Course Syllabus

ECE/MAE 6330 - Nonlinear and Adaptive Control Systems
Spring 2002

Instructor: YangQuan Chen, Center for Self-Organizing and Intelligent Systems
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NEW Class Time: MW 12:15 – 13:30pm.

Office Hours: MWF 11:15 AM to 12:15 PM or by appointment. Try to formulate your question in written form first (your question may no longer be a question during your write-up!)

http://www.usu.edu/registra/spring2002/courses/ECE.html

13371 ECE 6330 001 NONLINEAR/ADAPTIVE CON 3.0 M_W__ 1:30- 2:45 $20.00 Fullmer R EL 112

Text: Hassan K. Khalil, *Nonlinear Systems*, Third Edition, Prentice Hall, 2002.

References:

- William S. Levine (Editor), *The Control Handbook* (Electrical Engineering Handbook Series), CRC Press, March 1996 (1566 pages!)
- M. Vidyasagar, *Nonlinear Systems Analysis*, 2nd Ed., Prentice Hall, 1993.
- A. Isidori, *Nonlinear Control Systems*, 3rd Edition, Springer, 1995.
- S. Sastry and M. Bodson, *Adaptive Control: Stability, Convergence, and Robustness*, Prentice-Hall, Englewood Cliffs, NJ, 1989. (Online available here: http://www.elen.utah.edu/~bodson/acscr.html)

Prerequisites: Undergraduate control systems and graduate linear multivariable systems.

Course Requirements:

Homework	60 points
Midterm Exam	20 points
Focus Independent Study Project	20 points

There is no Final Exam.

Notes:

1. The course will follow the outline below.
2. The course will cover material from almost every chapter of the text as well as some material taken from the instructor's notes.
3. Homework will be assigned approximately weekly and will be due one week later.
4. The midterm will be a take home exam covering basic course concepts.
5. There is no final exam. Instead, a FISP (focused independent study project) will be assigned to each student with different topics. This FISP includes a survey report on the chosen specific topic and a case study via simulation of nonlinear system analysis and/or controller design. The topics can be proposed by the students upon instructor’s approval.
6. Computer simulations will be necessary for some homework problems. Matlab/Simulink is the preferred computing environment for these simulations.

Course Description:

This course presents a comprehensive exposition of the theory of nonlinear dynamical systems and its control. It will focus on (1) methods of characterizing and understanding the behavior of systems that can be described by nonlinear ordinary differential equations, and (2) methods for designing controllers for such systems. In the design part, we will focus on the nonlinear robust adaptive control. Both classical and modern concepts from nonlinear system theory will be introduced.

Outline of Topics:

Introduction	Chapter 1 and Notes
Motivation, Notation, Nonlinear System Behavior	
Modelling	
Qualitative Behavior of Nonlinear Systems	Chapter 2
Phase Plane for 2nd order systems, Linear Systems	
Essential Mathematics: Normed Vector Spaces	Notes
Nonlinear Differential Equations	Chap. 3
Analysis	
Lyapunov Theory	
Definitions (Stability and Functions)	Chap. 4.1,
Direct Method	Chap. 4.3,
Invariant Set Theory	Chap. 4.2, Notes
Linearization	Chap. 4.6,
Center Manifold Theorem	Notes, Chap. 8.1
Finding Lyapunov Functions	Notes
Input-Output Stability	Chap. 5
Lp-spaces, Lp-stability	
Aside: Norms for Linear Systems	
Lp-stability of State Models	
Lyapunov Stability of I/O Models	
L2-Gain,	
Analysis of Feedback Systems	Chap. 6, Notes
Small Gain Theorem	Chap. 6.1, 6.2
Passivity Approach to Stability	Chap. 6.5
Passivity of Linear Systems, PR Lemma.	Chap. 6.3
Absolute Stability	Chap. 7.1
Describing Function Analysis	Chapter 7.2
Design	
Integral control and gain scheduling	Chapter 12
Feedback Linearization Technique	Chapter 13
Sliding Mode	Chapter 14.1
Lyapunov-Based (re)Design and Backstepping technique	Chap. 14.2, 14.3
Robust Adaptive Control	Notes