ECE 5555 (Spring 2022) **Syllabus**

Stochastic Systems: Estimation and Control

1 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
- Exact and approximate Bayesian filtering methods (e.g., Kalman filtering, particle filtering)
- Linear quadratic Gaussian (LQG) control
- Model predictive control (MPC)
- Adaptive control
- Robust and chance constrained optimization
- Multi-armed bandits (time permitting)
- Approximate dynamic programming (time permitting)
- Applications to various domains will be discussed throughout the semester.

2 Prerequisites

Probability and stochastic processes, linear algebra, basic convex analysis, basic optimization theory, and comfort with mathematical proofs. Programming experience using Matlab or Python. Undergraduates must receive permission from the instructor to enroll in this course.

3 Course + Instructor Information

Instructor:	Eilyan Bitar
Email:	eyb5@cornell.edu
Lectures:	Tuesday/Thursday (2:45 - 4:00 PM)
Office Hours:	Tuesday (4:00 - 5:00 PM)
Course Canvas link:	https://canvas.cornell.edu/courses/37821

4 TA Information

Teaching Assistant:	Feras Al Taha
Email:	foa6@cornell.edu
Office Hours:	TBD

5 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, 2017.
2. P. R. Kumar and P. Varaiya. *Stochastic Systems: Estimation, Identification and Adaptive Control.* Society for industrial and applied mathematics (SIAM), 2015.

6 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

7 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.

8 Grading

Your final grade will be based on **homework** (50%, assignments equally weighted), **project proposal** (5%), and **final project** (45%).

9 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.