ECE 5555 (Fall 2021) **Syllabus**

Stochastic Systems: Estimation and Control

1 Course Information

Instructor:	Eilyan Bitar
Email:	eyb5@cornell.edu
Lectures:	Tuesday/Thursday (1:00 - 2:15 PM)
Office Hours:	Tuesday (5:00 - 6:00 PM)
Canvas link:	https://canvas.cornell.edu/courses/26114

Online Instruction: All lectures and office hours will be held over Zoom. Please refer to the course Canvas page for the Zoom meeting URLs. It is expected that students will attend lecture during the regularly scheduled time slot, provided the lecture time falls between 8 a.m. and 10:30 p.m. in their local time zone. Students who cannot attend lectures during the regularly scheduled time slot because they are in time zones that make synchronous participation untenable, should contact the instructor immediately.

Online Office Hours: Office hours will also be held over Zoom at the time specified above. If you plan to attend office hours on a particular day, please email the instructor in advance (right before is fine) letting him know that you will be attending office hours.

2 Prerequisites

Comfort with mathematical proofs, multivariable Calculus, probability and stochastic processes, linear algebra, basic convex analysis, and basic Matlab (or Python) programming. Undergraduates must receive permission from the instructor to enroll in this course.

3 Course Description

The problem of sequential decision-making in the face of uncertainty is ubiquitous. Examples include: autonomous vehicles, high frequency trading, power system operations, air traffic control, livestock and fishery management, supply chain optimization, internet ad display, data center scheduling, and many more. In this course, we will explore the problem of optimal sequential decision making under uncertainty over multiple stages—*stochastic optimal control*. We will discuss different approaches to modeling, estimation, and control of discrete-time stochastic dynamical systems (with both finite and infinite state and action spaces). Solution techniques based on dynamic programming will play a central role in our analysis. Topics include:

- Fully and partially observed Markov decision processes

- Optimal stopping problems
- Kalman filtering
- Linear quadratic Gaussian (LQG) control
- Model predictive control (MPC)
- Adaptive control
- Robust and chance constrained optimization
- Multi-armed and linear bandits (time permitting)
- Approximate dynamic programming (time permitting)
- Applications to various domains will be discussed throughout the semester.

4 Textbooks

There are two required textbooks for this course:

1. D. Bertsekas. *Dynamic Programming and Optimal Control.* Volume I, 4th ed. Nashua, NH: Athena Scientific, 2020.
2. P. R. Kumar and P. Varaiya. *Stochastic Systems: Estimation, Identification and Adaptive Control.* Society for industrial and applied mathematics (SIAM), 2015.

5 Software

We will occasionally use *Matlab* for computational assignments in this course. We will also make use of CVX—a Matlab-based software package for convex optimization.

- A brief video introduction to CVX: http://cvxr.com/news/2014/02/cvx-demo-video
- Instructions on how to download and install CVX: http://cvxr.com/cvx/download
- I recommend that you use the *Gurobi solver* with CVX. The Gurobi solver is an industry performance leader in linear, quadratic, and mixed-integer programming, and it is a fantastic solver to use in conjunction with CVX. Instructions on how to obtain a free academic license and installation can be found here: http://cvxr.com/cvx/doc/gurobi.html

6 Homework

Homework assignments, solutions, and general announcements related to homework will be posted on Canvas. There will be approximately 5 homework assignments. Your homework with the lowest score will be dropped, under the condition that you make a conscientious attempt at all of the homeworks. No late submission of homework will be accepted. If you don't submit your homework by the deadline, you are giving yourself a zero on that assignment. Any homework that is difficult to read will receive a score of zero. While it is not required, you are encouraged to prepare your homework solutions using LaTeX.

7 Grading

Your final grade will be based on **homework** (40%, assignments equally weighted), a **midterm exam** (12.5%) **project proposal** (5%), and **final project** (42.5%).

8 Collaboration and Code of Conduct

Every student attending this course is expected to abide by the Cornell University Code of Academic Integrity, which can be found at cuinfo.cornell.edu/Academic/AIC.html. Any piece of work you turn in for credit must be your own work. Discussion with other students about specific homework problems is permitted to the extent that discussion is limited to problem approach and does not include note taking. In writing up your homework solution, you must acknowledge anyone with whom you collaborated. If you use papers or books or other sources (e.g. material from the web) to help obtain your solution, you must cite those sources. You may not discuss exam problems with other students. Please ask if you are unclear as to what constitutes excessive collaboration.