Course Flyer for ME211: Nonlinear Controls

Dept. of Mechanical Engineering, University of California, Merced

Why bother?
It is obvious. We are facing complex worlds trying to better characterize it and to better control/manage it to behave as we desire. All systems are nonlinear absolutely. Being linear is simply for our own convenience, relatively speaking. You cannot just have a linear life. Cannot imagine a life without even knowing Lyapunov. BTW, all machine learning systems, all adaptive systems, all smart/intelligent systems are inherently nonlinear.

Who cares?
Yes you who want to put (complex) things under (nonlinear) control. Remember: simple, linear things were low-hanging fruits not publishable anymore, unfortunately. You are equipped with an ability to apprehend and appreciate the hardcore nonlinear control papers.

So what?
You can understand and characterize the nature and consequences of being nonlinear. You can also consider leveraging or putting in beneficial use of nonlinearities.

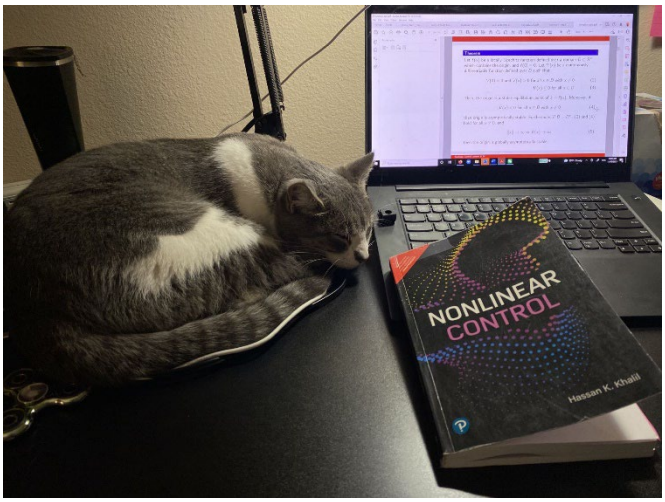
Basic information: Offered every 3 years (next offerings: Fall 2024, Fall 2027!!) So, do not miss it while you can take it this time. Instructor: Prof. YangQuan Chen (ychen53@ucmerced.edu) [+email subject line: me211] https://scholar.google.com/citations?hl=en&user=RDEIRbcAAAAJ

Catalog Description:
Phase plane and singularities. Methods for nonlinear analysis.
Lyapunov stability theory. Passivity. Lyapunov control design. Topics of nonlinear controls including feedback linearization, sliding control and back stepping design. Adaption algorithms and system identification. Discussion of current research topics in nonlinear controls.

Course Features:
No final exam. Group study sessions. Some FLIP lectures. Mathematical rigor. Serial labs.

Textbook:
H. K. Khalil. *Nonlinear Control*. Pearson Education 2015, ISBN-13: 978-0-13-349926-1

Reference textbook: Dingyu Xue and YangQuan Chen. "*System Simulation Techniques with MATLAB® and Simulink®*". 2013 John Wiley & Sons, Ltd. ISBN: 978-1-118-64792-9.
https://mechatronics.ucmerced.edu/simubook2013wiley



Learning outcomes: 1) Understand distinct features of nonlinear dynamical system vs. linear systems; 2) Analyze local and global stability concepts and their applications in control design and performance evaluation; 3) Learn the techniques of feedback linearization and their limitations, apply it to nonlinear control design; 4) Design variable structure controls and sliding mode control; 5) Analyze robustness and adaptivity of nonlinear controls; 6)Study mathematical skills and experimental perception of nonlinear dynamical systems and control; 7) Study practical application aspects of nonlinear controls

Course Calendar (Fall 2024)

Week#	Lecture #	Topic	Textbook Chapter
1	1	Introduction	1
1	2	Two-dimensional systems	2
2	3	Stability of equilibrium points	3
2	4		
3	5		
3	6		
4	7	Time-varying & perturbed systems	4
4	8		
5	9	Passivity	5
5	10	Passivity / Input-output stability	5, 6
6	11	Input-output stability	6
6	12	Stability of feedback Systems	7
7	13		
7	14		
8	15	Special nonlinear forms	8
8	16	State feedback stabilization	9
9	17		
9	18		
10	19	Robust state FB stabilization	10
10	20		
11	21		
11	22	Observers	11
12	23		
12	24	Output feedback stabilization	12
13	25		
13	26		
14	27	Tracking & Regulation	13
14	28		
15	29		
15	30	FISP Presentations	
16	31	FISP Presentations	
16	32	FISP Presentations	

FISP: (Focused Independent Study and Presentation) topic must be aligned with thesis research theme, 6 pages conference paper style final report, 25 min ppt recorded talk.

Why FISP?

"Students shouldn't go out into life without the ability to communicate. Your success in life will be determined largely by... -your ability to speak, -your ability to write, & -the quality of your ideas, **in that order**." -Late MIT Prof. Patrick Winston