CUHK-Shenzhen

DDA6210 Algorithmic Game Theory

Course Outline

1. Course identity

Course as listed in CUHK-Shenzhen

Course code	DDA6210
Course title (English)	Algorithmic Game Theory
Course title (Chinese)	算法博弈论
Units	3
Description (English)	Algorithmic game theory is a young research area at the intersection of theoretical computer science, mathematics and economics that deals with the algorithmic aspects of computing optimal strategic behavior. In this course, particular attention will be paid to algorithmic aspects of game-theoretic solution concepts such as Nash equilibrium and to the abstract design of economic mechanisms that negate the Price of Anarchy, where self-interest always results in a degraded system in terms of economic performance. The focus of the course is centered around the following questions: what game-theoretic tools offer scalable algorithmic solutions for Internet applications? How far is the performance of a decentralized system from optimality due to the conflict of interests of its users? How can we make such a system robust with respect to strategic manipulation? To address these fundamental problems at the interface of computer science and game theory, we put emphasis on computational aspects: the appropriate algorithms and computational complexity. The main focus will be on resource allocation mechanisms and auction design, algorithms for equilibria, the complexity of equilibria and fixed points, algorithmic tools in mechanism design, learning in games, and the price of anarchy.
Description (Chinese)	算法博弈论是理论计算机科学、数学和经济学的一个年轻交叉研究领域，研究计算最优策略行为的算法方面。 在本课程中，将特别关注博弈论解决方案概念的算法方面，例如纳什均衡，以及否定无政府状态价格的经济机制的抽象设计，在这种情况下，自利在经济表现方面总是会导致系统退化。 本课程的重点围绕以下问题：哪些博弈论工具为互联网应用提供可扩展的算法解决方案？ 由于用户的利益冲突，去中心化系统的性能离最优有多远？ 我们怎样才能使这样一个系统在战略操纵方面更加稳健？ 为了解决计算机科学和博弈论接口上的这些基本问题，我们将重点放在计算方面：适当的算法和计算复杂性。 主要关注点是资源分配机制和拍卖设计、均衡算法、均衡和不动点的复杂性、机制设计中的算法工具、博弈中的学习以及无政府状态的代价。

Corresponding course in CUHK

Course code	CSCI 5350
Course title (English)	Advanced Topics in Game Theory
Course title (Chinese)	博弈論高級專題
Units	3
Description (English)	This course covers fundamental concepts in game theory. The course starts with pure strategy and mixed strategy Nash equilibrium in strategic games. It then discusses some specific types of games, including zero-sum games, Bayesian games, and introduces other types of equilibriums including correlated equilibrium and evolutionary equilibrium. Extensive games, subgame perfect equilibrium, sequential equilibrium, framing effects, behavioural strategies will then be discussed. Finally, coalitional games and the core will be discussed. Advisory: Students are expected to have taken CSCI2110 or ENGG2440 or ESTR2004, ENGG2040 or ENGG2430 or ESTR2002.
Description (Chinese)	本科講授博弈論的基本概念。首先討論策略博弈中的純策略和混合策略納什均衡。隨之介紹一些特別博弈，如零和博弈、貝葉斯博弈，和其他種類的均衡，包括相關均衡和演化均衡。隨之講授擴展博弈、子博弈精煉均衡、貫序均衡、設計效應、行爲策略。最後討論聯盟博奕和核心。 建議：學生應曾修讀 CSCI2110 或 ENGG2440 或 ESTR2004, ENGG2040 或 ENGG2430 或 ESTR2002。

2. Prerequisites

Any advanced undergraduate course or a graduate course on algorithms or theory of computation. Discrete mathematics. Probability.

3. Learning outcomes

By the end of the course, students will be able to:

(1) **Recognize** strategic behavior and incentive issues in real-world applications.

(2) **Propose** a game-theoretic model for a real-world phenomenon.

(3) **Apply** concepts from algorithmic game theory to **analyze** equilibria, learning dynamics, and the inefficiency arising from players' strategic behavior in the proposed model.

(4) **Design** a mechanism (such as an auction, a contract, or an information structure) to achieve certain objectives.

(5) **Analyze and evaluate** the proposed mechanism using appropriate criteria, such as welfare, revenue, incentive compatibility, and computational complexity.

4. Course syllabus

13 weeks of teaching:

- Game theory basics (0.5 week)
- Inefficiency of equilibrium: price of anarchy (0.5 week)
- Mechanism design: auctions & contracts (4 weeks)
- Mechanism design without money: stable matching & fair allocation (1 week)
- Equilibrium computation: learning & complexity (4 weeks)
- Information economics: elicitation & design (2 weeks)
- Quizzes (1 week)

+ 2 weeks of student presentations.

5. Indicative teaching plan

2027 Spring semester time:

- Jan 11 ~ Jan 24, Tue & Thu, 15:30 - 17:00. (2 weeks)

- Feb 15 ~ May 14, Tue & Thu, 15:30 - 17:00. (13 weeks)

Location: TB 303

Week	Content/ topic/ activity
1	Introduction: Key concepts in (algorithmic) game theory. Price of anarchy: selfish routing.
2	Mechanism design basics: auctions & incentives. Welfare maximization: VCG auctions.
3	Revenue maximization: Myerson auctions.
4	Simple versus optimal mechanisms: posted price, prophet inequality. Prior-independent mechanisms: Bulow-Klemperer.
5	Case study: sponsored search auctions, spectrum auctions.
6	Contract design. **[Quiz 1]**
7	Mechanism design without money: stable matching & fair allocation.
8	Potential games & best-response dynamics. Equilibrium hierarchy: Nash, correlated, and coarse correlated equilibria.
9	No-regret dynamics & CCE. Swap-regret dynamics & CE.
10	Minimax theorem. Equilibrium computation: Lemke-Howson.
11	Equilibrium complexity: PLS, PPAD. **[Quiz 2]**

Week	Content/ topic/ activity
12	Information elicitation: scoring rules. Information design: Bayesian persuasion.
13	Cooperative game theory: coalitional games, core. Case study: data valuation via Shapley value.
14	Project presentations.
15	Project presentations.

6. Assessment scheme

Component/ method	% weight
Participation	10
Homework	20
Quiz 1	30
Quiz 2	30
Presentation	10

7. Course components

Activity	Hours/week
Lectures	3
Instructor office hour	1
TA office hour	1

8. Reading

Recommended reading

- Twenty Lectures on Algorithmic Game Theory, by Tim Roughgarden, Cambridge Books, Cambridge University Press, 2016.
- Algorithmic Game Theory, by Noam Nisan, Tim Roughgarden, Eva Tardos, Vijay V. Vazirani (eds.), Cambridge University Press, September 2007.

9. Version information

Version number	100
As of (date)	2026-11-20