EE 381V Game Theory

Instructor:	Prof. Evdokia Nikolova
Lecture Hours:	TTH 5:00-6:30 PM, ENS 115
Office Hours:	T 6:30-7:30 PM; Wed 3-5 PM
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Overview: As our world becomes increasingly connected, the mutual effect we have on each other's decisions and actions is ever more pronounced. Game Theory models the strategic interaction of multiple people (players, agents or users of a system). Algorithmic Game Theory merges computation with economic reasoning in order to better understand and improve the strategic interaction that occurs in the complex systems that surround us: the Internet, telecommunication and transportation networks, social networks, online markets, etc.

This class will provide an introduction to Game Theory with a focus on engineering and computation, as well as survey state-of-art research in the field. Sample topics include: Strategic Form Games (Matrix and continuous games), Zero-sum games, Nash Equilibria and computation, Learning, Potential/congestion games; Games with Incomplete Information; Mechanism Design; Network Effects and Games over Networks.

Prerequisites: Probability and Stochastic Processes (EE 381J or equivalent), Algorithms (EE 360C or equivalent), Optimization (EE 380N-11 or equivalent).

References:

- **[Osborne] "Introduction to Game Theory"** by Martin J. Osborne. Oxford University Press (2004)
- **[Fudenberg-Tirole] "Game Theory"** by Drew Fudenberg and Jean Tirole. MIT Press (1991)
- **[AGT] "Algorithmic Game Theory"** by Eva Tardos, Noam Nisan, Tim Roughgarden, Vijay V. Vazirani, editors. Cambridge University Press (2007)
- **[Krishna] "Auction Theory"** by Vijay Krishna. Academic Press, San Diego (2002). (Second edition, 2009)
- **[MWG] "Microeconomic Theory"** by Andreu Mas-Colell, Michael D. Whinston, Jerry R. Green. Oxford University Press (1995)

Additional relevant research papers and surveys will be posted as the class develops the list.

Course Policy: Course material will be available on Blackboard: http://courses.utexas.edu
You may discuss homeworks and papers with other students, but you are not allowed to copy from others. University disciplinary procedures will be invoked if any form of cheating is detected. Course and instructor evaluations will occur in the last week of lecture.

Grading:

20% Homeworks

25% Midterm Exam

50% Final Project (inc. proposal)

5% Class Participation and quizzes

Homework problems assigned in a given week are due on Thursday of the following week by the start of class, either turned in class before the start of lecture or under the door of Prof. Nikolova's office. You may discuss homeworks and papers with other students, but you are not allowed to copy from others. You must write the names of all the students you collaborated with at the top of your homework, but turn in your own version. Simply copying another student's paper is not acceptable, even if referenced as such. Copying without referencing will be treated as cheating. Late homework will be accepted only in the most extraordinary of circumstances. Homework will taper off considerably towards the latter part of the course as students focus on their projects.

Short (5 minute) quizzes will be given at the beginning of every Tuesday lecture. They will not figure heavily in your grade (just 5% total), but will help both you and the professor assess whether you are learning the key concepts presented in lecture. The quizzes will be worth 5 points each, and the two lowest quiz grades will be dropped. There are no make-up quizzes.

Regrade Policy: All requests for regrades, on homework or exam, must be submitted in writing within a week of their return to you. No verbal complaints will be considered. Mistakes can be made in the grading process and we will correct those, but it is unlikely that more partial credit will be given. The basic idea here is that we don't want to indirectly penalize those students who don't ask for regrades. Also be aware that the result of a regrade can actually be a lower score as we will regrade the entire problem being protested.

College Drop/Add Policy: An engineering student must have the Dean's approval to add or drop a course after the fourth class day of the semester.

Students with Disabilities: The University of Texas at Austin provides upon request appropriate academic accommodations for qualified students with disabilities. For more information, contact the Office of the Dean of Students at 471-6259, 471-4641 TDD or the College of Engineering Director of Students with Disabilities at 471-4382.

Tentative Syllabus

Lecture 1. Introduction: Course overview and administrative details; Nash equilibria.

Part I: Game Theory

1. Strategic form games, Nash equilibria. *Reading:* provided notes.
2. Nash equilibria in two-player zero-sum games, proof of existence and computation via LP Duality. *Reading:* provided notes.
3. Nash equilibria in separable multiplayer zero-sum games. *Reading:* provided notes.
4. Learning in games: Fictitious play and Multiplicative Weights Updates. *Reading:* provided notes.
5. Nash's theorem. *Reading:* provided notes.
6. Potential games. Application to network design. Reading:
   - Dov Monderer and Lloyd S. Shapley. "Potential Games", *Games and Economic Behavior* 14, pp. 124--143 (1996)
7. Network Congestion Games. Wardrop Equilibrium; Nash flow; Social Optimum; Price of Anarchy. *Reading:* provided notes.
8. Network Congestion Games with stochastic delays and risk-averse users. Reading:
   - E. Nikolova and N. Stier-Moses. "A Mean-Risk Model for the Traffic Assignment Problem with Stochastic Travel Times", forthcoming in *Operations Research*.
9. Computing approximate Nash equilibria in two-player games. *Reading:*
   - R. J. Lipton, E. Markakis, A. Mehta. "Playing Large Games using Simple Strategies." ACM Conference on Electronic Commerce (EC), pp. 36-41, 2003.
10. Games of Incomplete Information. Bayesian Nash equilibria. *Reading:* provided notes.

Part II: Mechanism Design

1. Introduction to Mechanism Design. *Reading:* Krishna, Chapters 1-5.
2. Second Price Auctions. *Reading:* Krishna, Chapters 1-5.
3. First Price Auctions. *Reading:* Krishna, Chapters 1-5.
4. Revenue Equivalence. *Reading:* Krishna, Chapters 1-5.
5. Direct mechanisms; Incentive-compatible mechanisms. *Reading:* Krishna, Chapters 1-5.
6. General revenue-equivalence principle; Individual rationality. *Reading:* Krishna, Chapters 1-5.
7. Optimal Mechanisms. *Reading:* Krishna, Chapters 1-5.
8. VCG Mechanisms.
9. The Generalized Second Price Auction with application to Sponsored Search. *Reading:*
   - Edelman, Benjamin, Michael Ostrovsky, and Michael Schwarz. “Internet Advertising and the Generalized Second-Price Auction: Selling Billions of Dollars Worth of Keywords" *American Economic Review*, 97(1): 242-259. 2007.
   - Hal Varian. “Position Auctions.” *International Journal of Industrial Organization*, Oct. 2006. http://people.ischool.berkeley.edu/~hal/Papers/2006/position.pdf

- Hal Varian. “The Economics of Internet Search.” Angelo Costa lecture delivered in Rome, February 2007. http://people.ischool.berkeley.edu/~hal/Papers/2007/costa-lecture.pdf

10. Application of the VCG Mechanism to Interdomain routing. *Reading:*
    - Joan Feigenbaum, Christos Papadimitriou, Rahul Sami, and Scott Shenker. “A BGP-based Mechanism for Lowest-Cost Routing.” *Distributed Computing 18:61--72 (2005).*