EE 87025: Hybrid Dynamical Systems

DeBartolo Hall 216
Spring 2013, T R 3:30p-4:45p
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Description:
Hybrid dynamical systems refer to a class of complex systems that involve interacting discrete-event and continuous-variable dynamics. They are important in applications in embedded systems, cyber-physical systems, robotics, manufacturing systems, traffic management, bio-molecular networks, and have recently been at the center of intense research activity in the control theory, computer-aided verification, and artificial intelligence communities. This class aims to introduce students to this newly emerged multidisciplinary research area. Started with reviews on necessary background materials on both continuous-variable and discrete-event systems, the class will cover a number of topics in hybrid systems, which include modeling, stability analysis, abstraction, verification, supervisory control, stabilization and optimal control of hybrid/switched systems. The applications of hybrid systems in studying real world systems, such as communication networks, networked control, and embedded systems, etc. will also be covered if time permits.

Topics:
1. Introduction
   Hybrid system examples, Motivations, Topics, Arrangements
2. Review of Continuous-variable systems and Discrete Event Systems
   Differential equation, State space model, linear time invariant systems, Basic concepts;
   Finite state machine, Automaton, Language, Regular language, Basic supervisory control,
3. Modeling hybrid systems
   Hybrid automata, Piecewise linear/affine systems, Switched systems
4. Verification
   Temporal logic, model checking, bisimulation, abstraction, verification
5. Stability and Stabilization
   Stability under arbitrary switching, Multiple Lyapunov function theorem, Stabilization
6. Supervisory control
   DES supervisory control, abstraction, symbolic control, multi-affine control systems
7. Optimal control
   Dynamical programming, Maximum principle, Switched systems optimal control,

Mixed-Logic Dynamical Systems, model predictive control

8. Applications
   Networked control, Robotic motion planning and coordination

Evaluation

Exam 1	20%
Exam 2	20%
Homework	20%
Project*	40%

* Each student needs to accomplish a project independently during the course. The nature of project can be, but not limited to, any of the following suggested topics.

1. Literature review of any topics in the hybrid literature not covered in class
2. Hybrid system toolkits evaluation and/or software development
3. Application case study using the approaches learn in class
4. New theoretical developments

One page proposal will be due before the spring break, and all students are highly encouraged to discuss with the lecturer throughout the semester. A 30 min presentation will be scheduled for each project, and a final report will be due at the end of the semester (the last week of class).

Honor Code:

This class follows the binding Code of Honor at Notre Dame (http://honorcode.nd.edu). The graded work you do in this class must be your own. In the case where you collaborate with other students make sure to fairly attribute their contributions to your report.