CSCI 3907/6907 Special Topics on Game Theory in Computer Science - *3 credits – Vora*

Modern computer systems enable several individual users to interact using algorithms that combine the power of personal data and artificial intelligence. The algorithms are generally not designed to be fair to the individual users, but, instead, tend to benefit the service provider or a special user. An active area of research in Computer Science explores the use of principles from game theory and mechanism design to incorporate notions of fairness into the interactions.

In this course, students will learn basic principles from game theory and mechanism design as used in computer science. Topics covered, all from a game theoretic perspective, will include the matching problem, auctions, predictions, reputations, incentives in cryptocurrencies and voting. In the last part of the class we will read papers on fairness and social good in mechanism design and students will do projects of their choosing (requiring instructor approval) on these topics.

Pre-requisites for this course include Calculus II (limits, derivatives and integrals) and Algorithms. Students (whether from computer science or other programs) who have not had Algorithms may substitute evidence of mathematical maturity beyond Calculus, for example:

For CSCI 3907

(a) an undergraduate level course in mathematical game theory such as ECON 3191 or

(b) mathematics classes in analysis, algebra or topology.

For CSCI 6907:

(a) a graduate level course in game theory or mechanism design or

(b) an undergraduate degree in mathematics.

This course is intended to complement the offerings in Game Theory and Mechanism Design in the Economics department. Students from other departments are encouraged to take it if they have satisfied the above pre-requisites. The flexibility in pre-reqs is because students may work on projects with more of an economics or math flavor if they so choose.

Instructor approval is required for all registrations.

Course Outcomes

Students will learn:

1. The basic types of games (complete/incomplete information, simultaneous/sequential moves), utility functions and solution concepts (Nash and Bayesian Nash equilibria, no equilibria) with a focus on discrete games.
2. Auctions as special types of games; classical results in auction theory and the computational challenges of auctions. Sponsored search.
3. Predictions, and the use of mechanism design to elicit good predictions. Prediction markets.
4. Strategic voting. Aggregation of results from ranking or AI algorithms or crowdsourcing, participatory democracy.
5. Approaches to the notion of fairness in learning, through mechanism design. Privacy and mechanism design in auctions.

Evaluation

Student will be evaluated on two HWs (10% each), paper presentations and reviews (40%) and final class project (40%).

Text and Readings

This course will draw from the following main sources:

1. Nisan, Roughgarden, Tardos and Vazirani: Algorithmic Game Theory.
2. Roughgarden, Twenty Lectures in Algorithmic Game Theory
3. Lectures Notes for COMS 4995, Incentives in Computer Science, taught by Tim Roughgarden at Columbia: http://www.cs.columbia.edu/~tr/s20/s20.html
4. Rediet Abebe's dissertation: Designing Algorithms for Social Good, Cornell University, December 2019. https://www.cs.cornell.edu/~red/AbebeDissertation.pdf

Sample Course Outline

Week 1: Introduction to the impact of modern computer science companies on economic life.

Week 2: Matching. College Admissions and Resident Matching.

Week 3: General characterization of a game, notions of equilibria.

Week 4: Simple games: Network Routing, Prisoner's Dilemma.

Week 5: Auctions: classical results.

Week 6: Auctions and sponsored search.

Week 7: Prediction Markets.

Week 8: Cryptocurrencies.

Week 9: Strategic voting.

In Weeks 10-14 students will present papers that look at privacy and fairness challenges in the above examples. Papers will include the literature on cheap talk, beginning with the paper by Crawford and Sobel; that on differential privacy and auctions; and Abebe's work on fairness and mechanism design.