Stochastic Estimation and control (ECE672s, 2 c.u.)

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Winter 2015, Mon (9:30a-11:00a) Thu (9:30a-11:00a), LR1 lecture hall
Indraprastha Institute of Information Technology, Delhi (IIIT-D)

Description

This course deals with the estimation of dynamical systems. We will begin with an introduction of probability, random variables, stochastic differential equations, and basics in parameter estimation. These concepts will then be applied to state-space descriptions of linear systems following up to the Kalman filter. Nonlinear estimation methods such as the extended Kalman filter and particle filter will be introduced. The final exam will include designing an estimator for a real-world scenario.[1]

Pre-requisites Probability and Random Processes (ECE530)

Post condition/learning outcomes At the end of this course, the student should be able to:

- Develop and linearize a measurement model for a dynamical system
- Pick an state estimator based on the system properties (nonlinearities, noise)
- Given a dynamical system with process and measurement noise, design a linear/nonlinear state estimator

Text

Class notes (adapted from Stochastic estimation and control course taught in University of Maryland, College Park). Some of the lectures will be flipped (f); students will be encouraged to read pre-assigned material and watch video tutorials and come to the class prepared to solve problems and answer questions. The following books may be used for reference:

- Papoulis, A., Probability, Random Variables, and Stochastic Processes, ISBN 0070484775
- Jazwinski, A. H., Stochastic Processes and Filtering Theory. Dover Publications, 2007
- Y. Bar-Shalom, X. R. Li, and T. Kirubarajan, Estimation with Applications to Tracking and Navigation: Theory Algorithms and Software. Wiley Inter-Science, 2001.

Grading

- Homework Assignments (3): 60%
- Final exam (filter design problem): 40%

[1] although the course name has control in it, we will only touch it briefly in Week 3. The full 4 c.u. course including stochastic control will be offered at later stage when enough students will have met a prerequisite of linear systems

Table 1: Schedule

Week	Assignments	Topics	Readings
9/3, 12/3	–	Introduction to probability and random processes: random variables, pdf, total probability theorem, Bayes Theorem, stochastic processes, stationarity, ergodicity	–
16/3, 19/3	hw 1 posted	Basics of estimation: Parameter estimation, maximum likelihood estimation, least squares estimation, maximum a posteriori estimation, minimum mean square estimation	–
23/3, 26/3		Estimation of dynamic systems: Specialize to LTI systems, state space form, Recursive static estimation, minimum variance (f)	–
30/3	hw 2 posted	The discrete time Kalman filter	–
6/4, 9/4		Discrete and continuous time Kalman filter (f)	–
11/4, 13/4	hw 3 posted	Nonlinearity in dynamic systems, measurement models/likelihood functions, linearization	
16/4, 20/4		Nonlinear estimators: Extended Kalman filter, sampling a pdf, particle filter	–
27/4	Exam		–

Homeworks There will be three homework assignments as part of this course. You are encouraged to collaborate on these, however, the work you submit should be entirely your own. No collaboration is permitted during the final exam and project. Please refer to academic dishonesty section below. 10% of maximum marks will be docked for late homeworks for every additional day; After three days no marks will be awarded.

Exam The course will end with a final exam. The exam will consist of designing an estimator for a real-world problem where you will be required to estimate the state of a dynamical system given measurements from a noisy sensor. For e.g. tracking people in an overhead video. A rubric detailing the grading procedure and the topic will be shared.

Office hours

Thursdays: 12–2pm

Academic dishonesty

Please read carefully `http://www.iiitd.ac.in/education/resources/academic-dishonesty`. Please discuss with me if you have doubts about what constitutes dishonesty, plagiarism, and cheating. You are responsible for your work!

References