

M5 : Switched Systems and Control
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This course will examine switched systems from a control -theoretic perspective. The main focus will be on stability analysis and control synthesis of systems that combine continuous dynamics with switching events. We will start with an introduction to the basic concepts and definitions for hybrid and switched systems. In the analysis part of the course, we will develop stability theory for switched systems. Here we will cover single and multiple Lyapunov function methods, stability criteria based on commutation relations, stability under slow switching, and stability of switched systems with various types of useful special structure. Computational techniques and properties beyond traditional stability will also be mentioned. The later portion of the course will be devoted to switching control design. We will describe several wide classes of continuous -time control systems for which the logic-based switching paradigm emerges naturally as a control design tool. Specific instances of this include: systems not stabilizable by continuous feedback (such as nonholonomic systems), systems with sensor or actuator constraints (such as quantized feedback systems), and systems with large modeling uncertainty (for which we will discuss switching adaptive control techniques). The course is suitable for engineering and mathematics students who are familiar with basic linear system theory. Along the way, we will introduce/review several more advanced concepts from mathematical control theory which are required in the course but also are important in their own right: Lyapunov and LaSalle theorems, Lie brackets of vector fields, maximum principle of optimal control, nonholonomic constraints, input-to-state stability, and others. Proofs of most results will be presented.



Daniel Liberzon was born in the former Soviet Union in 1973. He was a student in the Department of Mechanics and Mathematics at Moscow State University from 1989 to 1993 and received the Ph.D. degree in mathematics from Brandeis University in 1998 (under the supervision of Prof. Roger W. Brockett of Harvard University). Following a postdoctoral position in the Department of Electrical Engineering at Yale University from 1998 to 2000, he joined the University of Illinois at Urbana-Champaign, where he is now an associate professor in the Electrical and Computer Engineering Department and a research associate professor in the Coordinated Science Laboratory. Dr. Liberzon's research interests include nonlinear control theory, analysis and synthesis of switched systems, control with limited information, and uncertain and stochastic systems. He is the author of the book *Switching in Systems and Control* (Birkhauser, 2003) and the author or coauthor of over thirty journal articles on the above topics. Dr. Liberzon served as an Associate Editor on the IEEE Control Systems Society Conference Editorial Board in 1999-2000. He received the IFAC Young Author Prize and the NSF CAREER Award, both in 2002, and was elected a senior member of IEEE in 2004.

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