CS 580: List of Uncovered Topics and Research Problems

Ruta Mehta | Fall 2026

Since Algorithmic Game Theory is a very vast field, there are quite a few topics that we will not be able to cover in class. Here are some of them. I think these are good topics for survey projects as well; however, please do not feel constrained by them and choose any topic of your liking. The only requirement is that it should be related to AGT.

Games and Markets with AI Agents

- **Autobidders and auctions.** Equilibrium and PoA with value maximizers, ROI/budget constraints, heterogeneous bidder objectives, or approximately optimizing bidding agents.
- **Algorithmic collusion by AI agents.** Repeated pricing/auction games, learning dynamics, memory/communication needed for collusion, and collusion-resistant mechanisms.
- **Sybil-proof agent markets.** Mechanism and reputation design when autonomous agents can cheaply create or replace identities.
- **Fair allocation through AI delegates.** How EF1/EFX/MMS/PO guarantees degrade when an AI delegate only approximately represents its principal's valuation.
- **Strategic communication among AI agents.** Cheap talk, verifiable disclosure, and communication complexity in bargaining or mechanism interaction.
  Starting references: Junque de Fortuny & Cappelli, *LLMs as Strategic Agents* (2025); Bianchi et al., *NegotiationArena*, ICML 2024; Dütting et al., *Mechanism Design for Large Language Models*, WWW 2024; Fish, Gonczarowski & Shorrer, *Algorithmic Collusion by Large Language Models* (2024); Bichler, *Agentic Markets* (2026).

Fair Division and Market Equilibria

- Fair division of mixed goods and chores.
- Tradeoffs among EFX/EF1, MMS, Pareto optimality, and Nash social welfare.
- Fair division under strategic agents: truthfulness versus fairness and efficiency.
- Online/dynamic fair division with arrivals, departures, or changing supplies.
- Fair division with unequal entitlements.
- Query complexity of fair allocation under value/demand oracle access.
- Competitive equilibrium / CEEI with chores, nonstandard utilities, or heterogeneous agent types.
- Learning in markets through revealed preferences.

Games, Learning, and Equilibrium Computation

- Learning dynamics in games: best response, no regret, swap regret, etc.
- Last-iterate versus time-average convergence in structured games.
- Games in which players use heterogeneous learning algorithms.
- Equilibrium computation with approximate best-response or value oracles.
- Multi-player succinct games and computation of Nash, correlated, or coarse correlated equilibria.
- Correlated equilibrium in polymatrix, graphical, coordination, or extensive-form games.
- Simple stochastic games: computation and applications.
- Total function classes (TFNP): PPAD, PPA, PLS, CLS, etc., and relationships among game-theoretic problems in these classes.

Mechanism Design, Auctions, Matching, and Price of Anarchy

- Pros and cons of auctions used in practice.
- Multi-item / combinatorial auctions under structured valuations.
- Auctions with interdependent valuations.
- Simple versus optimal mechanisms; prior-independent and robust mechanism design.
- Online/dynamic matching with strategic agents (Uber/Lyft/TaskRabbit-like systems).
- Reward/review/reputation mechanisms without money.

- Security games: multiple attackers, bounded rationality, or quantal-response guarantees.
- Non-linear congestion games and extensions of the smoothness framework.
- Nash bargaining, cooperative stability/core, and applications.
- Mechanism design with costly computation or costly information acquisition.

Research Projects

I understand that it may not always be possible to finish what one aims for within a specific time window while doing research, especially in theoretical research. Therefore, if you choose to do a research project, I expect a sincere attempt. At the end, if no result is obtained, it is okay to report/present the literature survey, failed attempts, useful examples or counterexamples, and what you learned about the problem.

Ideally I want you to come up with a problem for the research project. Here are some theoretical problems to get you started. As far as I understand, these are not easy problems; in many cases the right semester project will be an interesting special case or partial result, and some may lead to publication.

Games and Markets with AI Agents (I do not have as much expertise for these topics)

- **Price of AI Delegation.** Given a game and a class of delegates, compare welfare when principals play directly with welfare at equilibrium when they strategically choose delegates.
- **Delegation equilibrium.** Find natural classes of games/delegate policies for which pure delegation equilibria always exist, or give impossibility results.
- **Mixed rational/AI populations.** Bound PoA in congestion, auction, or market games when some players exactly optimize and others only approximately best respond.
- **Strategic prompting as commitment.** Model a prompt/configuration as selecting a restricted policy class and analyze the meta-game in which principals strategically choose these restrictions.
- **Collusion-resistant mechanisms.** Design an auction or pricing mechanism with welfare/revenue guarantees when subsets of autonomous agents coordinate.
- **No-regret agents with communication.** Standard no-regret play yields CCE in time average. Characterize what additional outcomes can arise if agents can communicate before/during play.
- **Reputation with replaceable agents.** If an AI agent can discard its identity and restart at cost c, characterize the friction needed to sustain cooperation or truthful behavior.
- **Fair allocation under delegated preferences.** If the delegate valuation approximates the principal's true valuation, quantify degradation of EF1/EFX/MMS/PO guarantees.
- **Equilibrium with approximate best-response oracles.** Determine computational complexity and welfare guarantees when optimization is available only through an epsilon-best-response oracle.
- **Sybil-proof agent markets.** Design matching, auction, or reputation mechanisms when autonomous agents can cheaply instantiate additional identities.

Fair Division / Markets

- Efficient algorithms for fair + Pareto-optimal allocation with goods and/or chores under interesting valuation classes.
- Improve approximation guarantees or complexity bounds for EFX/MMS/NSW under restricted valuations.
- Truthfulness versus EF1/EFX/MMS: obtain possibility or impossibility results for strategic fair division.
- Computability of Exact Competitive equilibrium / CEEI with chores or mixed goods and chores.
- Online fair division: fairness and efficiency guarantees under arrivals/departures.
- Smoothed EFX existence.

Games / Learning / Complexity

- Convergence or cycling of best-response/no-regret dynamics in a structured class beyond potential games.
- Complexity of computing correlated equilibria with additional structural or optimality constraints.
- Relations among CLS problems arising from contraction maps, congestion games, market equilibria, and related fixed-point problems.
- Query/communication complexity of approximate equilibrium when only restricted oracle access is available.

Mechanism Design / Matching

- Good mechanisms for highly dynamic two-sided markets with strategic supply and demand.
- PoA or revenue guarantees for auctions with heterogeneous bidder objectives (utility maximizers, value maximizers, ROI-constrained agents).
- False-name-proof mechanisms for markets in which creating identities is inexpensive.
- Theoretical guarantees for security games with boundedly rational or multiple attackers.

Important: Grading for the projects will be based on the sincerity with which the project was executed, the intellectual quality of the work, and the quality of the report and presentation. For AI-agent projects, experiments with LLMs can be useful for motivation or conjecture formation, but the project should have a clear theoretical AGT core.