IE8534: Games and Mechanisms

Prof. Krishnamurthy Iyer

Syllabus

1 Course information

- IE 8534: Games and Mechanisms: Engineering Applications in Online Marketplaces
- Instructor: Prof. Krishnamurthy Iyer (email: kriyer@umn.edu)
- Time: Tue Thu 10:10am-12:05pm
- Canvas:
- Zoom link:
- Gradescope: see link and entry code on Canvas.
- Office hours: By appointment on Zoom.
- TA: Jiali Huang (email: huan1106@umn.edu)

2 Course description

The course will cover the foundations of *game theory*, focusing on incomplete information settings, with emphasis on the mathematical modeling and the rigorous formulation of various equilibrium concepts. The framework will be used to study *mechanism design*, i.e., the design of rules for strategic interaction that achieve desired goals. The theory will be supplemented with applications from a number of engineering contexts including the design and analysis of online marketplaces. The final part of the course will discuss the emerging area of *information design*, and look at some recent applications in service operations and market design.

This course is ideally suited for graduate students who are interested in formally studying strategic behavior in an application area of their interest, and/or in performing theoretical, computational or algorithmic research on these topics.

3 Prerequisites

Strong command of undergraduate-level stochastics and optimization will be assumed. Prior exposure to introductory game theory (static games of complete information) will be helpful, but not necessary. Above all, mathematical maturity, i.e., the ability to read, write and think rigorously, will be expected.

4 References

There are no required textbook for this course, but the following books provide excellent treatment of the topics covered in this course.

- *Game Theory*, Fudenberg and Tirole, The MIT Press.
- *Game Theory*, Maschler, Solan and Zamir. Cambridge University Press.

The book *Algorithmic Game Theory* by Nisan et al. details the computational aspects of some topics in the course. The book is available freely online through Cambridge University Press. Also a good reference for this purpose is the book *Game Theory, Alive*, by Karlin and Peres.

The classics listed below are a good source to understand some of the motivations and intricacies behind the various solution concepts:

- *A Course in Game Theory*, Osborne and Rubinstein.
- *Game Theory: Analysis of Conflict*, Myerson.

For certain topics, the books below are a great reference.

- *Microeconomic Theory*, Mas-Colell, Whinston and Green.
- *Auction Theory*, Vijay Krishna.
- *Putting Auction Theory to Work*, Milgrom.

Finally, the following books treat the subject matter at a more basic level, and can be a good initial reference:

- *Game Theory: An Introduction*, Steven Tadelis, Princeton University Press.
- *An Introduction to Game Theory*, Osborne, Oxford University Press.
- *A Primer in Game Theory*, Robert Gibbons, Princeton University Press.

5 Grading

Assignments (30%), midterm (30%), a class project with final report and a short presentation (40%).

6 Assignments

There will be 3-4 assignments over the semester. Unless there is legitimate reason (as defined in the University Makeup Work Policy), late homework submissions will not be accepted, except for at most one assignment and by at most 3 days. Homework/exam submissions will be through Gradescope.

7 Project

The course will involve a class project, with a written report (due Dec 15, 2020) and a presentation to the class. The project is open-ended, with the intention of preparing students to perform active research using the topics/tools in this course. Students may choose to do any of the following for their project:

1. Develop a model for a practical problem, and analyze using the tools/methodologies in the course.
2. Extend a preexisting game-theoretic model, adding a practically relevant feature and investigate the implications.
3. Design/implement a mechanism for an allocation setting, and study its properties (either theoretically or computationally).
4. Read recent literature on a research topic, and write a critical report, detailing the current state of affairs, and ideas for future work.

Students may also propose their own project plan. Further instructions on the project will be provided on Canvas.

8 Legitimate absences and makeup work

Due to the current circumstances surrounding the pandemic, we will adopt the University policy on legitimate absences and makeup work. You can find the policy here. The Makeup Work FAQ addresses some scenarios relevant to COVID-19.

9 Academic integrity

Each student in this course is expected to abide by the *Board of Regents Policy: Student Conduct Code*. Any work submitted by a student in this course for academic credit must be the student's own work. Complete code is available at `https://policy.umn.edu/node/7178`.

10 Prohibition against buying and selling of course materials

Course materials, video recordings, etc., posted on Canvas or otherwise, are intellectual property belonging to the author/instructor. Students are prohibited against buying or selling any course materials without the express permission of the instructor. Such unauthorized behavior constitutes academic misconduct.

11 Course outline

The broad course plan is as follows. Note, this tentative list is subject to change to accommodate mutual interests.

1. Basics of game theory
    - Strategic form, game play assumptions
    - Mixed strategies
    - Best response, Nash equilibrium, approximate NE

- Existence
- Other notions: Dominance (strict, weak), Correlated equilibrium

2. Special classes of games
    - Potential games
        - Definition, best response dynamics,
3. Bayesian games
    - Modeling framework
    - Pure strategy, mixed strategy, Bayesian equilibrium
    - Examples: First-price auction
4. Basics of mechanism design
    - Setting/framework
    - Definition: Mechanisms (static). Design problem.
    - Direct revelation mechanisms.
    - Revelation principle. Bayesian incentive compatibility
    - Individual rationality (ex ante, interim, ex post)
5. Single item settings with independent private values
    - Myerson lemma
    - Revenue equivalence theorem
    - Myerson optimal auctions
6. Efficient mechanisms
    - *Ex post* efficiency
    - VCG mechanism
    - Budget balance: AGV mechanism
    - Myerson-Satterthwaite impossibility result
7. Basics of dynamic games
    - Stackelberg setting
    - Extensive form: information sets, mixed and behavioral strategies
    - Subgame perfect NE
8. Perfect Bayesian equilibrium:
    - Signaling setting. Equilibrium requirements.
    - Example: Job market signaling (Spence 1973)
9. Bayesian persuasion & information design
    - Persuasion framework

- Straightforward/direct mechanisms.
- Optimal signaling mechanisms, LP formulation
- Multiple receivers. Public vs private signaling

10. Stochastic games
    - Framework
    - Markov perfect equilibrium, Mean field games.
11. Learning algorithms & computation
    - Regret minimization
    - Convergence to CE