Management Science and Engineering 336
Dynamics and Learning in Games

(Catalog title: Topics in Game Theory with Engineering Applications)

Mondays and Wednesdays, 1:15 PM–2:30 PM
Terman Engineering Center, Room 453
3 units

Instructor:

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Course webpage: http://eeclass.stanford.edu/msande336

Course description:

Game theoretic methods are prevalent in operations research, computer science, and electrical engineering. However, most engineers are typically exposed only to static game theoretic concepts, such as Nash equilibrium. In practice, engineering problems often require attention to dynamic behavior of the system under consideration, and game theoretic methods are notably less developed in this area.

This course studies the interaction of multiple decision makers in dynamic settings, i.e., dynamics and learning in games. The following is a tentative list of topics to be covered:

1. Definition and notions of equilibria for dynamic games; bounded rationality vs. equilibrium; and the general definition of a stochastic game.

2. Reputation.

3. Myopic best response dynamics and fictitious play.

4. Dynamics of supermodular games.

5. Adaptive game playing strategies.
6. Evolutionary game theory and the replicator dynamic.

The course will be taught using a mix of lecture format and seminar-style guided discussion. These are active research areas, so much of the reading material will be drawn from relevant papers in the literature; this material will be available from the course website. The focus will be on encouraging discussion of both open theoretical questions and modeling issues. This is particularly important because many areas of the university have active research programs that draw on elements of learning and dynamics in games (computer science, electrical engineering, operations research, and economics). The course should provide a unique forum for a lively exchange of ideas across these boundaries.

Given the advanced nature of the material, it is emphasized that the course should be viewed as a *research seminar* by prospective students.

Grading

The grading will be based primarily on a project to be completed by the end of the quarter. The choice of topics for the final project will be quite broad: students can choose to either discuss and present recent research results in the field, or develop their own problem statement and analysis.

Prerequisites

The listed prerequisite is a basic course in optimization, such as MS&E 211 or equivalent. However, the material in the course is mathematically advanced, so in addition real analysis at the level of Mathematics 115 is a requirement; students without this background may register credit/no credit. Finally, the course will require a background in probability as well, since many of the modules have a significant stochastic component.

Regarding game theory: this course assumes that registering students have had prior exposure to the basics of static and dynamic game theory, at the level of MS&E 246 or Econ 203.

Intending students who are not comfortable with the prerequisites listed above should expect to audit the course; any questions or concerns can be directed to Prof. Johari at the e-mail address above.

Textbooks

There will be no required textbook for this course. However, you may find some of the following books helpful.

Game theory books:

1. *Game Theory*, Fudenberg and Tirole. This reference should be on the shelf of every game theorist, but it is not necessarily the easiest book to learn from.

2. *A Course in Game Theory*, Osborne and Rubinstein. This is a good introductory level text in game theory, that still is quite rigorous. Although many game theory books are out there, I have found that this one is a good introduction for engineers.

3. *Game Theory: Analysis of Conflict*, Myerson. This is a more mathematically sophisticated treatment of the subject.

4. *Microeconomic Theory*, Mas-Colell, Whinston, and Green. This very large textbook is an encyclopedic reference on the subject, and likely very useful for many parts of this course.

5. *Game Theory for Applied Economists*, Gibbons. This is a basic undergraduate level text in game theory, appropriate if you have never seen the subject before; it provides an elementary treatment of most of the major topics.

Specific topics:

1. *Prediction, Learning, and Games*, Cesa-Bianchi and Lugosi. This recent text has a chapter on learning in games, which covers a significant subset of what we will do in class. They also make nice connections to online learning, forecasting, and prediction.

2. *The Theory of Learning in Games*, Fudenberg and Levine. This book is somewhat older now, but still a useful survey of various topics on learning in games.

3. *Repeated Games and Reputations*, Mailath and Samuelson. A recent text that covers most models of reputation studied in economics. It can be somewhat hard to navigate, but otherwise is a very good reference for this area.

4. *Evolutionary Game Theory*, Weibull. A nice survey introduction to evolutionary games.