AA278A Hybrid Systems: Modeling, Analysis, and Control
Course Outline

Professor Claire J. Tomlin
Department of Aeronautics and Astronautics
Stanford University
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Lecture Information

Lectures: Gates B12, TTh 11:00-12:15pm.

Contacts

Professor Claire J. Tomlin
Durand 028A
`tomlin@stanford.edu`
`http://www.stanford.edu/class/aa278a/`
Office hours: 1-2 TTh

Course Assistant: Steven Waslander
`stevenw@stanford.edu`
Office hours: TBD

Administrative Associate: Sherann Ellsworth
`sheranne@stanford.edu`
Durand 028, 723-3389

Course Description

The revolution in digital technology has fueled a need for design techniques that can guarantee safety and performance specifications of *embedded systems*, or systems that couple discrete logic with the analog physical environment.

Hybrid systems are dynamical systems with interacting continuous-time dynamics (modeled by differential equations) and discrete-event dynamics (modeled by automata). They are important in applications in CAD, real-time software, robotics and automation, mechatronics, aeronautics, air and ground transportation systems, process control, and have recently been at the center of intense research activity in the control theory, computer-aided verification, and artificial intelligence communities. In the past several years, methodologies have been developed to model hybrid systems, to analyze their behavior, and to synthesize controllers that guarantee closed-loop safety and performance specifications. These advances have been complemented by computational tools for the automatic verification and simulation of hybrid systems.

This course will present the recent advances in modeling, analysis, control, and verification of hybrid systems. Topics will include:

- continuous-time and discrete-event models
- safety specifications and model checking
- optimal control theory and differential games
- Lyapunov stability analysis and verification tools

- numerical simulation
- a range of engineering examples

Prerequisites

Familiarity with differential equations and control at the level of EE263 and E209A will be expected.

Evaluation

- Homework 40%
- Class Project 60%

Class Project

The projects can either be in the form of a review of a part of the literature or, preferably, involve the exploration of original research ideas. Project should be chosen in consultation with Claire Tomlin and Steven Waslander. The schedule is as follows:

- Project Proposal (two page summary) **due Friday April 15**
- Project Report (10-12 pages) and poster **due final week of classes**

Joint project proposals (with groups of 2 or 3 per group) are encouraged.

An initial suggestion of some project ideas are:
Investigation of a subclass of hybrid systems: linear hybrid systems (ellipsoidal calculus, switched Lyapunov functions); discrete-time hybrid systems; stochastic hybrid systems.
Hybrid system topics: multiple objective systems; topics from game theory (n-player pursuit evasion games, cooperative games, collective intelligence); hybrid system simulation; control and optimization of hybrid systems; observability of hybrid systems; model identification.
Applications: groups of coordinating vehicles; identification of modes in ATC observed data; gait modeling, stability and control; engine control; guidance of a UAV; biological modeling and control; embedded control and real time scheduling.
Lab experiment: inverted pendulum.

Course References

The course is based on a set of lecture notes and articles which will be made available throughout the term.