

International Graduate School on Control 2013



Independent Modules – one 21 hours module per week (3 ECTS)

Locations: Gif-sur-Yvette (France), Istanbul (Turkey), L'Aquila (Italy), Belgrade (Serbia)

www.eeci-institute.eu/GSC2013

M1 14/01/2013 – 18/01/2013	Randomized Algorithms for Systems	Roberto Tempo, CNR-IEIIT, Politecnico di Torino, Italy Fabrizio Dabbene, CNR-IEIIT, Politecnico di Torino, Italy	
N/2	Uncertain Optimization via	Marca C. Compi. University of Droccia. Italy	
IVIZ 21/01/2012 25/01/2012	Sample Resed Approaches	Simono Caratti, Bolitecnico di Milano – DEL Italy	
21/01/2013 - 25/01/2013	Sumple-Bused Approaches	Sinone Garacti, Pointechico di Windho – Dei, Italy	
WI3 28/01/2013 – 01/02/2013	Model Predictive Control	Eduado F. Camacho, University of Sevilla, Spain	
M6	Normal Forms for Nonlinear Control	Witch Despendels (NCA Deven France	
18/02/2013 - 22/02/2013	Systems and Their Applications	witold kespondek, INSA Rouen, France	
M7	Decentralized and Distributed	Giancarlo Ferrari-Trecate, University of Pavia, Italy	
25/02/2013 - 01/03/2013	Control	Marcello Farina, Politecnico di Milano, Italy	
	Modeling and Control of Automotive		
M8	and Aerospace Engines and	nd Ilya Kolmanovsky, University of Michigan, USA	
04/03/2013 - 08/03/2013	Dowernlants		
MO	Stability and Control of Time delay	Wim Michiels K II Lauven Bolgium	
	Submity and Control of Time-delay	Sibility Julian Niculoscu, CNPS / 25 Gif sur Vuette France	
11/03/2013 - 15/03/2013	Systems	Silviu-iulian Niculescu, CNAS L25, Gij-Sur-Tvette, France	
	Control of Nonlinear Delay Systems	Miroslav Krstic, University of California, San Diego, USA	
11/03/2013 - 15/03/2013	and PDEs	. ,,, ,, ,, ,, ,,	
M12 - BELGRADE	Verification and Correct-by-	Richard Murray, California Institute of Technology, USA	
18/03/2013 - 22/03/2013	Construction Synthesis of Control	Ufuk Topcu, California Institute of Technology, USA	
10,03,2013 22,03,2013	Protocols for Networked Systems	Nok Wongpiromsarn, Singapore-MIT Alliance Research & Tech	
M15 25/03/2013 – 29/03/2013	Model Predictive Control	Jan Maciejowski, University of Cambridge, UK	
M17	Event-triggered and Self-triggered	W.P.M.H. Heemels, Eindhoven Univ. of Tech., Netherlands	
22/04/2013 - 26/04/2013	Control	Karl-Henrik Johansson, Royal Institute of Tech. Sweden	
		Paulo Tabuada, University of California at Los Angeles, USA	
M18 - ISTANBUL	Stochastic Control with		
22/04/2013 - 26/04/2013	Contemporary Methods and	Roger W. Brockett, Harvard School of Eng. Applied Sc., USA	
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M20	Nonlinear and Adaptive Control	Alessandro Astolfi, Imperial College, UK	
13/05/2013 – 17/05/2013		Romeo Ortega, CNRS L2S, Gif-sur-Yvette, France	
M21	Distributed Control	A Stenhen Morse Vale University USA	
13/05/2013 - 17/05/2013			
M23	Pobuct Hybrid Control Systems	Ricardo Sanfolico, University of Arizona USA	
20/05/2013 – 24/05/2013	Robust Hybrid Control Systems	Ricardo Samence, Oniversity of Anzona, OSA	
NADA LAOUUA	Optimality, Stabilization, and		
	Optimality, Stabilization, and Feedback	Francis Clarke, Université Claude Bernard Lyon 1, France	
M24 – L'AQUILA 20/05/2013 – 24/05/2013	Optimality, Stabilization, and Feedback in Nonlinear Contro <u>l</u>	Francis Clarke, Université Claude Bernard Lyon 1, France	
M24 – L'AQUILA 20/05/2013 – 24/05/2013 M25- L'AQUILA	Optimality, Stabilization, and Feedback in Nonlinear Control	Francis Clarke, Université Claude Bernard Lyon 1, France Emmanuel Witrant, Univ. Joseph Fourier, GIPSA, Grenoble	
M24 – L'AQUILA 20/05/2013 – 24/05/2013 M25- L'AQUILA 27/05/2013 – 31/05/2013	Optimality, Stabilization, and Feedback in Nonlinear Control Modeling and estimation for control	Francis Clarke, Université Claude Bernard Lyon 1, France Emmanuel Witrant, Univ. Joseph Fourier, GIPSA, Grenoble, France	
M24 – L'AQUILA 20/05/2013 – 24/05/2013 M25- L'AQUILA 27/05/2013 – 31/05/2013 M26	Optimality, Stabilization, and Feedback in Nonlinear Control Modeling and estimation for control	Francis Clarke, Université Claude Bernard Lyon 1, France Emmanuel Witrant, Univ. Joseph Fourier, GIPSA, Grenoble, France	
M24 – L'AQUILA 20/05/2013 – 24/05/2013 M25- L'AQUILA	Optimality, Stabilization, and Feedback in Nonlinear Control Modelina and estimation for control	Francis Clarke, Université Claude Bernard Lyon 1, France Emmanuel Witrant, Univ. Joseph Fourier, GIPSA, Grenoble,	







M1 14/01/2013 – 18/01/2013 Randomized Algorithms for Systems and Control: Theory and Applications



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Fabrizio Dabbene CNR-IEIIT, Politecnico di Torino, Italy http://staff.polito.it/fabrizio.dabbene/ fabrizio.dabbene@polito.it

Abstract of the course

In this course, we provide a perspective of the area of randomization for systems and control, and study several topics which include the computation of the sample complexity and the connections with statistical learning theory. In particular, we address system's analysis and design using sequential and non-sequential randomized methods, and analyze advantages and disadvantages of these approaches.

In the second part, we show how randomization is successfully used in several applications within and outside engineering. We present an overview of these methods for aerospace and automotive control, hard disk drives, systems biology, congestion control of networks, quantized, switched and embedded systems, multi-agent consensus. Particular emphasis is given on the computation of PageRank in Google, web aggregation techniques, and control design of UAVs. The course is based on the book by R. Tempo, G. Calafiore, F. Dabbene, "Randomized Algorithms for Analysis and Control of Uncertain Systems with Applications," 2nd edition, Springer-Verlag, London, 2012.

- s: Uncertain systems
 - Probabilistic methods for analysis
 - Monte Carlo and Quasi-Monte Carlo algorithms
 - Random sampling techniques
 - Probabilistic methods for control design
 - Probability inequalities and statistical learning theory









M2 21/01/2013 – 25/01/2013 Uncertain Optimization via Sample-Based Approaches



Marco C. Campi Department of Information Engineering University of Brescia, Italy http://www.ing.unibs.it/~campi/ marco.campi@ing.unibs.it



Simone Garatti Dipartimento di Elettronica ed Informazione Politecnico di Milano, Italy http://home.dei.polimi.it/sgaratti/ sgaratti@elet.polimi.it

Abstract of the course:

Optimization problems involving uncertainty are ubiquitous, and emerge in diverse domains ranging from control to allocation, from planning to finance. In this course, we shall introduce the student to sample-based approaches where uncertainty is described by means of a finite number of samples, or scenarios, coming from the infinite set of possible uncertainty outcomes. Sample-based approaches represent a viable solution methodology in a variety of optimization problems involving uncertainty. Samples can as well be observations, and this covers data-based approaches in learning and identification. A particular emphasis in the course will be given to the "scenario approach".

The presentation will be gradual to allow an in-depth understanding of the fundamental concepts. Special attention will be given to a precise mathematical formulation of the problems and to a detailed presentation of the ensuing results. Practical examples will illustrate the ideas.

- Uncertain optimization
- Monte-Carlo sampling
- Scenario approach
- Applications to various domains
- Discussion of open problems that offer an opportunity for research







M3 28/01/2013 - 01/02/2013

Model Predictive Control



Eduardo F. Camacho Dept. System Engineering and Automatica University of Seville , Spain <u>http://www.esi2.us.es/~eduardo/home_i.html</u> EFCamacho@us.es

Abstract of the course:

Model Predictive Control (MPC) has developed considerably in the last decades both in industry and in academia. Although MPC is considered to be a mature discipline, the field has still many open problems and attracts the attention of many researchers. This courses provides an extensive review concerning the theoretical and practical aspects of predictive controllers. It describes the most commonly used MPC strategies, showing both the theoretical properties and their practical implementation issues. As part of the course the students will program and simulate different MPC structures. Special focus is made in the control of a real solar energy plant that will serve as an application example of the different techniques reviewed in the course.

The course is designed around the text book:

E. F. Camacho and C. Bordons, Model Predictive Control, 2nd edition, Springer, 2004

Prerequisites: Undergraduate-level knowledge of differential equations and control systems.

- 1. Introduction to MPC, process models, disturbance models, prediction equations.
- 2. MPC used in industry: FIR and step response based MPC. DMC.
- 3. MPC used in academy: GPC and State Space based MPC.
- 4. MPC of multivariable processes, dead time problems, choosing the control horizons, MPC and transmission zeros. Practical aspects for implementing multivariable MPC.
- 5. MPC and constraints: Handling constraints, QP and LP algorithms. Solving the constrained MPC, multi-parametric methods. Constrained and stability in MPC.
- 6. Nonlinear MPC, parametric models, local based function models, optimization methods.
- 7. Stability and robustness in MPC: Stability guaranteed MPCs, robust stability for MPC, robust constraint satisfaction, Min-max MPC.
- 8. Open issues: multi-objective MPC, MPC of hybrid systems, the tracking problem in MPC, distributed and hierarchical MPC, cooperative MPC.
- 9. MPC application to a solar power plant: plant models, MPC and intraday market, MPC and RTO: dynamical optimal set point determination, MPC for set point tracking. Choosing the appropriate models and horizon for each control level.







M6			
18/02/2013 - 22/02/2013			

Normal Forms for Nonlinear Control Systems and Their Applications

Abstract of the course: The aim of this course is to present a fairly complete list of normal forms for various classes of nonlinear control systems. Such forms have been obtained during the last 30 years for various purposes: classification, stabilization, tracking, motion planning, observation etc. We will attempt to present them in a systematic way, by providing normal forms, necessary and sufficient conditions for equivalence to them, and (whenever they exist) algorithmic procedures for obtaining them. We will show usefulness of the presented forms in various nonlinear control problems: linearization, flatness, stabilization, output and trajectory tracking, and nonlinear observers.



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Outline:

- 1. Feedback and state equivalence.
- 2. Feedback linearizable systems.
 - Globally feedback linearizable systems.
 - Partial feedback linearization.
- 3. Special classes of control systems.
 - Systems on R²
 - Locally simple systems.
- 4. Triangular forms.
 - Lower triangular forms and feedback linearizability.
 - p-normal forms.
 - Upper triangular forms and feedforward systems.
 - Linearizable feedforward systems
- 5. Formal feedback and formal normal forms.
 - General systems.
 - Feedforward systems.
- 6. Flatness, dynamic feedback, and normal forms for subclasses of flat systems
 - Normal forms for driftless systems: chained forms.
 - Normal forms versus search for flat outputs.
- 7. Nonlinear control systems with observations.
 - Local normal forms.
 - Global normal forms







M7 25/02/2013 - 01/03/2013

Decentralized and Distributed Control



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Marcello Farina Dipartimento di Elettronica ed Informazione Politecnico di Milano, Italy http://home.dei.polimi.it/farina farina@elet.polimi.it

Abstract of the course:

Advances in technology and telecommunications are steadily broadening the range and size of systems that can be controlled. Examples that bring new challenges for control engineering are smart grids, that are perceived as the future of power generation, and networks of sensors and actuators, that enable the monitoring and control of processes spread over large geographical areas. As an alternative to centralized regulators, that seldom make sense for large-scale systems, decentralized and distributed approaches to control have been developed since the seventies. Particular attention has been recently given to distributed control architectures based on model predictive control that are capable to cope with physical constraints.

The first part of the course will focus on classical results on stability analysis of large-scale systems, decentralized control and decentralized controllability issues. Then, distributed control design methods will be covered. In the last part of the course, more emphasis will be given to recent advances in distributed control strategies based on optimization and receding horizon control.

- Introduction to large-scale systems and multivariable control
- Decentralized control architectures
- Stability analysis of large-scale systems
- Decentralized controllability issues and design of decentralized control systems
- Design of distributed control systems







M8 04/03/2013 - 08/03/2013 Modeling and Control of Automotive and Aerospace Engines and Powerplants



Ilya Kolmanovsky Department of Aerospace Engineering University, of Michigan, USA http://aerospace.engin.umich.edu/ people/faculty/kolmanovsky/index.html ilya@umich.edu

Abstract of the course:

With increasing stringency of fuel efficiency and emissions requirements, opportunities emerge to improve engine performance through model-based control. This course will provide an introduction to modeling, estimation and control problems for engines and powerplants in automotive applications, and a briefer perspective on related problems in aerospace The use of control-theory based and applications. model-based approaches will be emphasized. Approaches to handling constraints in engines using reference governors and model predictive control will be discussed in detail. The topics covered include techniques for developing engine control-oriented models, control and estimation problems for naturally aspirated and turbocharged gasoline engines, and modeling and control of diesel engines. Topics of engine-transmission coordination and energymanagement for Hybrid Electric Vehicles will also be covered. Related modeling, control and constraint handling problems for aircraft gas turbine and internal combustion engines, and for hybrid aircraft powerplant will also be discussed.

Topics:

- 1. Basic principles and techniques of engine control-oriented modeling
- 2. Modeling, estimation and control of naturally aspirated gasoline engines
- 3. Modeling and control problems for turbocharged gasoline engines
- 4. Modeling and control problems for diesel engines

5. Constraint handling in automotive engines based on reference governors and model predictive control

- 6. Engine-transmission coordination
- 7. Hybrid Electric Vehicle energy management
- 8. Gas turbine engine modeling and control problems
- 9. Limit protection for gas turbine engines
- 10. Hybrid powerplant energy management in aircraft applications

11. Perspective and discussion on control challenges and opportunities for advanced and future engines









Stability and Control of Time-delay Systems



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Silviu Niculescu Lanoratoire des Signaux et Systèmes CNRS - Supélec , France http://www.lss.supelec.fr/perso/niculescu/ Silviu.Niculescu@lss.supelec.fr

Abstract of the course:

Time-delays are important components of many systems from engineering, economics and the life sciences, due to the fact that the transfer of material, energy and information is mostly not instantaneous. They appear, for instance, as computation and communication lags, they model transport phenomena and heredity and they arise as feedback delays in control loops. The aim of this course is to describe fundamental properties of systems subjected to time-delays and to present an overview of methods and techniques for the analysis and control design. The focus lies on systems described by functional differential equations and on frequency-domain techniques, grounded in numerical linear algebra (e.g., eigenvalue computations, matrix distance problems) and optimization. Several examples (from chemical to mechanical engineering, from tele-operation to high-speed networks, from biological systems to population dynamics) complete the presentation.

Theory:

- Classification and representation of time-delay systems
- Definition and properties of solutions of delay differential equations
- Spectral properties of linear time-delay systems

Computational methods:

- Stability determining eigenvalues
- Stability domains in parameter spaces
- Robustness and performance measures
- Controller synthesis via eigenvalue optimization

Control design:

- Fundamental limitations induced by delays
- Fixed-order optimal H-2 and H-infinity controllers
- Prediction based controllers
- Using delays as controller parameters







M11 - BELGRADE 12/03/2013 - 16/03/2013

Control of Nonlinear Delay Systems and PDEs



Miroslav Krstic Department of Mechanical & Aero. Eng. University of California, San Diego, USA http://flyingv.ucsd.edu/ krstic@ucsd.edu

Abstract of the course:

In the 1990s, the recursive backstepping design enabled the creation of adaptive and robust control algorithms for nonlinear systems with nonlinearities of unlimited growth and with uncertainties that are not matched by control.

Taking the backstepping recursion to the continuous limit provides a design methodology for boundary control of PDEs and for some key classes of delay systems. Contrary to standard PDE control that mimics LQR for finite-dimensional systems and yields virtually intractable operator Riccati equations, backstepping feedback laws come with explicit gain formulas. This course, mostly based on the instructor's book **Boundary Control of PDEs: A Course on Backstepping Designs (SIAM, 2008),** teaches how to derive such formulas for specific classes of PDE systems.

The explicit feedback laws allow the design of previously inconceivable parameter-adaptive controllers for PDE and delay systems. Backstepping also yields the first systematic method for control of large classes of nonlinear PDEs and for nonlinear systems with long delays.

Topics:

Lyapunov stability for PDEs; boundary control of parabolic (reaction-advection-diffusion) PDEs; observers with boundary sensing; wave and beam PDEs; first-order hyperbolic (transport-dominated) PDEs; systems with input delay and predictor feedback; delay-robustness of predictor feedback; time-varying input delay; delay-adaptive predictor feedback; stabilization of nonlinear systems with long input delays; basics of motion planning for PDEs; system identification and adaptive control of PDEs; introduction to control of nonlinear PDEs.







M12 - BELGRADE 18/03/2013 - 22/03/2013 Verification and Correct-by-Construction Synthesis of Control Protocols for Networked Systems



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Nok Wongpiromsarn Singapore-MIT Alliance for Research and Technology, Singapure http://smart.mit.edu/

Abstract of the course:

Increases in fast and inexpensive computing and communications have enabled a new generation of information-rich control systems that rely on multi-threaded networked execution, distributed optimization, sensor fusion and protocol stacks in increasingly sophisticated ways. This course will provide working knowledge of a collection of methods and tools for specifying, designing and verifying control protocols for distributed systems. We combine methods from computer science (temporal logic, model checking, reactive synthesis) with those from dynamical systems and control (dynamics, stability, receding horizon control) to analyze and design partially asynchronous control protocols for continuous systems. In addition to introducing the mathematical techniques required to formulate problems and prove properties, we also describe a software toolbox, TuLiP, that is designed for analyzing and synthesizing hybrid control systems using linear temporal logic and robust performance specifications

The following topics will be covered in the course:

- * Transition systems and automata theory
- * Specification of behavior using linear temporal logic
- * Algebraic certificates for continuous and hybrid systems
- * Approximation of continuous systems using discrete abstractions
- * Verification of (asynchronous) control protocols using model checking
- * Synthesis of control protocols and receding horizon temporal logic planning
- * Case studies in autonomous navigation and vehicle management systems







M15 25/03/2013 – 29/03/2013

Model Predictive Control



Jan Maciejowski Department of Engineering, University of Cambridge , UK http://www-control.eng.cam.ac.uk/jmm/jmm.html jmm@eng.cam.ac.uk

Abstract of the course:

Model Predictive Control (MPC) is the only 'advanced' control methodology (ie more advanced than PID) which has found wide application in the process industries. It offers advantages which make it very attractive for other industries too, such as automotive and aerospace, and its use in such industries is being actively explored at present. The course will start with the basic ideas of MPC, together with some specific examples of its advantages over 'classical' control. It will then discuss the structure of MPC controllers, present possible variations (such as non-quadratic cost functions and stabilised predictions), and deal with practicalities, especially important disturbance feedforward and disturbance modelling. A statespace framework will be used, but the connection with the well-known GPC framework will be made.

The course will then survey the state of more advanced MPC-related research, covering efficient computation, stability and robustness, prioritisation of objectives, the use of nonlinear models, the application of MPC to hybrid systems (which contain logic or mode switches as well as continuous dynamics), and distributed MPC. The course will be illustrated throughout with examples from various applications, including flight control, spacecraft control, and paper-making.

Topics covered:

- 1. Basic formulation of MPC
- 2. Solution of MPC. The GPC formulation.
- 3. Other formulations of MPC.
- 4. Stability and tuning of MPC.
- 5. Robust MPC.
- 6. Explicit MPC.
- 7. Case studies & applications.
- 8. Recent developments & perspectives.







M17 22/04/2013 – 26/04/2013

Event-triggered and Self-triggered Control



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Karl H. Johansson ACCESS Linnaeus Centre School of Electrical Engineering KTH Royal Institute of Technology Sweden http://www.ee.kth.se/~kallej kallej@kth.se



Paulo Tabuada Cyber-Physical Systems Laboratory Department of Electrical Engineering University of California, Los Angeles USA http://www.ee.ucla.edu/~tabuada http://www.cyphylab.ee.ucla.edu tabuada@ee.ucla.edu

Abstract of the course:

Classical sampled-data control is based on periodic sensing and actuation. Due to recent developments in computer and communication technologies, a new type of resource-constrained wireless embedded control systems is emerging. It is desirable in these systems to limit the sensor and control communication to instances when the system needs attention. This requirement calls for a paradigm shift in digital control implementations towards event-triggered and self-triggered control systems. Event-triggered control is reactive and generates sensor sampling and control actuation when, for instance, the plant state deviates more than a certain threshold from a desired value. Self-triggered control, on the other hand, is proactive and computes the next sampling or actuation instance ahead of time. As in both schemes the sampling period is varying, the vast literature on sampled-data control is no longer applicable to guarantee desirable closed-loop stability and performance properties. As a consequence, a new system theory for event-triggered and self-triggered control is needed. This course will provide an introduction to event-triggered and self-triggered control systems.

Topics:

The basics of event-triggered and self-triggered control will be presented showing the status and open problems in the emerging system theory for these new digital control strategies. Different design perspectives will be provided for both state feedback and output feedback event-triggered control and various types of event-triggering mechanisms. Also distributed variants, which are suitable for large-scale control applications, will be discussed in detail. The implementation of event- and self-triggered control using existing wireless communication technology and interesting applications to wireless control in the process industry will also be presented.







M18 - ISTANBUL	Stochastic Control with Contemporary Methods
22/04/2013 - 26/04/2013	and Applications

Abstract of the course:



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In many applications, stochastic models are being turned to as the most effective description of control problems. This is especially true in the study of highly autonomous systems, where learning may be involved, and also in financial engineering when stochastic models have long been seen as essential. Often the combination of Markov models and ordinary differential equations provide natural and effective descriptions. However, teaching stochastic processes to students whose primary interests are in applications has long been a problem. On one hand, the subject can quickly become highly technical and if mathematical concerns are allowed to dominate there may be no time available for exploring the many interesting areas of applications. On the other hand, the treatment of stochastic calculus in a cavalier fashion leaves the student with a feeling of great uncertainty when it comes to exploring new material. This problem has become more acute as the power of the differential equation point of view has become more widely appreciated.

In this course we will resolve this dilemma with the needs of those interested in building models and designing algorithms for learning, estimation and control in mind. The approach is to start with Poisson counters and to identify the Wiener process with a certain limiting form. The Poisson counter and differential equations whose right-hand sides include the differential of Poisson counters are developed first. This leads to the construction of a sample path (Ito) representations of a continuous time jump process using Poisson counters. This point of view leads to an efficient problem solving technique and permits a unified treatment of time varying and nonlinear problems. More importantly, it provides sound intuition for stochastic differential equations and their uses without allowing the technicalities to dominate. A variety of models will be developed. For example, the wide spread interest in problems arising in speech recognition and computer vision has influenced the choice of topics in several places. Examples will be drawn from applied work in communications (wireless), artificial intelligence (path planning), physics (NMR), and other branches of mathematics.







M20 13/05/2013 – 17/05/2013

Nonlinear and Adaptive Control



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Abstract of the course:



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Goal of this course is to present a class of recently developed control tools for the robust stabilization, by state and output feedback, of classes of nonlinear systems. These new tools enable to give an alternative formulation and solution to the stabilization problem for general nonlinear systems by means of the notions of systems immersion and manifold invariance (I&I). 1&I methods are particularly suited to robustify, with respect to unmodelled dynamics, a given controller scheme. They have also proved useful in adaptive control problems, where a stabilizing controller parameterized in terms of some unknown constant vector is assumed to be known. Adaptive control applications will be the main focus of this workshop. The proposed I&I approach, which is partly reminiscent of early contributions in the area of PI adaptation, is shown to yield superior performance, when compared with classical methods, and to provide improved design flexibility and additional tuning parameters. Moreover, this approach does not require linear parameterization, it can naturally include sign constraints in the estimated parameters, and yields a new class of non-certainty equivalent control laws. From a Lyapunov perspective this is the first systematic method to construct non-separable Lyapunov functions, i.e. Lyapunov functions containing cross terms depending upon the system state and the parameters estimation error, without assuming a specific structure of the nonlinear system to be controlled. The theory is illustrated by means of applications and experimental results. In particular, solutions to the adaptive stabilization problem for classes of power converters and electrical machines and for the problem of visual servoing of a planar robot are discussed.

Topics include: - State feedback stabilization and adaptive control via immersion and invariance

- Output feedback adaptive control via immersion and invariance
 - Applications in adaptive control
 - Applications to electromechanical systems







M21 13/05/2013 - 17/05/2013

Distributed Control



A. Stephen Morse Department of Electrical Engineering Yale University, USA http://www.eng.yale.edu/controls/ morse@sysc.eng.yale.edu

Abstract of the course:

Over the past decade there has been growing in interest in distributed control problems of alltypes. Among these are consensus and flocking problems, the multi-agent rendezvous problem, distributed averaging and the distributed control of multi-agent formations. The aim of these lectures is to explain what these problems are and to discuss their solutions. Related concepts from spectral graph theory, rigid graph theory, nonhomogeneous Markov chain theory, stability theory, and linear system theory will be covered.

Topics include:

- 1. Flocking and consensus
- 2. Distributed averaging via broadcasting
- 3. Gossiping and double linear iterations
- 4. Multi-agent rendezvous
- 5. Control of formations
- 6. Contraction coefficients
- 7. Convergence rates
- 8. Asynchronous behavior
- 9. Stochastic matrices, graph composition, rigid graphs





M23 20/05/2013 - 24/05/2013

Robust Hybrid Control Systems



Ricardo G. Sanfelice Dept. Aerospace & Mechanical Engineering University of Arizona, USA http://www.u.arizona.edu/~sricardo/

Abstract 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 through that may guarantee, hybrid control, performance, safety, and recovery specifications even in the presence of uncertainty. In the workshop, we will present recent advances in the theory and design of hybrid control systems, with focus on robustness properties.

Topics:

In this course, we will present a general modeling framework for hybrid systems and relevant modern mathematical tools. Next, we will introduce asymptotic stability and its robustness, and describe systematic tools like Lyapunov functions and invariance principles. The power of hybrid control for (robust) stabilization of general nonlinear systems will be displayed in applications including control of robotic manipulators, autonomous vehicles, and juggling systems







M24 – ĽAQUILA 20/05/2013 – 24/05/2013

Optimality, Stabilization, and Feedback in Nonlinear Control



Francis Clarke Institut Camille Jordan Université Claude Bernard Lyon 1, France http://math.univ-lyon1.fr/~clarke/ clarke@math.univ-lyon1.fr

Abstract of the course:

This course presents some modern tools for treating truly nonlinear control problems, including non smooth calculus and discontinuous feedback. The need for such tools will be motivated, and applications will be made to central issues in optimal and stabilizing control. The context throughout is that of systems of ordinary differential equations, and the level will be that of a graduate course intended for a general control audience.

Topics include:

- 1. Dynamic optimization: from the calculus of variations to the Pontryagin Maximum Principle
- 2. Some constructs of nonsmooth analysis, and why we need them
- 3. Lyapunov functions, classical to modern
- 4. Discontinuous feedback for stabilization
- 5. Sliding modes and hybrid systems







M25- ĽAQUILA 27/05/2013 – 31/05/2013

Modeling and Estimation for control



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Topics:

1. Introduction to modeling

Physical modeling

- 2. Principles of physical modeling
- 3. Some Basic Relationships in Physics.
- 4. Bond Graphs
- Simulation
- 5. Computer-Aided Modeling
- 6. Modeling and Simulation in Scilab

System identification

7. Experiment Design for System Identification

- 8. Non-parametric Identification
- 9. Parameter Estimation in Linear Models
- 10. System Identification Principles and Model Validation
- 11. Nonlinear Black-box Identification

Towards process supervision

12. Recursive Estimation Methods

For more details, see http://physique-eea.ujf-grenoble.fr/intra/Formations/M2/EEATS/PSPI/UEs/courses_MME.php



Abstract of the course:

The objective of this class is to introduce multiphysics models for complex dynamical systems, with different modeling, identification and estimation methods. The purpose of such models is to include physical knowledge of the systems as well as experimental data, and to allow for preliminary system design, predictive diagnostic and real-time control.





<mark>M26</mark> 27/05/2013 – 31/05/2013

Switched Systems and Control



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Abstract of the course:

Switched systems are dynamical systems described by a family of continuous-time systems and a rule that orchestrates the switching between them. Such systems are interesting objects for theoretical study and provide realistic models suitable for many applications.

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. In the analysis part of the course, we will develop stability theory for switched systems; properties beyond traditional stability, such as invertibility and input-to-state stability, will also be discussed. In the synthesis part, we will investigate several important classes of control problems for which the logic-based switching paradigm emerges as a natural solution.

Topics include:

- Single and multiple Lyapunov functions
- Stability criteria based on commutation relations
- Stability under slow switching
- Switched systems with inputs and outputs
- Control of nonholonomic systems
- Quantized feedback control
- Switching adaptive control

