University of Colorado Boulder
ASEN 5044 - Statistical Estimation for Dynamical Systems
Spring 2021 Course Syllabus

General Information

Instructor: Kirsten Strandjord (Kirsten.Strandjord@colorado.edu)
Instructor Office Hours: via Zoom, Friday at 2:00-3:00 PM
Teaching Assistant: Ofer Dagan (Ofer.Dagan@colorado.edu)
TA Office Hours: via Zoom, Monday at 4:00-5:00 PM

Lecture Time and Location: Tuesdays and Thursdays 2:50-4:05 pm, AERO 114. All lectures will be recorded and posted online via course website. Remote/distance learning will be recorded and posted online via the course website. Remote/distance learning students may participate live through the Zoom meeting interface (see course website for instructions). For distance students who wish to attend live lectures, this course requires the use of the Zoom conferencing tool. If you use assistive technology to access the course material, please contact the instructor immediately to discuss.

Note: due to limited COVID-19 room capacity, in person attendance is limited to students from the hybrid/in-person section of the course who have been assigned to either the Tuesday or Thursday lecture cohorts. Students may only attend for their designated cohort day and must conform to safety practices on campus (see COVID guidelines below). Per CU campus plan, fully remote/online instruction will take place until February 15th through recorded/posted Zoom lecture. The following is the current information from the Chancellor:

> *On Feb. 15, we intend to resume some in-person courses and on-campus student activities and experiences, and we will follow up with you by Jan. 14 to hopefully confirm this plan.*

Course Website: canvas.colorado.edu (will be used for posting all recorded lectures, assignments, exams, and announcements/corrections; links to Zoom lecture and office hours, Piazza, and Gradescope are also provided.

engineering applications. Major topics include: review of applied probability and statistic; modeling and optimal state estimation for stochastic dynamical systems; theory and design of Kalman filters for linear systems; linearized and extended Kalman filters for non-linear systems.

Learning Objectives: Students will gain both a fundamental and practical understanding of estimation algorithms from a general dynamical systems standpoint. This will prepare them to tackle challenging estimation problems that they will eventually encounter in later courses and in their own professional/research pursuits. By the end of this course, students will:

1. Be well-acquainted with basic theory and engineering usage of probability and statistics
2. Explore, explain, ad apply core concepts of estimation theory, especially to problems defined by discrete time stochastic linear and non-linear state space dynamic process and measurement models
3. Formulate and solve dynamic state estimation problems using Kalman filter, least-squares estimator, and other related estimation algorithms;
4. Design, simulate, evaluate, visualize and tune estimator performance for real applications in software (e.g. Matlab, Python).

Anticipated Course Schedule

WEEK(S)	TOPIC	TEXT CHAPS.
1	Intro & overview	
1-3	Basic linear dynamical systems theory, discrete time systems	1.1-1.7
3-6	Basic probability and stochastic process theory	2.1-2.7
6-8	Least squares estimation, stochastic linear systems	3.1-3.7, 4.1-4.2
8-11	The Kalman Filter (KF): basics, tuning, testing, generalizations	5.1-5.5, 6, 7
11-14	Nonlinear Filters: Linearized KF and EKF	13.1,13.2
14-15	Unscented KF; advanced topics (if time)	8, …

Grading, Assignments and Exams: Course grades will be determined on the basis of homework (15%), online Canvas quizzes (15%), midterm 1 (20%), midterm 2 (20%), and a final project (30%).

Important things to note:

Students will work in pairs for the final project (there may be one team of 3 students, depending on enrollment parity).

Weekly homework will be assigned, collected, and partially graded. Quizzes will be fully graded automatically on Canvas. Solutions for full problem and quiz sets will be posted to Canvas.

Collaboration on homework is encouraged, but students must turn in their own homework in a timely manner (see policies below). Students may use Piazza for online discussion (this will be loosely monitored by instructor and TAs).

A series of weekly quizzes will be assigned and administered through Canvas. These will be posted on Friday morning and be due the following Sunday at 11:59 pm (off-nominal posting/ due dates will come with special notification, if needed).

All exams will be take-home and open-book/open-note. Students will have exactly one week to complete exams and may not collaborate with each other on exams in any way (CU honor code applies).