Introduction to Multiagent Systems

Lecture 1

Lecture Overview

Course Description

This course examines the mathematical and computational foundations of modern multiagent systems, with a focus on game theoretic analysis of systems in which agents cannot be guaranteed to behave cooperatively. The course emphasizes student participation, featuring seminar-style discussion as well as traditional lectures. The course will culminate in a small research project in which students survey existing literature and possibly explore open research questions.

Course Topics

Overall, problems at the interface of economic theory and computer science. (No prior experience in economics is assumed.) Specific topic include: Games: normal-form; extensive-form; repeated; stochastic; Bayesian. Computation of game-theoretic solution concepts. Mechanism design: key positive and negative results. Single-good auctions. Combinatorial auctions: bidding; mechanisms; computational issues.

Prerequisites

There are no formal prerequisites, and it is assumed that most students in the class will be unfamiliar with Game Theory, Mechanism Design, Auction Theory, and the literature on Multiagent Systems. Since some of the material to be covered is quite formal mathematically, students will need to be able to construct and follow formal proofs. Relevant mathematical/CS background would include introductory knowledge of probability theory, computational complexity and combinatorial optimization. Much of the work associated with the course will revolve around reading papers from the Multiagent Systems literature, writing a survey or research paper, and presenting findings to the class. Students who have trouble reading, speaking or writing comfortably in English will find themselves at a disadvantage.

Academic Honesty

Plagiarism is a serious offence and will be dealt with harshly. I consider plagiarism to be the unattributed use of an external source (e.g., another student, a web site, a book) in work for which a student takes credit, or the inappropriate use of an external source whether or not attribution is made. The seriousness of the offence depends on the extent to which the student relied upon the external source. Assignments and midterms will include an "honour code" statement which you will be required to sign, specifying forms of collaboration and reference to non-course materials that are acceptable. For projects, you must cite all external sources that you use, and the vast majority of the project must be written in your own words. Any text that you take verbatim from another source must be in quotation marks and followed by a citation.

Grading Scheme

Assignments (three or four)	20 %
Test 1 (probably in-class)	20 %
Test 2 (probably take-home)	20 %
Project outline	7 %
Project writeup	20 % (10% instructor; 10% peer) + up to 2 bonus marks
Peer review of other students' final project papers	3 %
Participation in Discussions; Attendance	10 %

Assignments

The course will include three or four assignments. Dates on which assignments will become available and due dates are given in the schedule on the web page; assignments are always due at the beginning of class. Assignments will probably not be weighted equally: weighting will be proportional to the total number of available points. In particular, the last assignment may be weighted substantially more heavily since it will cover material not reviewed on the midterm exam. Students will be given three late days for use on the assignments. These are intended to help avoid scheduling conflicts with other courses, personal commitments, and emergencies. Therefore, no additional late days will be granted except under truly exceptional circumstances. Late assignments will be penalized at 20% per day.

Project

CPSC 532L will culminate with a final project that allows students to explore material that was not covered in class and to share that material with other students. The project involves students writing a paper on a topic of interest within Multiagent Systems, and then reading and evaluating each other's papers. I strongly recommend that you work with a partner unless you are considering multiagent systems as a research area. (Projects prepared by pairs of students will not be graded any more harshly than projects prepared by individual students.) Here is the "pipeline":

- submit a one-page outline of the paper you intend to write
- hand in the paper itself, which will be sent out to other students for peer review
- perform peer review of papers from other students in the class

The topic of the final project need not be too ambitious; it's fine to perform a survey of a subarea in Multiagent Systems or a compare-and-contrast study of two or more influential papers. If you plan to do more work in the area, you can also use the project to develop your own research ideas. In future weeks a list of possible topics will appear in this space. Please note that assignment late days cannot be applied to the final project.

Curving Grades and Peer Review

Final grades will be curved to give the overall distribution of grades a desired mean and standard deviation. Bonus marks will be applied after grades are curved. Peer review is an important component of the class, and will be taken into account when evaluating papers. Since this is a Multiagent Systems course, a grading scheme has been constructed that does not provide students with any ability to influence their own grades by reviewing other students strategically. The curve for a given student x will be calculated disregarding x's presentation and paper reviews of other students.

Textbook

We will be using the textbook Y. Shoham and K. Leyton-Brown, *Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations*, Cambridge University Press, 2009. It is available from the bookstore, and for free on-screen use at `http://www.masfoundations.org`.
Supplemental texts are listed on the course web page.

Schedule

Date	Lecture Topic (textbook sections)	Milestones
January 13	Introduction (§ Introduction)	
January 15	Utility Theory and Game Theory Intro (§ 3.1 - 3.2)	
January 20	From Optimality to Equilibrium (§ 3.2 - 3.3)	
January 22	Mixed Strategies; Maxmin (§ 3.3 - 3.4.1,)	
January 27	Computing Maxmin; Domination (§ 4.1, 4.4, 3.4.3, Appendix B)	
January 29	Computing Domination; Correlated Equilibrium (§ 4.5, 3.4.5)	
February 3	Computing CE; Perfect-Information Extensive-Form Games (§ 4.6, 5.1 - 5.1.3)	
February 5	Backward Induction; Imperfect Information Extensive-form Games (§ 5.1.4 - 5.2.2)	
February 10	Repeated Games and the Folk Theorem (§ 6.1 - 6.1.2)	
February 12	Stochastic Games; Bayesian games (§ 6.2, 6.3.1)	
February 24	*Midterm exam*	
February 26	Analyzing Bayesian Games; Social choice (§ 6.3.2, 9.1 - 9.3)	
March 2	Arrow's Impossibility Theorem (§ 9.4 - 9.5)	
March 4	Mechanism Design (§ 9.5 - 10.1)	
March 9	Revelation Principle; Quasilinear utility (§ 10.2 - 10.3.2)	
March 11	Quasilinear Mechanism Design; Groves (§ 10.3.2 - 10.4.1)	
March 16	The VCG Mechanism (§ 10.4.2 - 10.4.4)	
March 18	Advanced Mechanism Design (§ 10.4.5 - 10.7)	
March 23	Single-Good Auctions (§ 11.1 - 11.1.3)	
March 25	Revenue Equivalence (§ 11.1.4 - 11.5)	
March 30	Advanced Single-Good; Multiunit Auctions (§ 11.1.6 - 11.2)	
April 1	Combinatorial Auctions (§ 11.3)	
April 6	Coalitional Game Theory Intro (§ 12.1)	
April 8	The Shapley Value and the Core (§ 12.2)	

Lecture Overview

Pictures and Introductions

Please:

- Write your name on a piece of paper
- Introduce yourself by saying what country you're from, where you did your undergrad, your favourite flavour of ice cream, and anything else you'd like...
- Pose for a photo, holding your piece of paper!

Lecture Overview

1. Syllabus
2. Pictures and Introductions
3. MAS

Cooperative vs. Competitive MAS

Cooperative MAS:

- same desires: the strategic/non-strategic distinction is not very significant
- example: multirobot control, uncertain environment
- issues:
    - coordination
    - bandwidth, computational limits
- optimality well-defined

Competitive MAS:

- potentially different utility function (but may be the same)
- example: P2P file-sharing system on the internet

Resource Allocation in MAS

- easy in cooperative settings
  - optimality is well-defined
  - everyone wants the same thing
- difficult in competitive settings, because people can lie
  - mechanism design
  - maximizing payoff
  - design of agents
  - auctions: why important