Syllabus for MAE207
Hybrid Systems - Fall 2008

Jorge Cortés

November 2, 2008

This is the Syllabus for MAE207 - Hybrid Systems, Fall 2008. This course covers the modeling, analysis, and design of hybrid dynamical systems. Topics include: Definition of hybrid system. Examples in mechanics, vision, and multi-agent systems. Trajectories of hybrid systems. Chattering, Zeno phenomena. Stability analysis. Arbitrary switching: common Lyapunov functions. Slow switching: dwell time. State-dependent switching: multiple Lyapunov functions, Invariance Principle. Hybrid control design. Applications.

Instructor

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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. appreciated the complexities in the notion of trajectories of hybrid systems
3. learned and used tools for the stability and stabilization of hybrid systems
4. known and played around with hybrid systems in a variety of applied scenarios

Prerequisites

MAE281a. 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. There are two main books we will resort to:

- 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. Freely available online at `http://www.springerlink.com/co`
- D. Liberzon. *Switching in Systems and Control*. Systems & Control: Foundations & Applications. Birkhäuser, 2003

Additional recommended readings

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

[A1] R. Goebel, J. P. Hespanha, A. R. Teel, C. Cai, and R. G. Sanfelice. Hybrid systems: generalized solutions and robust stability. In *IFAC Symposium on Nonlinear Control Systems*, pages 1–12, Stuttgart, Germany, 2004

[A2] Z. Manna and A. Pnueli. *Temporal Logic of Reactive Systems: Specification*. Springer, New York, 1992

[A3] J. Hespanha. Stabilization through hybrid control. In H. Unbehauen, editor, *Encyclopedia of Life Support Systems (EOLSS)*, volume Control Systems, Robotics, and Automation. Eolss Publishers, Oxford, UK, 2004

[A4] R. G. Sanfelice, R. Goebel, and A. R. Teel. Invariance principles for hybrid systems with connections to detectability and asymptotic stability. *IEEE Transactions on Automatic Control*, 52(12):2282–2297, 2007

[A5] J. P. Hespanha. A model for stochastic hybrid systems with application to communication networks. *Nonlinear Analysis*, 62(8):1353–1383, 2005

Calendar (this version: November 2, 2008)

The following calendar is tentative.

Date	Topics	Reading	*Tests & Deadlines*
(1st wk) Sep 25	Syllabus and intro	vdS-S, chp 2	
(2nd wk) Sep 30 Oct 2	Modeling of hybrid systems Trajectories: degeneracies	vdS-S, chp 1 [A1]	
(3rd wk) Oct 7 Oct 9	Properties of hybrid automata	[A2]	*Hwk #1 due on 10/9*
(4th wk) Oct 14 Oct 16	Safety and reachability Stability of ODEs		
(5th wk) Oct 21 Oct 23	Stability of hybrid systems	vdS-S, chp 5; L, chp 2-3 [A3,A4]	*Hwk #2 due on 10/23*
(6th wk) Oct 28 Oct 30	Stability under arbitrary switching Stability under slow switching	L, chp 2 L, chp 3	
(7th wk) Nov 4 Nov 6	Stability under state-dep switching	L, chp 3	*Project selection due*
(8th wk) Nov 11 Nov 13	Veteran's Day Holiday Hybrid control design	vdS-S, chp 6; L, chp 4-5	*Hwk #3 due on 11/13*
(9th wk) Nov 18 Nov 20	Feedback stabilization Control with limited information	L, chp 4 L, chp 5	
(10th wk) Nov 25 Nov 27	Stochastic hybrid systems Thanksgiving Holiday	[A5]	*Hwk #4 due on 11/25*
(11th wk) Dec 2 Dec 4	Project presentations Project presentations		

Homework

There will be a set of homework problems every other week. Due dates for the assignments are listed in the calendar of this syllabus. No late homework will be accepted.

Final project

Each student should select a project for presentation in the final week. A project can be any of the following:

- reading and understanding of a paper or book chapter from the hybrid systems literature;
- a research topic that combines the hybrid systems theory explained in class with the student's own research.

The selection of the project should be coordinated with the instructor.

Grading policy

Homework: 40%
Final project: 60%

Room location and hours

Lectures take place at the Humanities and Social Sciences Building, room 1138, Tuesdays and Thursdays, from 5:00pm to 6:20pm.

Office hours

Instructor: Wednesdays, from 2:00pm to 3:00pm. Please, send me email describing the problem before coming to office hours. Be prepared to show attempts at solving the problem.

If you have any questions about the course, please send me email. 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.

Course webpage

http://tintoretto.ucsd.edu/jorge/teaching/mae207/

The webpage contains this syllabus and the list of homework due. Please check it periodically for updates and other announcements related to the course.