China-Japan Joint Workshop on

Advanced Robust Control and Adaptive Control:
Theory and Applications

Final Program

Sponsored by

Technique Committee on Control Theory, Chinese Association of Automation (China)

Committee of Electric Mathematics, Chinese Association of Electrical Engineering (China)

Committee of Adaptive Leaning Control, SICE (Japan)

Administrational Responding Institutions

Institute of Systems Science, Chinese Academy of Sciences, China

Dept. of Electrical Engineering, Tsinghua University, China

Dept. of Mechanical Engineering, Sophia University, Japan

Dept. of Electrical System Engineering, Keio University, Japan

Financially Supported by

Natural Science Foundation of China (NSFC)

Japan Science Promotion Society (JSPS)

Fragrant Hill Hotel, Beijing, China

September 22 - September 26, 2004

Conference Web Site:

http://tcct.amss.ac.cn

Advisory Committee:

Han-Fu Chen,	Chinese Academy of Sciences,	China
Lei Guo,	Chinese Academy of Sciences,	China
Qian Lu,	Tsinghua University,	China
Yasuhiko Mutou,	Sophia University,	Japan

Steering Committee:

Daizhan Cheng,	Chinese Academy of Sciences,	China
Tielong Shen,	Sophia University,	Japan
Yuanzhang Sun,	Tsinghua University,	China
Hiromitsu Ohmori,	Keio University,	Japan

Welcome from Steering Committee

Dear Colleagues,

Welcome you to participate the China-Japan Joint Workshop on Advanced Robust Control and Adaptive Control: Theorem and Applications (ARCAC). The purpose of this workshop is to provide a forum for scientists on automatic control from both China and Japan to exchange contemporary research results, to promote the applications of advanced control theory to practical engineering problems and as a result to enhance the development and spread new results of advanced robust and adaptive control.

The topics of interest for the workshop include but not limited to: Nonlinear Control, Robust Control, Adaptive Control, Hybrid Systems, Control of Power Systems, Electric Machine.

The workshop program consists of three parts:

Part 1. Presentation of research results: Over 20 papers will be presented on the symposium. All the speakers are invited. They are among the most active scientists in control theory and applications in the international control community as well as in China and/or in Japan.

Part 2. Case study on a benchmark design problem. A benchmark design problem for

the excitation of synchronous generator will be set-up by the steering committee. Challenge from participants is welcome to provide a control strategy for the benchmark problem. The National Key Laboratory of Power System in Tsinghua University will provide equipment for testing the control strategies, and the testing results will be demonstrated during the workshop.

Part 3. Three panel sessions are arranged.

Panel Discussion 1: Control of hybrid and switched systems, chaired by Daizhan Cheng

Panel Discussion 2: Advanced robust adaptive control theory, chaired by Yasuhiko Mutou

Panel Discussion 3: Application of high tech to engineering control problems, chaired by Yuanzhang Sun

A set of selected papers will be organized into a book: Advanced Control on Nonlinear, Robust, Adaptive Control (tentative title), and published jointly by Tsinghua University Press and Springer.

The workshop is financially supported by the Natural Science Foundation of China (NSFC) and the Japan Science Promotion Society (JSPS) under the Japan-China Scientific Cooperation Program. The Steering Committee would like express their sincere thanks to them. The Steering Committee would also like to show its appreciation to the Institute of Systems Science, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, China, the Department of Electrical Engineering, Tsinghua University, China, and The Department of Mechanical Engineering, Sophia University, Japan for their academic and administrational support for the workshop.

Autumn is the best season in Beijing. Beijing is one of the oldest cities in China and one of the fastest changing cities in the world. In addition to the academic activities, please also enjoy some beautiful and historical sites in and around the city.

Steering Committee, ARCAC
Daizhan Cheng, Tielong Shen,
Yuanzhang Sun, Hiromitsu Ohmori.
September 21, 2004

General Information

City

Beijing, as the capital of China, is the nation's political, cultural and economical center and is unique in history, tradition and characteristics. About 3,000 years ago, a small city appeared on the present site of southwest on Beijing. From the 12th century to 1991, it was the capital of Jin, Yuan, Ming and Qing Dynasties. Now, it is shaping itself into a modern metropolis on the 16800 square kilometers with a population of 10 million. You will find the city an unforgettable destination, with its ancient Great Wall, the Forbidden City, the numerous palaces telling legends of dynasties long lost in the mist of history. Moreover, the city has refreshed its complexion by the growing numbers of parks and recreational centers, the folk shows of holiday celebration, the splendid theatrical stages, and the grand city outlook. As the city for 2008 Olympic Games, it is being renovated and is developing in an accelerative speed.

Climate

Late September to early October is the best season in Beijing, sunny and comfortable. The average daily temperature is $17^oC/62^oF$ with the high at around $26^oC/78^oF$ and low at $8^oC/45^oF$. The updated weather information can be found in the website:

http://www.cnn.com/WEATHER/Asia/frct.html

Workshop Site

Venue: Fragrant Hill Hotel. Fragrant Hill is one of the most attractive sightseeing plots in fall of Beijing. Its red leaf in fall is famous world over. In addition to beautiful environment, the hotel is a four star elegant one.

Facilities:

- Overhead project for transparent sheets;
- Multi-media LCD projector for portable computer (laptop) with PowerPoint etc.
- If you need other equipments, please contact Workshop Secretariat in anticipate.

Secretariat Office

Before Conference:

Department of Electrical Engineering

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On Site:

Fragrant Hill Hotel
Hotel Room: (to be announced on site)
Phone: (to be announced on site)

Academic Agenda

Day	Time	Activity	Place
Tuesday, Sep.21	10:00-18:00	Registration	Loby, FH Hotel
Wednesday, Sep.22	8:00-12:00, 14:00-17:00	Lectures	Conf. Room, FH Hotel
Thursday , Sep.23	8:00-12:00, 14:00-17:00	Lectures	Conf. Room, FH Hotel
Friday, Sep.24	8:00-17:00	Case study	Tsinghua Univ.
Saturday, Sep.25	8:00-17:00	Academic Visite	to be arranged

Social Activities

Day	Time	Activity	Place
Tuesday, Sep.21	14:00-16:00	Meeting of Steering Committee	Conf.Room, FH Hotel
Tuesday, Sep.21	18:30-20:30	Welcoming Reception	Rest., FH Hotel
Wednesday, Sep.22	18:30-20:30	Conference Banquet	to be arranged
Saturday, Sep.25		Social and Academic Tour	to be arranged
Sunday, Sep.26		Social and Academic Tour	to be arranged

Wednesday, September 22

Lecture Room, FH Hotel

Opening Ceremony 8:30-8:40

(Welcome Address by Prof. D.Cheng, Prof. Y.Mutou)

Session 1: Adaptive Control and Modelling (1)

Chair: Prof. Yasuhiko Mutou

Time	Lecture
8:40-9:05	T. Chai, Northeast University (China) Multivariable Intelligent Control System and its Application
9:05-9:30	Kang-Zhi Liu, Chiba University (Japan) Adaptive Control of 2-Mass-Spring Systems with Large Load Uncertainty –A State Space Approach
9:30-9:55	Yoshihiko Miyasato, Institute of Statistical Mathematics (Japan) Adaptive Control of Nonholonomic Systems Based on Inverse Optimality and Its Application to Mobile Robot

9:55-10:15 Coffee Break

Session 2: Adaptive Control and Modelling (2)

Chair: Prof. Shinji Shinnaka

Time	Lecture
10:15-10:40	Naoki Mizuno, et.al., Nagoya Institute of Technology (Japan) Design and Application of Simple 2-Delay Input Adaptive Control System Based on Relative Degree Model
10:40-11:05	Tong Zhou, Tsinghua University (China) NCF Representation and Closed-Loop Nonparametric Estimation
11:05-11:30	Kanya TANAKA, et.al. Yamaguchi University (Japan) An Approximate Design Method of Pneumatic Servo Systems Based on MRAC and Neural Network Techniques

11:30-13:30 Lunch

Session 3: Nonsmoothness and Discontinuity in Control Systems

Chair: Prof. Daizhan Cheng

Time	Lecture
13:30-13:55	Yiguang Hong, Chinese Academy of Sciences (China) Finite-time Stabilization of Nonlinear Systems via Non-smooth Feedback
13:55-14:20	Kazuhisa Ito, Sophia University (Japan) Robust Angle Control Design of Hydraulic Motor with Unknown Dead Zone of Servo Valve
14:20-14:45	Long Wang, Beijing University (China) Robust H-infinity Control and Quadratic Stabilization of Uncertain Switched Systems
14:45-15:10	Takashi Nakakuki, et.al., Sophia University (Japan) A solid analysis and control design employing rigorous nonsmooth analysis

15:10-15:30 Coffer Break

Session 4: Nonlinear Control Systems

Chair: Prof. Yuanzhang Sun

Time	Lecture
15:30-15:55	Zhiyong Chen, et.al., and Hongkong Chinese University (China) A new class of nonlinear internal models and the enhanced solution to the global robust output regulation problem
15:55-16:20	Daizhan Cheng, et.al., Chinese Academy of Sciences (China) Feedback Equivalence of Port Controlled Hamiltonian Systems
16:20-16:45	Toru Yamamoto et.al., Hiroshima University (Japan) Memory-Based PID Control of Nonlinear Systems
16:45-17:10	Jifeng Zhang, Chinese Academy of Sciences (China) Output-Feedback Control of Stochastic Nonlinear Systems
17:10-17:35	Xiaohong Jiao, et.al., Tsinghua Univ. (China), Sophia Univ. (Japan) Recursive Design Approach to Adaptive Stabilizing Controller

18:30-20:30 Conference Banquet

Thursday, September 23

Lecture Room, FH Hotel

Session 5: Applications of Robust Control (1)

Chair: Prof. Hiromitsu Ohmori

Time	Lecture
8:30-8:55	Seiichi Shin, et.al., Tokyo University (Japan) Sound measuring of motorcycle engine with wavelet analysis
8:55-9:20	Yuanzhang Sun, et.al., Tsinghua University (China) Comparison of two methods of applying IDA-PBC to improve the transient stability of 3-machine power systems with transfer conductance
9:20-9:45	Shinji Shinnaka, Kanagawa University (Japan) A Dynamic Mathematical Model and Vector Block Diagrams for Field-Winding Synchronous Machine
9:45-10:10	Yijia Cao, Zhejiang University (China) Design Effective FACTS Controller with Time-delay Signals in Wide-area Measurement Systems

10:10-10:30 Coffee Break

Session 6: Applications of Robust Control (2)

Chair: Prof. Long Wang

Time	Lecture
10:30-10:55	Jo Sato, et.al., Keio University (Japan) Extremum Seeking Method and Its Application for Operational Cost Minimization Control of Effluent Quality for Advanced Wastewater Treatment Process
10:55-11:20	H. F. Wang, University of Bath (U.K.) Co-ordinated Design of Multiple Robust Stabilizers in Multi-Machine Power Systems
11:20-11:55	Shengwei Mei, et.al.,Tsinghua University (China) Nonlinear Control of A Class of Differential-Algebraic Equation Systems

12:00-14:00 Lunch

Penal Sessions: (Free Discussion)

General Penal Chair: Prof. Tielong Shen

14:00-17:00

Xiang-Shan Park

Remark: It also provides a forum for a general discussion on FURTHER ARRANGEMENT and COLLABORATIONS.

Friday, September 24

National Key Lab. of Power Systems, Tsinghua University

Control Practise on Power System , **Chair: Y. Sun**

Saturday-Sunday, September 25-26

Academic and Social Tour

(Visiting Universities and/or Factories in and around Beijing for academic exchanges and possible collaborations. (Under arranging.))

ABSTRACTS of LECTURES

Session 1: Adaptive Control and Modelling (1)

Multivariable Intelligent Control System and its Application

Tianyou Chai
Northeast University, China

Abstract: Many industrial processes have compositive complexities including multivariable, strong coupling, nonlinearity, time-variant and operating condition variations. Combining multivariable adaptive decoupling control with neural networks, this paper presents a multivariable neural network-based decoupling control algorithm. This control algorithm is integrated with distributed control technique and intelligent control technique, and a three-leveled intelligent decoupling control system consisting of basic control level, coordinating control level, and management and decision level is developed. The configuration and function of the control system are discussed in detail. This system has been successfully applied in ball mill pulverizing systems of 200MW power units, and remarkable benefits have been obtained.

Adaptive Control of 2-Mass-Spring Systems with Large Load Uncertainty–A State Space Approach

Kang-Zhi Liu
Chiba University, Japan

Abstract: Abstract: In practice, the loads of the same type of motor may vary tens of times according to the needs of users. Such large uncertainty can not be handled by robust control. Therefore, some parameter estimation mechanism has to be introduced. The author has proposed a state feedback adaptive control scheme to resolve this design problem. However, as the transfer function from motor torque (input) to motor velocity (measurement) has zeros on the imaginary axis, the output adaptive control design remains a challenging problem.

In this paper, we propose a totally new type of adaptive control scheme for this problem. The basic idea is that no matter how the load varies, there exists a set of constant state

feedback gains which can stabilize the state for loads ranging from zero to infinity. This corresponds to tuning the response speed according to the value of load. Then, we construct the minimal order adaptive observer to recover the unmeasured states based on the idea of Kreisselmeier for full order adaptive observer. And it is proved the asymptotic stability of the adaptive output feedback system is guaranteed. Simulations show that this approach has a promising potential in dealing with such problems.

Adaptive Control of Nonholonomic Systems Based on Inverse Optimality and Its Application to Mobile Robot

Yoshihiko Miyasato
Institute of Statistical Mathematics, Tokyo, Japan

Abstract: Design methods of adaptive control of uncertain nonholonomic systems are presented based on the notion of inverse optimality. The proposed methodologies are applied to chained systems of high orders, and the controller designs by both state and output feedbacks are shown. It is seen that the resulting control strategies are optimal to certain meaningful cost functionals. Those application to mobile robots are also provided.

Session 2: Adaptive Control and Modelling (2)

Design and Application of Simple 2-Delay Input Adaptive Control System Based on Relative Degree Model

Naoki Mizuno*, Kazuyuki Fujiwara* Akira Satou**
*Nagoya Institute of Technology , **Yokogawa electric corporation, Japan

Abstract: Thus far, several types of sophisticated adaptive control schemes have been applied to real systems. However, the complexity of these algorithms makes it difficult to implement and evaluate the feasible controller. In this paper, we propose a new design method of simplest 2-delay input adaptive control technique for real systems. In this method, only one parameter is updated to obtain the fast and robust adaptation for various operating conditions. In order to confirm the effectiveness of the proposed method, extensive simulations are carried out using some detailed model of the real systems.

An Approximate Design Method of Pneumatic Servo Systems Based on MRAC and Neural Network Techniques

Kanya TANAKA, Jinhua LI and Wan Khairunizam Wan AHMAD
Yamaguchi University, Yamaguchi, Japan

Abstract: Pneumatic servo systems intrinsically have nonlinear elements due to air compressibility and friction, and therefore, it is difficult to realize accurate control by means of typical and classical control methods such as a PID control method. In addition, there is a problem that a discrete-time model of the pneumatic servo system tends to be non-minimum phase because of a choice of the sampling period, change in load mass, and so on. To resolve these problems, a new model reference adaptive control method is proposed which is combined with a neural network and the so-called delta operator technique. It is shown that the stable discrete-time model is always regarded as a minimum phase system for sufficiently small sampling period, and that the neural network can compensate for the nonlinearity of the pneumatic servo systems. Experiments are provided to demonstrate the effectiveness of the proposed method.

NCF Representation and Closed-Loop Nonparametric Estimation

Tong Zhou
Tsinghua University, China

Abstract: A model set with normalized coprime factor perturbations (NCFPMS) is widely adopted in robust controller design. It is, however, not a very easy task to identify a NCFPMS from experimental data. In this talk, we give a complete parametrization of all the normalized coprime factors (NCF) of plants internally stabilizable by a known controller. A linear fractional transformation representation is derived, owing to the Youla-Kucera parametrization and the two-sided Nudelman interpolation theory. On the basis of this parametrization, an analytic expression is obtained for the frequency response estimate of NCFs from closed-loop experimental data, based on likelihood maximization and constrained data fitting. The experimental data may be in the time-domain, or in the frequency-domain. It is proved that when the auxiliary plant is appropriately chosen, the estimate is correct and asymptotically unbiased. A computationally tractable procedure is also suggested for this selection. Parametric NCFPMS identification from frequency response estimates is also briefly discussed.

Finally, some numerical simulation results and open problems on NCFPMS identification are reported.

Session 3: Nonsmoothness and Discontinuity in Control Systems

Finite-time Stabilization of Nonlinear Systems via Non-smooth Feedback

Yiguang Hong

Chinese Academy of Sciences, China

Abstract: In this talk, global finite-time stabilization problem for a large class of nonlinear control systems is considered. An iterative design approach is given based on Lyapunov function and homogeneity. The finite-time stabilizing control laws are constructed in the form of non-smooth time-invariant feedback. Illustrative examples are also included to show the design ideas.

Robust Angle Control Design of Hydraulic Motor with Unknown Dead Zone of Servo Valve

Kazuhisa Ito

Sophia University, Japan

Abstract: To meet recent demands for high precision position and/or force control in hydraulic industries, robust controller design of electrohydraulic servo valve is a key technology. It is well known that especially in water hydraulic case, dead zone caused by tight seal leads to the deterioration of control performance. This paper deals with a robust angle controller design of hydraulic motor with dead zone of servo valve. The proposed controller compensates for unknown dead zone of servo valve as well as physical parameters and load fluctuation. Based on Lyapunov recursive design, L_2 robust disturbance attenuation design for parameter error is discussed, and then it is extended to an adaptive robust controller.

Robust $H-\infty$ Control and Quadratic Stabilization of Uncertain Switched Systems

Long Wang

Beijing University, China

Abstract: Robust H-infinity control of discrete-time switched systems with norm-bounded time-varying uncertainties is investigated. Linear matrix inequality conditions are established for quadratic stability of switched systems with a prescribed H-infinity bound. The switching law is explicitly constructed and does not depend on uncertainties.

A solid analysis and control design employing rigorous nonsmooth analysis

Takashi Nakakuki, Tielong Shen, Yasuhiko Muto and Katsutoshi Tamura
Sophia University, Japan

Abstract: The paper presents a robust control approach for nonlinear systems with uncertainty in the presence of complex nonlinearities such as backlash, stick-slip motion, etc. The approach is based on the Filippov's framework and generalized Lyapunov stability theory.

Session 4: Nonlinear System Control

A new class of nonlinear internal models and the enhanced solution to the global robust output regulation problem

Zhiyong Chen and Jie Huang
Hongkong Chinese University

Abstract: It is known that the robust output regulation problem for a given nonlinear plant can be converted into a robust stabilization problem of an appropreately defined augmented system provided that the given plant has a well defined steady-state generator. The augmented system consists of the given plant and some dynamic compensator called internal model. Roughly, an internal model is any dynamic system that can capture the asymptotic property of the steady-state generator and it is constructed to facilitate the robust stabilization of the augmented system. The existing internal models requires certain function to satisfy the global Lipschitz condition. In this paper, we propose a new class of nonlinear internal models that utilize the saturation function. With this new class of nonlinear internal model, we can remove the global Lipschitz condition.

Feedback Equivalence of Port Controlled Hamiltonian Systems

Daizhan Cheng†, Romeo Ortega‡
†Chinese Academy of Sciences, China ‡Supelec Institute, France

Abstract:

A port controlled Hamiltonian (PCH) system is defined as

$$\begin{cases} \dot{x} = [J(x) - R(x)] \frac{\partial H}{\partial x}(x) + g(x)u, \quad x \in \mathbb{R}^n,\ u \in \mathbb{R}^m, \\ y = g^T(x) \frac{\partial H}{\partial x}, \quad y \in \mathbb{R}^m, \end{cases} \tag{1}$$

where $H : \mathbb{R}^n \mapsto \mathbb{R}$ is the total stored energy, $J(x) = -J(x)^T$, $R(x)^T = R(x) \geq 0$ is positive semi-definite.

The theory of port controlled Hamiltonian system plays an important role in the control of a large class of energy based systems. But to apply the technique of port controlled Hamiltonian systems to a general control system

$$\begin{cases} \dot{x} = f(x) + G(x)u, \quad x \in \mathbb{R}^n,\ u \in \mathbb{R}^m \\ y = h(x), \end{cases} \tag{2}$$

the first necessary and key step is to convert (2) into the form of controlled Hamiltonian system (1). We call it the Hamiltonian realization of (2).

Under a non-singularity assumption the paper investigates necessary and sufficient conditions for the solvability of the Hamiltonian realization problem.

The smallest number of PDE, which have to be solved is obtained. The proof for the main result is constructive, which provides a serious formulas to perform the Hamiltonian realization.

Memory-Based PID Control of Nonlinear Systems

Toru Yamamoto and Kenji Takao

Hiroshima University

Abstract: Since most processes have nonlinearities, controller design schemes to deal with such systems are required. On the other hand, PID controllers have been widely used for process systems. Therefore, in this paper, a new design scheme of PID controllers based on a memory-based modeling(MB modeling) is proposed for nonlinear systems. According to the MB modeling method, some local models are automatically generated based on input/output data pairs of the controlled object stored in the data-base. The proposed scheme generates PID parameters using stored input/output data in the database. This scheme can adjust the PID parameters in an online manner even if reference signals are changed and/or system

parameters are changed. Finally, the effectiveness of the newly proposed control scheme is numerically evaluated on some simulation examples.

Output-Feedback Control of Stochastic Nonlinear Systems

Jifeng Zhang

Chinese Academy of Sciences, China

Abstract: Some recent research results on output-feedback control design of stochastic nonlinear systems will be presented in this talk, and the design problem of satisfaction output-feedback controls will be addressed for stochastic strict-feedback nonlinear systems in observer canonical form with stable zero-dynamics under long-term average tracking risk-sensitive cost criteria. The cost function considered here is of quadratic-integral type usually encountered in practice, rather than of quartic-integral one used to avoid difficulty in control design and performance analysis of the closed-loop system. A sequence of coordinate diffeomorphisms is introduced to separate the zero-dynamics from the entire system so that the transformed system has an appropriate form suitable for integrator backstepping design. For any given risk-sensitive parameter and desired cost value, by using the integrator backstepping methodology, an output-feedback control is constructively designed such that: a) the closed-loop system is bounded in probability and; b) the long-term average risk-sensitive cost is upper bounded by the desired value. Furthermore, under some additional conditions, an output-feedback control is designed to ensure the closed-loop system asymptotically stable in the large and admit a zero risk-sensitive cost.

Recursive Design Approach to Adaptive Stabilizing Controller for a Class of Nonlinear Time-Delay Systems

Xiaohong Jiao†, Yuanzhang Sun†and Tielong Shen‡

†Tsinghua University, China, ‡Sophia University, Japan

Abstract: This paper investigates adaptive stabilization problem for a class of uncertain nonlinear time-delay systems with triangular structure. Based on the technical lemma that ensures the convergence of a part of the solution with stability for a class of functional differential equations, a recursive design approach to adaptive stabilizing controller is proposed. The adaptive stabilizing control law is recursively obtained by constructing the Lyapunov-Razumikhin function and independent of the delayed states.

Session 5: Applications of Robust Control (1)

Sound measuring of motorcycle engine with wavelet analysis

Masaki Suido, Seiichi Shin, and Tetsuya Tabaru
The Tokyo University, Japan

Abstract: This paper presents an example of sound measurement, which is effective and low cost method of measuring intended for a practical application. We use wavelet analysis for visualizing a sound because sound signal is significant for expert engineers and visualization is useful for understanding knowledge of them. We apply this method to motorcycle. The engine sound is recorded by a commercial IC voice recorder and the signal is visualized by wavelet transformation. A decision logic of number of engine cylinders is established based on the visualized data.

Comparison of two methods of applying IDA-PBC to improve the transient stability of 3-machine power systems with transfer conductance

Yuanzhang Sun, Shan He
Tsinghua University, China

Abstract: In this paper, we provide a simulation-based comparison of two methods of designing control law using the new control method— Interconnection and Damping Assignment Passivity-Based Control (IDA-PBC) to improve the transient stability of 3-machine power systems with transfer conductance, and explore the feasibility of applying this new control method to systems with transfer conductance.

A Dynamic Mathematical Model and Vector Block Diagrams for Field-Winding Synchronous Machine

Shinji Shinnaka
Kanagawa University, Japan

Abstract. This paper proposes a new dynamic mathematical model and new block diagrams for field-winding synchronous motors (FWSM). The proposed new mathematical model has the following completeness and generality. 1) It consists of three consistent basic equations such as circuit, torque and energy-transmission equations. 2) It deals with pole saliency

and contains non-saliency as a special case. 3) It is a dynamic model and contains static one as a special case. 4) It is established in the general reference frame including stator and rotor reference frames as special cases. The proposed new block diagrams using vector signals for FWSM is established based on the new model. It has the following attractive features. 1) It succeeds in realizing clear configurations with physically meaningful vector signals, which are helpful for understanding motor electromagnetic mechanism and useful for designing controllers for FWSM. 2) Vector signals utilized as transfer signals between blocks are defined in the general reference frame. Consequently, the vector-signal block diagrams in the frame can be directly and easily reduced to the ones in such a specific frame as stator and rotor frames. 3) It is compact. The proposed vector-signal block diagrams for HFSM can be easily converted into that of field-wind synchronous generator. The vector-signal block diagrams can lead directly to dynamic simulators for the machines.

Design Effective FACTS Controller with Time-delay Signals in Wide-area Measurement Systems

Yijia Cao
Zhejiang University, China

Abstract: The wide-area measurement system will introduce the time delay signals and these signals often make the power system controllers design difficult. In this paper, the negative effects of time delay of WAMS on the dynamic performances of FACTS nonlinear controller are investigated, a LMI-based approach is proposed to design FACTS controller which takes communication time delays into account. The linear and nonlinear time-domain simulation results validate of the proposed FACTS controller.

Session 6: Applications of Robust Control (2)

Extremum Seeking Method and Its Application for Operational Cost Minimization Control of Effluent Quality for Advanced Wastewater Treatment Process

Jo Sato, Tomokazu Ueda and Hiromitsu Ohmori
Keio University, Japan

Abstract: In this presentation, a new method is proposed to achieve both clean effluent

quality and low operational cost simultaneously. This is accomplished by minimizing the certified cost function directly through an extremum seeking approach. The effectiveness of the proposed method is tested on biological wastewater treatment simulator SIMBA.

Co-ordinated Design of Multiple Robust Stabilizers in Multi-Machine Power Systems

H. F. Wang
University of Bath, U.K.

Abstract: In this paper, a method for the co-ordinated design of multiple robust FACTS-based stabilizers and PSS's in multi-machine power systems is presented. The method is based on the technique of damping torque analysis, selection of the "least effective" operating condition and phase compensation. The application of the method is demonstrated by an example power system, where a robust TCSC-based stabilizer and PSS are designed in co-ordination to damp multi-mode oscillations.

Nonlinear Control of A Class of Differential-Algebraic Equation Systems

Shengwei Mei, Feng Liu , and Qiang Lu
Tsinghua University, China

Abstract: This paper is concerned with the control problems of nonlinear systems described by a class of Differential-Algebraic Equations (DAE). With some sufficient conditions, the studied DAE system can guarantee the existence and uniqueness of solutions, on which the sequential analysis and design are based. By reducing the index of DAE systems and establishing their equivalent constrained systems, the standard input-output linearization scheme is available to be applied to solve the problems of decoupling and linearization in the sense of input-output with some assumptions. The decoupled and linearized form of the system is one of the state-space realizations of the original DAE system. Based on that, the asymptotical stabilization and output tracking problems are solvable with some standard assumptions. Besides, it shows that most of geometric control theory based on vector fields can be applied to solve the control problems of a class of DAE systems.