Course Title:

CAP 4506 Introduction to Game Theory

Catalog Description

Introduction to major topics of game theory, including game representations, solution concepts, algorithms & complexity, repeated games, learning, auctions, voting, applications to many disciplines.

Course Description

Game theory is the study of strategic interaction. It has been applied to every scientific discipline -- most notably economics, but also political science, business, military, biology, and many others. Recently it has been a major area of research in computer science, as the field of artificial intelligence, which initially studied settings with a single agent, is expanding its scope to domains with multiple strategic (and potentially adversarial) agents. Topics will include game representations, solution concepts, imperfect information, repeated games, learning, auctions, and voting. There will be a project to pursue an application (or theoretical topic) of interest. The class could be of interest to students in computer science, mathematics, physical sciences, business, social sciences, engineering, and life sciences (including medicine). It would be helpful to have familiarity with mathematical proofs, and some problems will involve computational implementation.

3 Credits

Prerequisites

MAC2312 AND (MAD 2104 OR COT 3100 OR Permission of the instructor).

Type

This is an advanced undergraduate elective course.

Objectives

Introduce the main concepts of game theory, which has been applied to every scientific field -- most notably economics, but also political science, business, military, and biology.

Evaluation

Homeworks (every 1-2 weeks), midterm exam, final exam, class project. Each component is worth 25% of the final grade (subject to modifications). Undergraduate students have a choice of either taking the final exam or doing the class project (while graduate students do both). The choice must be specified by the third day after the midterm exam. Each of the three components will be worth 1/3 of the final grade (subject to modifications).

Topics

1. Strategic-form games and solution concepts
   - pure vs. mixed strategies, domination, best response, Nash equilibrium, zero-sum games, minimax/maximin, evolutionarily stable strategies
2. Extensive-form games
   - game trees, relationship to strategic form, imperfect information, perfect vs. imperfect recall, behavior strategies, Kuhn's Theorem, sequence form
3. Algorithms and complexity

- P/NP/PPAD, linear programming, two-player zero-sum formulation, Lemke-Howson algorithm, support enumeration, game abstraction, Gambit software

4. Equilibrium refinements
   - subgame perfect equilibrium, backwards induction, trembling-hand perfect equilibrium, sequential equilibrium, proper equilibrium
5. Repeated games
   - finitely and infinitely repeated games, solution concepts, Folk Theorem
6. Learning in games
   - fictitious play, no-regret algorithms, counterfactual regret minimization, robust responses, opponent modeling and exploitation
7. Alternative solution concepts
   - strategy commitment, Stackelberg equilibrium, correlated equilibrium, application to national security
8. Auctions
   - English/Dutch/sealed-bid/Vickrey auctions, equilibria, mechanism design
9. Social choice (voting)
   - Arrow's Impossibility Theorem, Gibbard-Satterthwaite Theorem, majority/Borda/Condorcet rules, range voting
10. Stable matching
    - Gale-Shapley algorithm, application to National Resident Matching Program

Textbook(s)

Game Theory by Michael Maschler, Eilon Solan, and Shmuel Zamir