THE UNIVERSITY OF TEXAS AT AUSTIN
Department of Aerospace Engineering and Engineering Mechanics

ASE 381P: Game-Theoretic Modeling of Multi-Agent Systems
Fall 2025

SYLLABUS

Unique Number: 15700

Instructor: David Fridovich-Keil
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Tentative office hour: W 9:30-10:45am

Time: MW 11-12:30 CT

Location: ETC 2.102

Teaching Assistant: None

Web Page: Canvas

Catalog Description:
In recent years, autonomous systems have become more and more integrated with society, from the gig economy to smart grids to autonomous cars. This course will introduce the mathematics which characterize groups of agents interacting rationally over time: dynamic game theory. While the tools we develop are generally applicable, we will use self-driving vehicles as an ongoing case study, where we shall see the importance of game-theoretic ideas as well as some of their shortcomings. Instruction will follow three related themes: (1) static games and complementarity programming, (2) dynamic game theory, and (3) special topics in game theory and multi-agent control. There will be several hands-on programming assignments, followed by a group project in which students are encouraged to find new and interesting applications of course material in their own area of research.

Course Objectives:
This course is intended for graduate students with a strong interest in optimization, control theory and multi-agent systems. Overall, the course aims to:

- introduce students to game-theoretic models of multi-agent interaction
- build both mathematical and programming expertise
- probe various robotic applications of game-theoretic planning
- expose students to recent advances in the literature of game-theoretic decision making

Prerequisites:
There are *no strict prerequisites* for this class. However, successful students should be fluent in linear algebra and vector calculus, and ideally have prior exposure to optimization. Students should also be familiar with programming in a high-level language such as MATLAB, Python, or Julia. No background in game theory is assumed.

If you have any questions about these expectations, please do not hesitate to consult the instructor. Undergraduates must obtain the instructor's explicit approval before enrollment.

Attendance:
Regular attendance is expected. If you are sick, please do not attend so that your classmates stay healthy!

Recordings:

The classroom is equipped with an automatic recording system, and recordings will be posted on Canvas automatically. These recordings are only intended for use by students enrolled in the class, and may not be distributed outside of class. Viewing the recording is not intended to be a substitute for attending lecture.

Topics:
The course will cover static games, finite dynamic games, smooth dynamic games, and assorted special topics.

Class Schedule:
A tentative schedule is given in the table below. The content of each lecture and assignment due dates are subject to change.

Date	Category	Topics	Assignment	Reading
8/25	Introduction			
8/27	Static games	Normal form, equilibrium concepts		BO 2.2, 3.2, 3.3 + notes ch. 1
9/1	HOLIDAY			
9/3	Static games	Smooth unconstrained static games		Papers 1 and 2 + notes ch. 2
9/8	Static games	Mixed strategies, constrained games	Julia tutorial	BO 2.3, 3.4, NW 12 + notes ch. 3
9/10	Static games	Complementarity programming		
9/15	Static games	Inverse static games		
9/17	Guest lecture	Lasse Peters		
9/22	Finite dynamic games	Extensive form, information patterns	Tag	BO 3.4, 3.5 + notes ch. 4
9/24	Finite dynamic games	Tree search		Paper 3
9/29	Interlude	Perfect equilibria, informational inferiority, time consistency		BO 3.5.5, 5.6 + notes ch. 5
10/1	Interlude	Perfect equilibria, informational inferiority, time consistency		
10/6	Smooth dynamic games	QPs, Minimum principle / HJB for LQR		
10/8	Guest lecture	Zachary Sunberg	Tic tac toe	BO 5.5
10/13	Smooth dynamic games	LQ feedback Nash + Stackelberg		BO 6.2.2, 7.3 + notes ch. 6
10/15	Smooth dynamic games	LQ open-loop Nash		BO 6.2.1
10/20	Smooth dynamic games	Equality-constrained SQP, nonlinear open-loop Nash		NW 18.1, 18.2
10/22	Guest lecture	Negar Mehr		
10/27	Project proposals		Proposal	
10/29	Smooth dynamic games	Nonlinear feedback Nash		Paper 4
11/3	Smooth dynamic games	Inequality-constrained programming	LQ solvers	NW 16.5
11/5	Guest lecture	Jingqi Li		
11/10	Smooth dynamic games	Reach-avoid and pursuit-evasion games		Paper 5
11/12	Smooth dynamic games	Continuous-time subtleties		
11/17	Guest lecture	Eric Mazumdar		
11/19	Guest lecture	Mustafa Karabag	Trajectory games	
11/24	HOLIDAY			
11/26	HOLIDAY			
12/1	Final presentations			
12/3	Final presentations			
12/8	Final presentations			

Text:
We will cover material in both dynamic game theory, control theory more broadly, and nonlinear programming. The course will follow the **monograph/notes** here, which itself draws heavily from two texts:

- Dynamic Noncooperative Game Theory, 2nd Edition (Başar and Olsder) – "BO" above
- Numerical Optimization (Nocedal and Wright) – "NW" above

Several other relevant background textbooks are:

- Differential Games: A Mathematical Theory with Applications to Warfare and Pursuit, Control and Optimization (Isaacs)
- Dynamic Programming and Optimal Control (Bertsekas)
- Finite-Dimensional Variational Inequalities and Complementarity Problems (Facchinei and Pang)

Assignments:
There will be five programming assignments, which students will complete individually, using the Julia programming language. In lieu of exams, we will have a final (team) project which will include both a written and oral component, roughly corresponding to a formal workshop paper and presentation.

Grading:
Grades will be computed according to the following proportions:

- Final project: 40%
- Programming assignments: 50%
- Attendance: 10%

Grades will be assigned as letter grades with plus/minus modifiers as appropriate.

Homework Policy:
Programming assignments should be completed and submitted independently by each student. Grading is generally automated through GitHub. Late submissions will not be accepted. Exceptions may be granted at the instructor's discretion, e.g. for medical or other emergencies that could not have been planned for in advance. However, please understand that everyone is busy and, to be fair to all students, exceptions will not be granted for conference travel, other deadlines, etc.

Examinations:
There are no exams in this class. However, there may be occasional pop quizzes, which will be counted in the "attendance" category for grading purposes.

Important Dates:
Please refer to the university academic calendar for important administrative dates.

Special Notes:
The University of Texas at Austin provides upon request appropriate academic adjustments for qualified students with disabilities. For more information, contact the Office of the Dean of Students at 471-6259, 471-4641 TDD or the Cockrell School of Engineering Director of Students with Disabilities at 471-4321.

Evaluation:
The Measurement and Evaluation Center forms for the Cockrell School of Engineering will be used during the last week of class to evaluate the course and the instructor. They will be conducted in an electronic format.

Class Recordings:
Any recordings which are made are reserved only for students in this class for educational purposes and are protected under FERPA. The recordings should not be shared outside the class in any form. Violation of this restriction by a student could lead to Student Misconduct proceedings.

DISABILITY & ACCESS (D&A):
The University of Texas at Austin is committed to creating an accessible and inclusive learning environment consistent with university policy and federal and state law. Please let me know if you experience any barriers to learning so I can work with you to ensure you have equal opportunity to participate fully in this course. If you are a student with a disability, or think you may have a disability, and need accommodations please contact Disability & Access (D&A). Please refer to the D&A website for more information: https://disability.utexas.edu. If you are already registered with D&A, please deliver your Accommodation Letter to me as early as possible in the semester so we can discuss your approved accommodations and needs in this course.

University Resources
For a list of university resources that may be helpful to you as you engage with and navigate your courses and the university, see the University Resources Students Canvas page.

Prepared by: David Fridovich-Keil Date: 8/11/2025