2005 年中国控制会议

会 前 专 题 讲 座

中国自动化学会控制理论专业委员会主办
华南理工大学自动化科学与工程学院协办

主　　席： 姜钟平 教授（Polytechnic University）
苏为洲 教授（电话：020－87114256，Email：wzhsu@scut.edu.cn）

报到时间： 7 月 14 日早上 8：00－全天

报到地点： 华南理工大学正门口 / 华南理工大学西湖苑 / 华南理工大学正门五山宾馆

注 册 费： 100 元

住　　宿： 华南理工大学西湖苑/华南理工大学正门五山宾馆（食宿费自理）

专题讲座 1 （Tutorial 1）

时间 Time: 7 月 15 日 **8：30—12：00**
地点 Place: 华南理工大学 12 号楼 101
专题 Topic: Switched Control Systems
讲　课　人: Daizhan Cheng
（Academy of Mathematics & Systems Science, Chinese Academy of Sciences）

内容摘要 Abstract：

In recent years, switched cnotrol systems have been attracting much attention on the control community .The reason for this increasing interest is because of the following two reasons:

1. Switching systems are practically important because various natural, social and engineering systems can not be described by a single model. Many systems encountered in practice exhibit switching between several models depending on various environments. Some examples are as follows: (i) power supply system; (ii) formation control of aircraft, mobile robot, air traffic control etc.; (iii) automotive industry, vehicle control; (iv)analysis of fuzzy systems and logic-based switching; (v) control techniques based on switching between different controllers; (vi) supervisory control over multi-controller.

2. Theoretically, it is challenging. Many exist control analysis and synthesis methods can be naturally extended to switched systems. Meanwhile, it has many new properties and provides more freedom for control scientists and engineers to manipulate the system.

This lecture consists of four parts:

Part 1. Common (quadratic) Lyapunov function.
This part will introduce the concept of common Lyapunov function. Particular affort will be put on (i) the history and the current situation of the research on common quadratic Lyapunov function; (ii) quadratic stabilization of planar switched linear systems.

Part 2. Controllability of switched linear systems.

This part will study (i) the necessary and sufficient condition for the controllability and the largest controllable subspace. (ii) accessibility Lie algebra and the controllability sub-manifold.

Part 3. On switched nonlinear systems:
This part will investigate (i) the controllability of switched nonlinear systems. A particular interest will be focused on the controllability of bilinear systesm. Sufficient conditions will be given for some particular kinds of nonlinear systems. (ii) stabilization of switched nonlinear systems.

Part 4. Further research topics. Optimization of switched systems; (ii) Relationship with (formation) control of complex systems.

专题讲座 2 （**Tutorial 2**）

时间 **Time:** 7 月 15 日 **8:30—12:00**

地点 **Place:** 华南理工大学 12 号楼 113

专题 **Topic:** Composite Nonlinear Feedback Control Technique and Its Applications

讲 课 人**:** BEN M. CHEN, KEMAO PENG

(Department of Electrical and Computer Engineering, The National University of Singapore)

内容摘要 **Abstract:**

The tracking control problem has been a mature subject in the literature. Many excellent classical textbooks have covered this topic in details. Not only the steady state tracking performance but also the transient tracking performance are required in most of the tracking control applications, such as motion control and process control. For the closed-loop transient performance, settling time and overshoot are concerned during the control design procedure. However, it is well known that, in general, quick response results in a large overshoot. It is hard to achieve a control system that would yield a fast settling time and a small overshoot. Such a task is even harder to accomplish when the given system is with actuator saturation, which is existent almost in every physical system in our real-life environment. Thus, most of the design schemes in the literature have to make certain trade-offs between these two transient performance indices.

In order to improve the transient tracking performance for systems subject to input saturation, Lin et al. (1998) proposed a so-called composite nonlinear feedback (CNF) control technique in their pioneer work for a class of second order SISO linear systems. Turner et al. (2000) extended the technique to higher order and multiple input systems under a restrictive assumption on the system. Both the works of Lin et al. (1998) and Turner et al. (2000) are focused on control law design with state feedback. Recently, Chen et al. (2003) have developed a CNF control to a more general class of systems with measurement feedback, and successfully applied the technique to solve a hard disk servo problem. The result of CNF control for SISO discrete-time systems were reported in Venkataramanan et al. (2003). More recently, the technique has been extended in Peng at al. (2004) to tackle the situation when the given system has external disturbances, in He et al. (2003, 2004) to handle general multivariable continuous- and discrete-time systems, and in Lan et al. (2005) and He et al. (2005) to solve the problem for a class of nonlinear systems.

The CNF control is a scheme consisting of a linear feedback law and a nonlinear feedback law without any switching element. The linear feedback part is designed to yield a closed-loop system with a small damping ratio for a quick response, while at the same time not exceeding the actuator limits for desired command input levels. The nonlinear feedback law is used to increase the damping ratio of the closed-loop system as the system output approaches the target reference to reduce the overshoot caused by the linear part. From the structure of the CNF control law, it is clear that the CNF controller reduces to a linear controller when the gains in the nonlinear feedback law vanish. Therefore, the additional nonlinear feedback makes it possible to change the feedback gains to improve the transient performance. The merits of the CNF control lie in its simple structure and using linear controller as a basic element which is of especial interest to many researchers and practical engineers as it can be easily implemented.

The aim of this workshop is to give an overview on the theory of this newly developed CNF control technique together with some real-life applications. The detailed design procedure will be illustrated through numerical examples and real application problems using a toolkit under MATLAB environment. In particular, implementation results on the applications of the CNF technique to an actual commercial hard disk drive servo system design and an unmanned helicopter flight control system design will also be presented and demonstrated in the class.

The course duration is 3 hours. The intended audience includes graduate students, practicing engineers and researchers in areas related to control engineering. An appreciate background for this workshop would be some first year courses in systems and control.

The composite nonlinear feedback (CNF) control software toolkit in MATLAB (Cheng et al., 2004) will be made available for free to all participants of the workshop.

专题讲座 3 （Tutorial 3）

时间 **Time:** 7 月 15 日 **13：30—17：00**

地点 **Place:** 华南理工大学 12 号楼 101

专题 **Topic:** Control Systems with Actuator Saturation

讲 课 人**:** Zongli Lin, Charles L. Brown

（Department of Electrical and Computer Engineering, University of Virginia）

内容摘要 Abstract：

Every physical actuator is subject to saturation. For this reason, the original formulation of many fundamental control problems, including controllability and time optimal control, all reflect the constraints imposed by actuator saturation. Control problems that involve hard nonlinearities such as actuator saturation, however, have been difficult to deal with. As a result, even though there have been continual efforts devoted to addressing actuator saturation, its effect has often been ignored or given a minor treatment in most of the modern control literature. On the other hand, it has been well recognized that, when the actuator saturates, the performance of the closed-loop system designed without considering actuator saturation may seriously deteriorate. In extreme cases, the system stability may even be lost. Indeed, actuator saturation has been identified as a contributing factor to the Chernobyl catastrophe and the mishaps of several high performance aircraft.

Partially because of its practical relevance and partially because of the theoretical challenges it presents, the problem of actuator saturation has been attracting a significant amount of attention from the control research community. In particular, since late 80’s, there has been a surge of research activities that examine various aspects of the analysis and design of control systems in the presence of actuator saturation. As a result of these research activities, rather systematic approaches to the analysis and design of these systems have gradually emerged.

The main objectives of the workshop are to summarize some of the results on the analysis and design of control systems with actuator saturation that we are familiar with, and to exchange ideas through open discussions. It is hope that such a summary will give our colleagues in the general field of control theory an update on the activities in this specific research area. In the mean time, it is also hope that the workshop will help to pave a common ground for further exchange of ideas and collaboration.

No specific prerequisite knowledge, beside basic linear control theory and some familiarity with Lyapunov stability theory, is required to participate in the workshop. Graduate students are welcome.

专题讲座 4 （Tutorial 4）

时间 Time: 7 月 15 日 **13：30—17：00**

地点 Place: 华南理工大学 12 号楼 113

专题 Topic: Advanced Nonlinear Robust Control for Mechanical and Electrical Systems: Fundamental Theory and Applications

讲　课 人: Tielong Shen

（Department of Mechanical Engineering, Sophia University, Tokyo, 102-8554 Japan）

内容摘要 **Abstract：**

The arm of this workshop is to provide a bridge between recent development of nonlinear robust control theory and their application in the laboratory and industry. The first half of the workshop will give a brief review on the passivity-based robust control and adaptive control system design methods. As is well-known, mechanical and electrical systems have the Lagrangian or Hamiltonian structure. This part of the workshop will give the attendees the design guidelines to take this physical property into account in the controller design. In the second half of the workshop, some selected applications of the theoretical methods to the tracking problem of robotic systems, torque control of induction motor, traction control of vehicles and control of print machine with time-delay, will be presented. Finally, some open problems in mechanical and electrical system control will be referred in the last few minutes of the workshop.