Syllabus for MAE286
Hybrid Systems - Winter 2014

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This course covers the modeling, analysis, and design of hybrid dynamical systems. Topics include: Basic notion of hybrid system. Examples from mechanics, vision, and multi-agent systems. Modeling approaches to hybrid systems. Switching systems. Solutions of hybrid systems. Chattering, Zeno phenomena. Graphical convergence. Stability analysis. Robustness. Lyapunov functions. Arbitrary switching: common Lyapunov functions. Slow switching: dwell time, average dwell-time. State-dependent switching: multiple Lyapunov functions. Invariance Principle. Hybrid control design. Applications.

Instructor

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Teaching Assistant

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Course Objectives

By the end of the course, you would/should have:

1. learned and used various modeling and analysis techniques for hybrid systems
2. learned and used tools for the stability and stabilization of hybrid systems
3. known and played around with hybrid systems in a variety of scenarios

Prerequisites

Knowledge of calculus, linear algebra, and ordinary differential equations is assumed. Familiarity with simulation software of your choice (e.g., Matlab/Mathematica/Maple).

Text

We will use a variety of sources for reference. Our main book is

(M1) R. Goebel, R. G. Sanfelice, and A. R. Teel. *Hybrid Dynamical Systems: Modeling, Stability, and Robustness*. Princeton University Press, 2012

with the following two used often throughout the course

(M2) A. J. van der Schaft and H. Schumacher. *An Introduction to Hybrid Dynamical Systems*, volume 251 of *Lecture Notes in Control and Information Sciences*. Springer, 2000

(M3) J. Lygeros, C. Tomlin, and S.S. Sastry. *Hybrid Systems: Modeling, Analysis and Control*. 2008. Unpublished. Available at http://www-inst.cs.berkeley.edu/~ee291e/sp09/handouts/book.pdf

Additional recommended readings

Depending on the specific topic we are dealing with, we will complement the books above with the following material

[A1] D. Liberzon. *Switching in Systems and Control*. Systems & Control: Foundations & Applications. Birkhäuser, 2003

[A2] P. Tabuada. *Verification and Control of Hybrid Systems: A Symbolic Approach*. Springer, New York, 2009

Course webpage

http://tintoretto.ucsd.edu/jorge/teaching/mae286/

The webpage contains this syllabus and the list of homework due.

Calendar

Introduction and examples (M2, Ch 2; M1, Ch 1; M3, Ch 1)

Modeling

- Modeling approaches to hybrid systems (M2, Ch 1; M1, Ch 1; M3, Ch 3)
- Trajectories: time domains, notion of solution, degeneracies (M1, Ch 2; M3, Ch 4)
- Systems with state perturbations, hybrid regularizations (M1, Ch 4)
- Well-posed hybrid systems, graphical convergence (M1, Ch 5)

Analysis

- Review of stability of ODEs
- Stability and asymptotic stability (M2, Ch 5; M1, Ch3&7; A1, Ch 2-3; M3, Ch 5)
- Arbitrary switching, slow switching, state-dependent switching (A1, Ch 2-3)
- Invariance principle (M1, Ch 8; M3, Ch 5)

Design

- Hybrid control design (M2, Ch 6)
- Feedback stabilization (A1, Ch 4)
- Control with limited information (A1, Ch 5)

Homework

There will be a set of homework problems per week. Homework assignments are due weekly, on Tuesdays (specific dates for your reference are included in the webpage). No late homework will be accepted.

Exams The midterm will be on February 6 and the final on March 18, both in class

Grading policy

Homework: 30% Midterm: 30% Final: 40%

ted

Your grades will be available via ted at http://ted.ucsd.edu

Room location and hours

Lectures take place at the McGill Hall (campus bulding # 246), room 2315, Tuesdays and Thursdays, from 12:30pm to 1:50pm.

Office hours

Instructor: Mondays, from 3:30pm to 4:30pm, at EBUI, room 1603. Please, send me an email describing the problem before coming to office hours. I will try to respond as quickly as possible. Additionally, I will share questions that are particularly good (and their answers) with the rest of the class by broadcasting my answer to the entire class.