Analysis and Design of Hybrid Control Systems

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Description of the course:
Hybrid control systems arise when controlling nonlinear systems with hybrid control algorithms — algorithms that involve logic variables, timers, computer program, and in general, states experiencing jumps at certain events — and also when controlling systems that are themselves hybrid. Recent technological advances allowing for and utilizing the interplay between digital systems with the analog world (e.g., embedded computers, sensor networks, etc.) have increased the demand for a theory applicable to the resulting systems, which are of hybrid nature, and for design techniques that may guarantee, through hybrid control, performance, safety, and recovery specifications even in the presence of uncertainty.
This course will present recent advances in the analysis and design of hybrid control systems from a control theory viewpoint. The power of hybrid control for robust stabilization will be displayed in several applications including power systems, robotic networks, underactuated rigid bodies, integrate-and-fire oscillators, neurons, and genetic networks.

Schedule

2015.3.16 (Monday) Room: N702	
Lecture 1 (8:30~9:30)	Modeling hybrid systems
Lecture 2 (9:40~10:40)	Concept of solution
Lecture 3 (10:50~11:50)	Simulation of hybrid systems
2015.3.17 (Tuesday) Room: N205	
Lecture 4 (8:30~9:30)	Introduction to stabilization for hybrid systems
Lecture 5 (9:40~10:40)	Well-posed hybrid systems
Lecture 6 (10:50~11:50)	Lyapunov functions and sufficient conditions
Lecture 7 (14:00~15:00)	Examples
Lecture 8 (15:10~16:10)	Well posedness
Lecture 9 (16:20~17:20)	Invariance principles
2015.3.18 (Wednesday) Room: N205	
Lecture 10 (8:30~9:30)	Effect of small noise
Lecture 11 (9:40~10:40)	Generalized solutions
Lecture 12 (10:50~11:50)	Perturbed hybrid systems
Lecture 13 (14:00~15:00)	Robustness of stability
Lecture 14 (15:10~16:10)	Control Lyapunov functions
Lecture 15 (16:20~17:20)	Existence of stabilizing state-feedback laws
2015.3.19(Thursday) Room: N205	
Lecture 16 (8:30~9:30)	Minimum norm control
Lecture 17 (9:40~10:40)	Passivity based control
Lecture 18 (10:50~11:50)	Tracking control
Lecture 19 (14:00~15:00)	Applications
Open discussions (15:10-17:10)	Open discussions

References:

1. R. Goebel, R. G. Sanfelice, and A. R. Teel. Hybrid Dynamical Systems: Modeling, Stability, and Robustness. Princeton University Press, 2012.
2. R. G. Sanfelice Control of Hybrid Dynamical Systems: An Overview of Recent Advances. In Hybrid Systems with Constraints, Wiley, 2013.

Ricardo G. Sanfelice is an Associate Professor at the Department of Computer Engineering, University of California at Santa Cruz. He received the B.S. degree in Electronics Engineering from the Universidad Nacional de Mar del Plata, Buenos Aires, Argentina, in 2001. He joined the Center for Control, Dynamical Systems, and Computation at the University of California, Santa Barbara in 2002, where he received his M.S. and Ph.D. degrees in 2004 and 2007, respectively. During 2007 and 2008, he was a Postdoctoral Associate at the Laboratory for Information and Decision Systems at the Massachusetts Institute of Technology. In 2008, he visited the Centre Automatique et Systemes at the Ecole de Mines de Paris for four months. From 2009 to 2014, he was an Assistant Professor at the Department of Aerospace and Mechanical Engineering at the University of Arizona. He is the recipient of the 2013 SIAM Control and Systems Theory Prize, the National Science Foundation (NSF) CAREER award, the Air Force Young Investigator Research Award (YIP), the 2010 IEEE Control Systems Magazine Outstanding Paper Award, and the 2012 STAR Higher Education Award for his contributions to STEM education. He is a Senior Member of IEEE and was an Air Force Summer Faculty Fellow in 2010 and 2011. His research interests are: Modeling, stability, robust control, observer design, and simulation of nonlinear and hybrid systems with applications to power systems, aerospace, and biology.

注：参加此课程的博士生在课程结束后完成相关试卷，可作为博士生课程。