ME 533: Nonlinear Dynamics Analysis

(Actually more Nonlinear Dynamics and Control Analysis)

Spring 2018

4 Credits

Instructor
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Class hours:
MW 12–2 PM, BAT 144

Instructor office hours:
Tu 330—430 PM, Graf 315

Textbook
Applied Nonlinear Control
J-J. E. Slotine and Weiping Li
Prentice Hall, 1991

Reference material for fundamental/linear control system topics
Any one and any edition of the following books:
1) N. S. Nise, Control Systems Engineering, Wiley, 6th edition, 2010.
2) K. Ogata, Modern Control Engineering, 5th edition, Prentice Hall, 2009.

Course description
This course seeks to present the fundamental results of modern nonlinear dynamics and control and demonstrate their use in the design of practical nonlinear control systems. The course starts by providing fundamental analytical tools such as phase-space analysis and then move on to more advanced techniques such as Lyapunov methods, linearization, and Lie Algebra techniques and perform stability analysis. The course will also introduce how nonlinear control systems are prevalent in everyday dynamic systems such as human musculoskeletal movements and locomotion systems. Finally, the course will include a short project applying the concepts learned.

Grading
Class participation (including topic presentations by students): 30%
Homeworks: 10%
Final project proposal: 20%
Final project proposal presentation: 10%
Final project paper: 20%

Final project presentation: 10%

Final Project
Focusing on the models/chapters/papers covered in class or your own research problem, the students in groups of two will prepare a four-page term paper (single-line spaced, double column, 11 pt font) on a topic of interest in consultation with the instructor. The project must include a computational model (say in Matlab or Mathematica) of some nonlinear dynamic system. It must also include a literature survey of the topic and discuss the importance of the topic to research in the field of nonlinear dynamics.

Learning Outcomes
By the end of this course students will:

1) Have an understanding of how nonlinear dynamics and control is a key aspect of everyday systems.
2) Have an introduction to key tools for nonlinear control analysis.
3) Identify what tools will be useful for a specific nonlinear dynamics/control problem.
4) Conduct a research project that explores one specific problem in nonlinear control and write a research paper on it.

Tentative Course Schedule (subject to change):

Date	Lecture	Tentative Deadlines
M 4/2	Nonlinear systems: introduction	
W 4/4	Phase space analysis (chapter 2)	HW1 out
M 4/9	Basic Lyapunov theory (sections 3.3, 3.4.1, 3.4.2)	
W 4/11	Instructor traveling	
M 4/16	Lyapunov stability analysis (section 3.4.3)	HW1 due HW 2 out
W 4/18	Convergence to invariant sets (sections 3.4.3 and 3.6)	
M 4/23	Stability of time varying systems (sections 4.2, 4.5)	
W 4/25	Sliding variables (section 7.1)	HW2 due
M 4/30	Robust control (sections 7.2, 7.3)	HW 3 out
W 5/2	Adaptive control (chapter 8)	

M 5/7	Robust adaptive control (section 8.8)	
W 5/9	Adaptive robot control (chapter 9) Example Systems: Guest lecture?	HW3 due HW4 out
M 5/14	Feedback linearization (section 6.1) Example Systems: Guest lecture?	
W 5/16	Basic differential geometry tools (section 6.2)	
M 5/21	Controllability, integrability, and backstepping (section 6.3 and pp. 258—262) Example systems: Guest lecture by Dr. Ross Hatton	HW4 due Begin thinking about term paper
W 5/23	Example systems: Guest lecture by Dr. Chris Hoyle	
M 5/28	Neuro-musculo-skeletal control system Error-recovery for mobile robots	Term paper proposal due
W 5/30	Synchronization (if time permits)	Term paper proposal presentations due
M 6/4	Work on term paper ideas	
W 6/6	Work on term paper ideas	
6/11-6/15	Finals week	Term paper due 6/8. Presentation on 6/12.

Statement Regarding Students With Disabilities:
Accommodations are collaborative efforts between students, faculty and Disability Access Services (DAS). Students with accommodations approved through DAS are responsible for contacting the faculty member in charge of the course prior to or during the first week of the term to discuss accommodations. Students who believe they are eligible for accommodations but who have not yet obtained approval through DAS should contact DAS immediately at 737-4098.

Student Conduct Code and Academic Integrity:
Link to student conduct code:
http://oregonstate.edu/studentconduct/code/index.php