AE514 - Estimation Theory

Introduction

A great many control design and analysis applications require state information for feedback control, for model identification, or for design verification. Generally, the mechanics of acquiring state information comes not from direct access to the state but from sensor-based measurements. From these measurements, state information must be constructed. To address this need, system observers have been developed for a number of classes of systems. This course will focus on development of observers and optimal observers for both discrete and continuous time with emphasis on continuous time. Both linear and nonlinear systems will be considered. The course will include a project - with students working individually or in pairs.The goal of this course is to enable all students to have the skills and knowledge to successfully apply estimation techniques to a variety of applications.

Contact Info

Instructor: Dan Calderone
Email: djcal@uw.edu

Lecture

Date & Time: TBA
Location: TBA
Zoom link: TBA

Materials

Notes/Slides

Collected materials can be accessed here.
Teaching website: https://danjcalderone.github.io/teaching.html

Textbook

J. L. Crassidis and J. L. Junkins,*Optimal Estimation of Dynamic Systems* Second Edition" Chapman Hall/CRC, 2004.
Link to m-files for examples in book:
(1st Edition) http://ancs.eng.buffalo.edu/index.php/Optimal_Estimation_of_Dynamic_Systems_1st_Edition
(2nd Edition) http://ancs.eng.buffalo.edu/index.php/Optimal_Estimation_of_Dynamic_Systems_2nd_Edition
(required - see library link for online version)

Other Resources

UW library link to text (UW restricted): https://ebookcentral-proquest-com.offcampus.lib.washington.edu/lib/washington/detail.action?docID=800953

References (on reserve in Engineering Library)

- A. Gelb, *Applied Optimal Estimation*, MIT Press, 1974.
- A. E. Bryson and Y. -C. Ho, *Applied Optimal Control*, Taylor Francis, 1975.

- Simon, *Optimal State Estimation*, John Wiley Sons, 2006. eBook (UW restricted): http://www.knovel.com/web/portal/basic_search/display?_EXT_KNOVEL_DISPLAY_bookid=3180

- Chen, *Linear System Theory and Design*, Oxford University Press, 2012. Hespanha, "Linear Systems Theory," Princeton University Press, 2009.

Video Resources

*some of these videos are the best references on the subject
3blue1brown: https://www.3blue1brown.com/
Brian Douglas: https://www.youtube.com/channel/UCq0imsn84ShAe9PBOFnoIrg
Steve Brunton: https://www.youtube.com/channel/UCm5mt-A4w61lknZ9lCsZtBw

Graphing Tools

- https://www.geogebra.org/graphing

Grades

- Homeworks: 70% (probably about 8 homeworks total)

- Final Project: 30%

Homeworks

General Policy

Homeworks will be assigned each week after class and due 10 days later. Self-grades/error explanations for the previous week's homework will be due at the same time. Your writeup must be submitted as a single self-contained `.pdf` document, including commented source code for any computational tools used to complete the assignment. Every student can turn in one homework late for full credit with no questions asked. Other extensions can be given for exceptional circumstances but must be requested well in advance (teacher discretion) of the deadline. Homeworks will be worth 80% of your grade. Solutions will be provided after each assignment is due.

Self-assessment/Rubric

Each homeworks will divided into sub-problems worth 2 points each. To provide training and feedback that helps cultivate self-reflection, you will grade your homework assignments and receive oversight and feedback from the instructional staff regarding the accuracy of your self-assessment. Self-assessment will be due with the next assignment. We will provide detailed solutions on the day of the homework submission deadline, and you will have until the following due date to grade each of your homework sub-problems on a 0,1,2 point scale:

- **0 points:** - no effort / not attempted

- **1 points:** - attempted, but incomplete or incorrect solution

- **2 points:** - complete and correct solution

For any sub-problem that earns a 1, you have the opportunity to explain the error in your solution and how to correct it; if this explanation is correct, you earn the full 2 points on the problem. You do not give yourself the 2 points if you got an incorrect problem and corrected it. The grader will assign you the extra point after going through your homework. To specify grades and provide explanations of any errors, use the Comment feature in Canvas's Assignment page for the homework.

Notes and caveats intended to ensure the integrity of this process:

- if you did not attempt the problem initially, you will receive 0 points;
- if you do not grade a problem, you will receive 0 points;
- if you grade incorrectly (i.e. initial solution is incomplete or incorrect and your explanation is incomplete or incorrect), you will receive 1 or 0 at the discretion of the instructional staff (this ensures you cannot simply assign all "2"s, nor can you receive full credit for incomplete or incorrect explanations).

Frequently Asked Questions (FAQ)

Q: Should I download my.pdf, add comments (e.g. via Adobe Acrobat), and re-upload the .pdf?
A: That's fine, but it's probably easier to use the in-browser "CrocoDoc" viewing and annotation pane provided in Canvas.

Q: Does my .pdf need to contain all of my homework writeup materials, or can some be in an .m file?
A: Your writeup must be submitted as a single self-contained .pdf document, including commented source-code for any computational tools used to complete the assignment.

Submission guidelines

Please make homeworks neat and organized. Points may be deducted if not. You are welcome (and we encourage you) to typeset your homework assignments rather than write them by hand. We will provide both .pdf and .m files for homework assignments and solutions. If you write your solutions by hand, you must create a legible scan; if you have any doubts about the fidelity of your scans, send a sample to the TA / Prof in advance of the homework deadline.

Final Project

Students will complete a project consisting of applying techniques learned in class to a real world control problem of their choosing. You are encouraged to use systems that you work with in an industry or research context. At the end of the quarter, you will prepare a report formatted in the IEEE conference publication style. The project will be worth 30% of your grade.

Coding Resources

Coding can be done in Matlab or Python.

- Control Tutorials for MATLAB and Simulink: http://ctms.engin.umich.edu/CTMS/index.php?aux=Home
- Python: https://colab.research.google.com/