UIUC: ME547 Robust and Adaptive Control

MechSE Lecturer Kevin A. Wise

**Robust and Adaptive Control Syllabus**

Text: Lavretsky and Wise, Robust and Adaptive Control: With Aerospace Applications, Springer Verlag, 2013 (Advanced Textbooks in Control and Signal Processing). ISBN 978-1-4471-4396-3.

UIUC Prerequisites:

ME 543 Applied Control System Design With Aerospace Examples, or

EE 515 Control System Design and Theory

3 credit hours

Lectures are virtual (recorded) and live via Zoom mtg on Friday afternoons (also recorded).

Wednesday evening Zoom mtg with Professor, TA, students are held to discuss homework questions and or any questions regarding class material. Contact with the Professor and TA can be made during Zoom mtg sessions or at times arranged via email.

This control system design course begins with linear optimal based methods in robust control, and is followed by observer-based nonlinear model reference adaptive control. These design methods are currently used in most industry control system design problems. For example, optimal control is used to design a baseline control system (ideal performance characteristics), and then the design is augmented with model reference adaptive control to compensate for uncertainties, nonlinear effects, failures, and unknown unknowns.

Dr. Eugene Lavretsky (Boeing STF, teaches at CalTech) and I have written a new text book that covers these topics. These are the design methods that engineers at Boeing need to know to design control system for aerospace products. (I will be providing chapters and lectures notes until the book is published.) This course follows the text book chapter by chapter.

This course summarizes the important control system theory and design methods found to be useful in the aerospace industry over the last 30 years. The text book was written for this course, and details aerospace examples that will prepare students for future engineering challenges.

These methods will be designed, analyzed, and simulated using Matlab. Computer homework design projects will be given for each method. Matlab code implementing each design method (the examples in the text) will be given for which students can use to base their design.

**Course Outline**

Part 1 (Robust Control)

Review of Linear Control Theory

Frequency Domain Analysis and Robustness Theory (Chapter 5)

Optimal Control and the Robust Servomechanism (Chapter 2 and 3)

Mu-Analysis (Chapter 5)

H-infinity Optimal Control using State Feedback (Chapter 4)

Robust Output Feedback Controls (Chapter 6)

Kalman Filter Theory and Design (Chapter 6)

Doyle and Stein Linear Quadratic Gaussian with Loop Transfer Recovery (Chapter 6)

Observer-Based Loop Transfer Recovery (Chapter 6)

Part 2 (Model Reference Adaptive Control (MRAC))

Introduction to Adaptive Control(Chapter 7)

Lyapunov Theory, LaSalle extensions, Barbalat’s Lemma

Uniform Ultimate Boundedness

Model Reference Adaptive Control {scalar and MIMO systems)

Model Reference Adaptive Control augmentation of a baseline control

Robust Servomechanism MRAC

MRAC robustness and the projection Operator

On-line parameter estimation, convergence, and Persistence of Excitation

Artificial Neural Networks, Adaptive Control with State Constraints

State Feedback Model Reference Adaptive Control

Singular Perturbations and Asymptotic Properties of the Algebraic Riccati Equation

Observer-Based MRAC (State feedback and Output feedback)

Homework

There are 9 graded homeworks. Each is an aerospace control system design project that requires MATLAB. Homework design projects follow the chapters in the text book.

Grading Policy

Computer Projects 60%

Midterm Exam 20%

Final Exam 20%

Kevin A. Wise, PhD

VP, Distinguished Senior Technical Fellow, The Boeing Company

Boeing Office Phone: 314-232-4549

Cell: 636-866-9162

Email: [kevin.a.wise@boeing.com](mailto:kevin.a.wise@boeing.com)

Email : kawise@illinois.edu

Email : [kwise@wustl.edu](mailto:kwise@wustl.edu)