ELEG 5423 Optimal Control

Fall 2019: WebEx Meetings on Tuesdays 6:30PM

Textbooks:
Optimal Control Systems
by Naidu (CRC Press)
ISBN 978-0849308925

Optimal & Robust Estimation & Stochastic Control Theory (CRC Press)
By Frank Lewis
ISBN 978-0849390081

Recommended: Control System Design:
An Introduction to State-Space Methods
By Bernard Friedland
Dover (low-cost paperback)
ISBN 978-0486442785

Instructor: Roy McCann, Ph.D., P.E

This course covers the introductory theory of optimizing dynamic systems. The scope is the classical and modern methods that are often used or referenced in recent engineering research and practical applications. There is a large body of knowledge for optimizing the solutions to many types of problems in the quantitative sciences. This course emphasizes:

(1) Real-time systems where the variables of interest are functions of time and the optimal solution is often computed during system operation.

(2) Design optimization of dynamic systems to achieve inherently robust operation with respect to component variation.

Early applications were for aircraft, missile and space systems with constraints on mass, time and fuel usage. However, optimal control and estimation theory has been applied to many diverse applications such as robotics, power generation-transmission, biomedical and automotive systems.

The examples examined in this course will emphasize electric power systems and power electronics. This course covers deterministic systems with an introduction to stochastic quadratic optimization and Kalman filters. A familiarity with linear systems theory is assumed. This course will provide detailed use of Matlab-Simulink in formulating design solutions to engineering problems.

Outline
1. **Week 1**: Introduction and Mathematical Preliminaries (3 lectures)
   a. Formulating a Performance Index
   b. Optimization Examples
   c. Matrix Calculus and State Space Models

2. **Week 2**: Calculus of Variations (3 lectures)
   Sections 2.1 - 2.7

3. **Week 3**: Linear Quadratic Optimal Control Part 1 (3 lectures)
   Sections 3.1 - 3.5

4. **Week 4**: Linear Quadratic Optimal Control Part 2 (3 lectures)
   Sections 4.1 - 4.5

5. **Week 5**: Discrete-Time Optimal Control (3 lectures)
   Sections 5.2 - 5.4

6. **Week 6**: State Estimation (3 lectures) (Frank Lewis book)
   a. Kalman Filter as the Quadratic Optimal Estimator (Handouts)

7. **Week 7**: Intro to $H_2$ & $H_\infty$ Control (3 lectures) (Control Systems Handbook)

8. **Week 8**: Design Project

**Class Project**
A Matlab-Simulink based class project is required for the course. The topic can be selected by the student or a problem provided by the instructor can be used. The purpose is to more deeply explore the implementation details than what can be accomplished in the homework assignments.

**Grading:**

8 homework assignments 40% (combined)
2 Exams (10% each) 30% (combined)
Class Project 30% (with online presentation)

Overall course grades will be assigned based on an assessment of the student's mastery of the subject matter and participation in classroom discussions and presentations. As a general guideline, the approximate course grade breakdown:

>90% → A  >80% → B  >70% → C  <60% → D or F