EE621 Syllabus

Catalog Description: EE621: Nonlinear Control

Methods for analysis and design of nonlinear control systems emphasizing Lyapunov theory. Second order systems, phase plane descriptions of ononlinerar phenomena, limit cycles, stability, direct and indirect method of Lyapunov, linearization, feedback linearization, Lyapunov-based design, and backstepping.

Prerequisite: EE 478 Fundamentals of Control or equivalent.
Credit: 3.

Textbook:

H. K. Khalil, *Nonlinear Systems*, Prentice Hall, Third Edition, 2002.

Reference Books:

- J.-J. E. Slotine and W. Li, *Applied Nonlinear Control*, Prentice Hall, Englewood Cliffs, NJ, 1991.
- Zhihua Qu, *Robust Control of Nonlinear Uncertain Systems*, John Wiley & Sons, Interscience Division, New York, NY, 1998.
- A. Isidori, *Nonlinear Control Systems I*, Communications and Control Engineering, Springer-Verlag, Third Edition, 1995.
- H. Nijmeijer and A. J. van der Schaft, *Nonlinear Dynamical Control Systems*, Springer-Verlag, New York, 1990.

Instructor:

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Goals:

The course is designed to acquaint students with the techniques in the analysis and design of nonlinear control systems. In recent years, the availability of powerful low-cost microprocessors has spurred great advances in the theory and applications of nonlinear control. Many practical nonlinear control systems have been developed, ranging from digital "fly-by-wire" flight control systems for aircraft, to "drive-by-wire" automobiles, to advanced robotic and space systems. The subject of nonlinear control is occupying an increasingly important place in automation control engineering, autonomous mobile robotics, and has become a necessary part of the fundamental background of many engineering subjects.

Students will be able to use tools for the stability analysis of nonlinear systems, with emphasis on Lyapunov's method. Nonlinear feedback control tools include linearization, feedback linearization, Lyapunov redesign, and backstepping. Case studies include the design of nonlinear control for mobile robotic systems (car-like robots, underwater vehicles) to achieve stabilization and asymptotic tracking of reference trajectories. The goal is to provide tools and methods that will enable students to analyze and control complex engineering systems.

Course Components:

Engineering: 80%
Science and Math: 20%

Schedule of Topics (tentative):

Week 1: Review of linear system theory

Week 2: Nonlinear models and nonlinear phenomena

Week 3: Second-order systems, phase portraits, limit cycles

Week 4: Fundamental properties of ordinary differential equations

Week 5: Lyapunov stability, Lyapunov direct and indirect methods

Week 6: Autonomous systems, the invariance principle, boundedness

Week 7: Nonautonomous systems, Barbalat's lemma

Week 8: Mid-term exam

Week 9: Control design, linearization, stabilization via linearization, tracking

Week 10: Feedback linearization, input-output linearization, state feedback control

Week 11: Lyapunov redesign

Week 12: Backstepping

Week 13: Nonlinear control applications

Week 14: Review

Topics and Textbook Chapters

Topic	Textbook Chapter
Introduction to Nonlinear Control	1
Second-Order Systems	2
Fundamental Properties	3
Lyapunov Stability	4
Advanced Stability Analysis	8
Feedback Control	12
Feedback Linearization	13
Nonlinear Design Tools	14.1-14.3

Grading Policy:

Mid-Term Exam: 40%
Final Project: 60%

Homework will be assigned regularly. Exams may be based on the homework.