

Program Title: Explorations in Algorithmic Game Theory

Pioneer Syllabus

Term: Summer 2023

Program Topic Description:

We will study the design and analysis of algorithms which must interact with strategic agents. This is known as "algorithmic game theory," and combines ideas from computer science, economics, and mathematics. Potential topics include, but are not limited to:

- 1- Essentials of Algorithmic Game theory: Equilibria and how to compute them. Algorithms for optimal play in competitive and cooperative settings.
- 2- Algorithmic Mechanism Design: How to design the rules of a game so that selfish play leads to optimal outcomes, and the algorithmic challenges involved. This includes, for example, the design of auctions and voting protocols.
- 3- Algorithmic Persuasion: How to persuade someone else to take an action you like, even though they may have different priorities.
- 4- Security games: How to use randomized patrolling and surveillance to dissuade, and prevent, attacks on critical resources and infrastructure.

During the group sessions, we will cover the fundamentals of such topics through readings and discussions. Students will use what they learn to guide their individual research projects, which will involve a detailed exploration of one or more aspects of algorithmic game theory. This exploration may be theoretical, using mathematical reasoning to design and analyze algorithms in these settings. It may also be applied, involving the implementation of existing and/or novel algorithms, and using experiments to discern their performance and properties.

Professor Title and Background:

Shaddin Dughmi is an Associate Professor in the Department of Computer Science at USC, where he is a member of the Theory Group. He received a B.S. in computer science, summa cum laude, from Cornell University in 2004, and a PhD in computer science from Stanford University in 2011. He is a recipient of the NSF CAREER award, the Arthur L. Samuel best doctoral thesis award, and the ACM EC best student paper award.

Shaddin's research lies broadly in the design and analysis of algorithms, with an emphasis on settings involving strategic behavior and/or uncertainty. His research focus areas have included:

- 1- Algorithmic mechanism design: How do you design efficient algorithms which "govern" strategic interactions and obtain a "desired" outcome, even though agents may try to "game" the system?

2- Algorithmic information design: How do you efficiently decide which information to share with competing agents in order to facilitate a desired outcome?

3- Algorithmic contract theory: How do you efficiently design a "contract" which incentivizes someone else to do your work for you?

3- Security games: How do you protect physical targets from attack by a strategic adversary, through randomized patrolling with limited resources?

4- Online and stochastic decision making: How can algorithms make effective decisions despite uncertainty about future and unavailable data?

Professor Statement:

I look forward to meeting all of you! Please take time to think through which topics are most interesting to you, and I will try to steer our discussions accordingly.

Contact Method:

All communication outside of meeting times will be conducted on the Pioneer Learning Management System (LMS). As per the student agreement, use of email to communicate with the professor mentor during the program is strictly prohibited. If you have problems using the Pioneer LMS, contact your Pioneer Cohort Advisor.

Pioneer LMS Link: pioneeracademics.schoology.com

Required Program Material:

We will use several resources. Most notably, we will refer to the books [“Twenty Lectures on Algorithmic Game Theory” by Roughgarden](#), and [“Essentials of Game Theory” by Leyton-Brown and Shoham](#), during the first few sessions. We might refer to other sources as needed, most of which should be available for free on the web, or through the Oberlin online library.

Learning Goals:

- Use mathematical reasoning to design and analyze algorithms, test conjectures, judge the validity of arguments, formulate valid arguments, and communicate the reasoning and the results
- Recognize and use connections between mathematics, computer science, and game theory.
- Utilize current scientific literature to formulate new research questions and appropriately cite sources in discussion of results

Grading Policy:

90%: Final Paper

The final paper should include a summary of existing research on a topic related to the content of this program. Moreover, the final paper should initiate research pertaining to the topic through any number of the following: Identify research questions and discuss their potential impact; suggest possible approaches for tackling these questions and outline the associated

challenges; make progress on these research questions through mathematical reasoning and/or experiments.

5%: Participation and initiative during the sessions. In particular, students should read around the topic in advance and come prepared with illuminating questions and ideas.

5%: Written peer review

Assignments and Milestones:

Below is an outline of topics and expectations for the program. Assigned readings are due *before* each session. Please attempt the reading, even if you don't understand much of it, and come prepared with discussion questions. The exception is the first session, where it's fine to just skim the readings in advance to get an idea.

Group Session 1 : Introduction and discussion. Basics of Game theory and equilibria. Please skim the following in advance of the session: Chapters 1 and 13 of Roughgarden, and Chapters 1, 2, 3.1, 3.5, 4 of LBS.

Group Session 2: Basics of Game theory and equilibria, continued. Readings: Same as last session, but read more carefully.

Group Session 3: Algorithmic Mechanism design. Readings: Chapters 2,3,4,7,10 of Roughgarden.

Group Session 4: Algorithmic Persuasion. Readings: This [survey](#) on the topic, plus whatever references in that survey interest you.

Group Session 5: Security Games and/or additional topics based on student interests. Readings: TBD.

Individual Session 1: Come prepared with a one paragraph proposal for the project. We will discuss the proposal and refine it during this session, and pin down some related literature.

Individual Session 2: Come prepared with a proposal of up to two pages. We will make final modifications to the proposed topic, and come up with a literature reading list. This proposal will be subject to peer review by one of your colleagues soon after this session.

Individual Session 3: Perform and receive peer review, and delve into the related literature, prior to this session. We will discuss how to incorporate the peer review and literature into your project.. You will start working on your final paper immediately after this session.

Individual Sessions 4 and 5: You should be already working on your final paper at this point. We will continue discussions of your individual project during these sessions, and make sure your paper is on the right track.

Final Paper Deadline: Two weeks after the final session.

Final Paper Requirements:

The final paper should be at least 15 pages, with citations in any standard style. Using LaTeX+BibTex to prepare your report is recommended, but not required.

Peer Feedback:

Students will be paired up by the instructor for peer review. This will entail reading your peer's proposal and providing written feedback via the provided peer review form. This will occur between the second and third individual sessions.

Pioneer Writing Center:

All scholars can use the Pioneer Writing Center to review up to four drafts of their paper. The Pioneer Writing Center guarantees feedback within 2 days of submission. Scholars can submit drafts by sending their work to writingcenter@pioneeracademics.com. The Pioneer Writing Center accepts submissions starting the last week of May for Spring-through-Summer cohorts and the third week of July for Summer cohorts.

Turnitin:

All final papers must be submitted through the "Submit your final paper here" Turnitin assignment in the Course Materials section of the LMS. The Turnitin software will compare the submitted paper against websites, books, journal articles, other student papers etc., and highlight any sections of the paper that are a match for such materials. The Turnitin tool is a part of our dedication to academic integrity. Scholars can check their own papers before submitting the final version for grading, by using the "Check your paper for plagiarism here" assignment, also located in the Course Materials section on the LMS.

Pioneer Research Seminars:

All Pioneer Scholars are required to participate in Pioneer's three Research Seminars, a program that helps scholars develop essential knowledge, research, and writing skills they need to successfully complete an excellent independent research paper. Each Research Seminar offers a live session and corresponding asynchronous resources, including a handbook for each seminar and additional worksheets. Scholars are required to attend all live sessions and read all asynchronous materials. Scholars will be contacted to register for each live session and have access to the asynchronous materials on the Pioneer LMS as they continue through the program. It is your responsibility to carefully study all available resources. Attendance will be reported in the Professor-Student Group on the Pioneer LMS.

The content covered through the Research Seminars (both live and asynchronous) is as follows (but is not totally limited to):

Tech Training: (*asynchronous, must be completed before the first session*)

- ☐ How to use Pioneer technology including Zoom, Schoology, etc.
- ☐ Where to find important materials such as the syllabus

Research Seminar: Orientation *(live session will be held before scholars' first session with their professor)*

- ☐ Program expectations (how to contact their Pioneer Cohort Advisor and Professor, when to expect a response, and how to solve common problems)
- ☐ How to participate in a college-level academic seminar, including proper interaction during sessions with their professor

Research Seminar: The Research Process *(live session will be held after the group sessions begin and before individual sessions begin, asynchronous content will be available earlier)*

- ☐ Choosing a research topic
- ☐ Brainstorming, evaluating, identifying, and revising essential components of the research process. This includes finding a research topic, focusing this topic into a research question, and understanding how to create a research methodology to help answer the research question.
- ☐ Using scholarly sources, such as those found in the Oberlin library, evaluating sources, and best practices for organizing sources, notes, and information
- ☐ Reviewing the Pioneer Research Journal for examples
- ☐ Preparing a research proposal

Research Seminar: The Writing Process *(live sessions will be held shortly before or after individual sessions begin; asynchronous content will be available earlier)*

- ☐ How to work with professors 1:1
- ☐ Large scale planning, outlining, and structuring a research paper, including examples across a variety of research disciplines
- ☐ How to avoid plagiarism and the importance of academic integrity
- ☐ The revision process, including how to use the Pioneer Writing Center, self review, and peer review

Technical Support:

For any technical issues relating to program software, the Pioneer LMS or the Oberlin College library system that are not urgent, scholars should contact their Pioneer Cohort Advisor. For all issues that require immediate attention call the Pioneer Support Line at +1 (267) 461-8849. A Pioneer staff member will respond to help resolve any problem quickly.

Rescheduling Sessions:

Each Pioneer Scholar has the privilege of requesting to reschedule one individual session with a valid reason. No other reschedule will be allowed except in case of an emergency, such as a sudden illness or family emergency. Each reschedule request will be evaluated on a case-by-case basis.



Any rescheduling request must be submitted to Pioneer at least 48 hours in advance of the relevant session, using the Rescheduling Request Form. The form is available in Course Materials on the LMS (Schoology).

Scholars are responsible for being aware of their schedule, any applicable time zone conversion, and ensuring that they have a strong enough internet connection ahead of the session time.

If a scholar should miss a session without having submitted and received approval of a rescheduling request form, that session is forfeited. Rescheduling of the missed session will be addressed on a case-by-case basis.