

Algorithmic Game Theory

Martin Hoefer

General Information

Winter 2024/25

What is this course about?

Dynamic systems with rational users and interaction, e.g.

- ▶ Rational Behavior, Incentives, and Stability in Resource Allocation (in Computer Networks)



- ▶ Mechanism Design, Allocation, and Pricing in (Online) Markets (Auctions, Sponsored Search, Platform Markets...)



- ▶ Algorithmic Aspects of Social Networks



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- ▶ ... an **analytic approach** for modelling, and
- ▶ ... a variety of **mathematical tools** for analysis.

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We study **algorithmic optimization** and **search problems** in game theory and foundational models for applications.

Topics and Applications

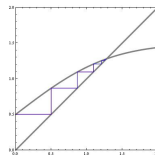
Traffic Routing

- ▶ Users are units (e.g., cars or packets)
- ▶ Each user routes in a selfish way
- ▶ Is there a stable routing they agree upon?
- ▶ What if users dynamically react to delays?



Convergence and Learning

- ▶ Natural behavior in competitive scenarios?
- ▶ Does such behavior lead to convergence?
- ▶ How long does it take to converge?
- ▶ Can agents learn to play “optimally”?



Topics and Applications

Matching and Allocation with Preferences

- ▶ Users strive to match up in pairs (dating, kidney exchange, etc)
- ▶ They have preferences over their matches
- ▶ Does a stable matching exist?
- ▶ Can it be computed efficiently?



Market and Mechanism Design

- ▶ Selling and Buying of Goods and Services
- ▶ Design good allocation algorithms
- ▶ Avoid manipulation of users
- ▶ Fairness properties of the allocation



Methods and Analysis

We are interested in **properties**, **models** and **algorithms** for scenarios involving dynamic decision making.

- ▶ **Stability:** Is there a stable state in a system?
- ▶ **Learning:** What if users use learning to adapt their actions?
- ▶ **Convergence:** Does the interaction of users lead to stability?
- ▶ **Design:** How to optimize in the presence of incentives and uncertainty?
- ▶ Approximation Algorithms and Computational Complexity

This is a **theory course**, so...

- ▶ Fundamental models capturing the essence of competition
- ▶ Agent behavior governed by game-theoretic assumptions
- ▶ Analysis of equilibrium properties and algorithm design
- ▶ Mathematically rigorous analysis by proving lemmas and theorems

- ▶ Prerequisites:
Introductory-Level Background in Algorithms, Graphs, Probability, and Linear Programming.
- ▶ Course sessions on Mon 10:30h (AH III) and Tue 10:30h (AH II).
- ▶ Lecture will mostly be given by writing on the board.
- ▶ Course Webpage:
Algorithms & Complexity → Lehre Winter 24/25 → AGT

Organizational

- ▶ Teaching Assistants: Rilind Sahitaj, Sukanya Pandey
- ▶ Exercises every week. Sign up via Moodle asap
- ▶ Sheet published online on Tuesday of week i .
(first sheet: next week, Oct 15)
- ▶ Solutions due Tuesday week $i + 1$, **23:55pm**.
(via Moodle).
- ▶ Discussion in week $i + 1$.
- ▶ Solutions should be handed in by **groups of 3 students**.
- ▶ Correction rules and bonus: TBD