AAE 568
Applied Optimal Control and Estimation

Spring 2020

Instructor: Prof. Inseok Hwang
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Class hour: MWF 10:30 – 11:20am @ TBD

Office hour: MW 9:30 – 10:30 am @ ARMS 3323 or by appointment

Prerequisites
Linear systems (AAE564/ECE602/ME… or equivalent)

Course Materials
The course is based on a set of lecture notes and articles which will be made available during the class.

Course Description
The main objective of this course is to study analysis and synthesis methods of optimal controllers and estimators for (stochastic) dynamical systems. Optimal control is a time-domain method that computes the control input to a dynamical system which minimizes a cost function. The dual problem is optimal estimation which computes the estimated states of the system with stochastic disturbances by minimizing the errors between the true states and the estimated states. Combination of the two leads to optimal stochastic control. Applications of optimal stochastic control are to be found in science, economics, and engineering. The course presents a review of mathematical background, optimal control and estimation, duality, and optimal stochastic control.

Topics covered in this course:
- Review of some mathematical background
- Classical estimation
  - Minimum variance unbiased estimation
  - Least squares estimation
  - Maximum likelihood estimation
- Optimal control
  - Pontryagin's Maximum/Minimum principle
  - Hamilton-Jacobi-Bellman equation
  - Dynamic Programming
  - Linear Quadratic (LQR) problems

- Stochastic optimal control and estimation
    - Stochastic dynamic programming
    - Kalman Filter: discrete/continuous-time filters
    - Duality of LQR with Kalman filter (LQE)
    - Linear Quadratic Gaussian (LQG)

References

- B.D.O. Anderson and J. Moore, *Optimal Control: Linear Quadratic Methods*, Prince Hall.
- A. Gelb, *Applied optimal Estimation*, MIT press.
- P. Maybeck, *Stochastic Models, Estimation, and Control*, Academic Press
- R. Stengel, *Optimal Control and Estimation*, Dover.
- R. Brown and P. Hwang, *Introduction to Random Signals and Applied Kalman Filtering*, Wiley.
- A. E. Bryson and Y.C. Ho, *Applied Optimal Control*.

Homework

- A few problem sets per semester.
- No late homework will be accepted.

Class Project

The project is a **team project with two persons** (the exact team size may change depending on the class size and progress). The project could be an extension of existing algorithms in the literature or, preferably, involve the original research ideas related to your current research. The project topic should be related to the class contents. The tentative schedule is as follows:

- Project Proposal (two-page summary) **due TBD**
- Project report (10-12 pages) **due the dead week of classes**
- Project presentation: Presentations will be given at the classes in the dead week of classes. The schedule may change depending on the number of project teams.

The proposal and report should be written in 11-size font with a single line space and should have a technical paper format: abstract, introduction, main body, conclusions, and references. *The dues are subject to the progress of the lectures*. Reports that do not comply the format won't be accepted.

Evaluation

- Homework 30%
- Class Project 70%

Course webpage: Blackboard (All class materials are available from Blackboard)

Information

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances. Information about changes in this course will be announced in the class, via email and/or in the class webpage (Blackboard). Additional information is available from the following link:
http://www.purdue.edu/ehps/emergency_preparedness/index.html

Academic Misconduct: Incidents of academic misconduct in this course will be addressed by the course instructor and referred to the Office of Student Rights and Responsibilities (OSRR) for review at the university level. Any violation of course policies as it relates to academic integrity will result minimally in a failing or zero grade for that particular assignment, and at the instructor's discretion may result in a failing grade for the course. In addition, all incidents of academic misconduct will be forwarded to OSRR, where university penalties, including removal from the university, may be considered. Purdue's Honor Pledge: As a boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do. Accountable together - we are Purdue.

The course follows the University policy.