UNIVERSITY OF FLORIDA
DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

EML 6934 Robust and Adaptive Control for Aerodynamic Systems Fall 2020 3 Cr

Course Description: In this course, students will learn modern robust and adaptive control theory that address flight control challenges relevant to real-life aerospace systems. This course is presented in two parts. In Part One, students will extend and strengthen understanding of frequency domain and state space control theory for single-input single-output (SISO) and multi-input multi-output (MIMO) systems. Topics will include: optimal control, robust servomechanism design, linear quadratic methods, optimal observer-based feedback, loop transfer recovery, single and multivariable time and frequency domain analysis methods, and guidance fundamentals. In Part Two, students will learn how robust linear controllers may be augmented with nonlinear model reference adaptive control (MRAC). Material will be introduced with progressive complexity beginning with single variable direct model reference control, followed by scalar state feedback MRAC, MIMO MRAC, MRAC augmentation with optimal baseline control. If time allows, neural network uncertainty approximation based adaptive control, and output feedback approximation based MIMO MRAC may be included. At the end of this course, students develop a set of modern control-theoretic tools through assignments as well as a basis of understanding for how to systematically tune flight control systems and address flight control challenges of aerial vehicles and missile systems.

Prerequisites: Students should be familiar with linear algebra, ordinary differential equations, classical control for SISO systems, and state space control theory. Basic programming skills in MATLAB are essential.

Class Times:

Three 50 minute lectures will be pre-recorded and posted weekly.

Course Website: Access the course website through eLearning at: https://elearning.ufl.edu/. Check the course website often. It is updated frequently.

Required Text: Lavretsky E. and Wise K., *Robust and Adaptive Control: With Aerospace Applications*, Springer, 2013

Supplementary Texts:

- Stevens, B. and Lewis F., *Aircraft Control and Simulation*, 2nd Ed., Wiley, 2003
- Anderson, B. and Moore, J., *Optimal Control Linear Quadratic Methods*, Dover, 2007.

Instructor:

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Office Hours: Wednesday, 1-2pm (Google Meet link will be provided)

Grading: Grades are based on assignments, midterms, projects, and the final exam. Grading may be scaled to class performance and will be no more rigorous than: 90 and above A, 85 to 89 B+, 80 to 84 B.

Homework	50 %
Final Exam	25 %
Project	25 %

In order to graduate, graduate students must have an overall GPA and an upper-division GPA of 3.0 or better (B or better). Note: a B- average is equivalent to a GPA of 2.67, and therefore, it does not satisfy this graduation requirement. For more information on grades and grading policies, please visit:

http://gradschool.ufl.edu/catalog/current-catalog/catalog-general-regulations.html#grades

Homework: The assignment of homework, its availability, and its due date is all communicated through the course website. In general, late homework is not accepted. Extenuating circumstances are at the discretion of the instructor and proof may be required.

Exams: The final exam date and time is to be determined. The exam will be electronically delivered through the course website. Exams are to be taken individually, are unproctored, and open book, open notes.

Make-up Exam Policy: The exam date and time will be selected to best accommodate student schedules. For the retaking of a missed exam, valid extenuating circumstances are at the discretion of the instructor and proof may be required.

Honesty Policy: All students admitted to the University of Florida have signed a statement of academic honesty committing to be honest in all academic work and understanding that failure to comply with this commitment will result in disciplinary action. This statement is a reminder to uphold your obligation as a UF student and to be honest in all work submitted and exams taken in this course and all others.

Accommodation for Students with Disabilities : Students requesting classroom accommodations must first register with the Dean of Students Office. That office will provide the

student with documentation that he/she must provide to the course instructor when requesting accommodation.

UF Counseling Services : Resources are available on-campus for students having personal problems or lacking clear career and academic goals. The resources include:

- UF Counseling & Wellness Center, 3190 Radio Rd, 392-1575, psychological and psychiatric services.
- Career Resource Center, Reitz Union, 392-1601, career and job search services.

Software Use: All faculty, staff and student of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Course Schedule:

Week	Topics	Reading
1-4	Course introduction, Review of aircraft equations of motion, Trim and linearization, Rigid body modal dynamics, Longitudinal and lateral directional linear time invariant control models, Modern control design, Robust servomechanism model design (RSMDM), Linear quadratic (LQ) control	Chapters 1, 2 and 3
4-7	RSMDM and LQR tuning, SISO frequency domain methods review, Multivariable stability margins, Multivariable Nyquist, Output feedback control, Linear quadratic Gaussian design (LQG), Observer based loop transfer recovery (OBLTR)	Chapters 5 and 6
8	Classical guidance laws (proportional navigation), Project assigned	-
9-11	Direct model reference adaptive control (MRAC), Lyapunov theory and analysis, State feedback direct (MRAC),	Chapters 7, 8, and 9
12-15	MRAC with integral feedback, Robust adaptive control Course review, Final exam,	Chapters 10 and 11
As time allows	Feedforward neural networks (NN), NN approximation based MRAC, Improving transients in MRAC, Output feedback approximation based MRAC,	Chapters 12, 13, and 14