Indian Institute of Technology, Kanpur

Department of Computer Science and Engineering

New Course Proposal

Title: Topics in Game Theory and Collective Choice

Course No: CS698W

Units: 3-0-0-0

Pre-requisites: This course will assume familiarity with formal mathematical reasoning, some probability theory, basic calculus, the basics of computational complexity, rational agent models, and will require you to write programs in Python (this is a soft constraint). A prior course on game theory or multi-agent systems will be a plus, but not necessary. If you are unsure, please contact the instructor.

Proposed by: Swaprava Nath

Estimated Enrollment: 50 or less

Departments which may be interested: CSE, EE, IME, ECO

Level of the course: PG (6xx level).

Short Description

This course deals with some selected topics in the intersection of Economics and Computation. The focus will be more on the applications of game theory in social decision making. For example, how online advertising slots are allocated among competing advertisers or how the mobile telephony spectrum is distributed among the competing service providers such that certain "good" and "fair" properties are satisfied. Problems of similar flavor exist in many more applications like crowdsourcing, internet routing, fair division of goods, matching of students to advisors, facility location, social networks and many more. To understand these applications and to improve them, technology needs to partner with economic principles that drive them. This course is aimed to develop those economic principles.

The course will primarily be focused on mechanism design (without and with money) -- which is the inverse problem of game theory. However, for the uninitiated, there will be a brief refresher of the game theoretic principles that is needed. The later part will see a bit of cooperative game theory and several application domains.

Course Plan (tentative coverage and sequence)

Introduction to game theory:
Simultaneous move games – normal form representation. Domination of strategies. Common knowledge with examples. Mixed strategies. SDSE, WDSE, Nash equilibrium. Existence result for mixed and pure. Correlated equilibrium.
Sequential move games – extensive form representation. Subgame perfect equilibrium. Backward induction. Information set. Perfect Bayesian Equilibrium. Analogies with pure and mixed Nash equilibrium. Repeated games. Folk theorems.

Introduction to social choice theory:
Setting up the model. Illustrations and examples from voting. Examples of paradoxes (MAS book). Desirable axioms. Social welfare functions. Pareto efficiency, Independence of irrelevant alternatives. Arrow's impossibility result.

Social choice function – relaxation:
Axioms: weak pareto, monotonicity. Muller-Satterthwaite result. Special domains: ranking and positive results.

Strategic considerations – mechanism design without money:
Notation setup. Revelation principle. Truthfulness in dominant strategies – surjectivity and strategyproofness. Gibbard-Satterthwaite result. Randomized social choice function. Gibbard's characterization by unilateral and duples.

Special domains with positive results:
Single peaked: Moulin's characterization. Private good: Sprumont's uniform rule.

Non-strategic recent results in domains without money:
Cardinal voting and distortion. Voting for single or k objects. Participatory budgeting. Cake-cutting. Rent division. (any 2 topics)

Matching:
One sided: object allocation, house allocation. Top trading cycle with fixed endowments and its properties.
Two sided: school admission problem. Stable marriage problem.

Mechanism design with money in quasi-linear form:
Allocative efficiency and Pareto efficiency equivalence. Axioms: dominant strategy incentive compatibility, efficiency, budget balance, individual rationality. Groves class, VCG mechanism. Affine maximizer allocation rules. Roberts' theorem. Unrestricted preferences. Restricted domains: combinatorial auctions and selfish valuations.
Single object auction – Myerson's characterization. Green-Laffont theorem: efficiency, budget balance, truthfulness impossibility. Approximation approaches: redistribution and sink mechanisms.

Further topics in mechanisms with money:
Drawbacks of VCG mechanism. Axiom: ex-interim individual rationality with Bayesian incentive compatibility. Myerson-Satterthwaite result. AGV mechanism: ex-ante individual rationality.

Cooperative games:
Shapley value – characterization. Core. Nucleolus. Bondereva-Shapley theorem.

Theory to practice:
Online advertising auctions. Combinatorial auctions. Prediction markets. Reputation systems.

References

No specific textbook, the book that will be closest to the content is by Yoav Shoham and Kevin Leyton-Brown: Multiagent Systems (www.masfoundations.org). Other relevant references and texts (if needed) will be posted on the course homepage from time to time. Some of the following books may be useful.

- Martin Osborne and Ariel Rubinstein: A course in game theory
- Martin Osborne: An Introduction to Game Theory
- Y. Narahari: Game Theory and Mechanism Design
- Tilman Borgers: An Introduction to the Theory of Mechanism Design
- Andreu Mas-Colell, Michael Whinston, and Jerry Green: Microeconomic Theory
- Debasis Mishra
  Game Theory course notes: http://www.isid.ac.in/~dmishra/gm1doc/notes_2016.pdf
  Mechanism Design course notes: http://www.isid.ac.in/~dmishra/gmdoc/mdnotes.pdf