the course

The course is a combination of lectures and tutorial style classes.

5 Learning outcomes

After completing this course, students will know how to model multi-agent and strategic optimization problems in large-scale settings. They will be aware of computational approaches to Nash equilibrium, as well as learning approaches. Modern applications, like multi-agent reinforcement learning will be discussed as well.

6 Recommended literature

There will be self-contained lecture notes made available at the beginning of the course. Complementary readings are:

1. Maschler, Michael, Shmuel Zamir, and Eilon Solan. Game theory. Cambridge University Press, 2020.
2. A Modern Introduction to Online Learning by Francesco Orabona
3. Cesa-Bianchi, N., & Lugosi, G. (2006). Prediction, learning, and games. Cambridge: Cambridge university press.
4. Albrecht, S. V., Christianos, F., & Schäfer, L. (2024). Multi-agent reinforcement learning: Foundations and modern approaches. MIT Press.