IP1

Stochastic Target Problems

In these class of optimization problems, the controller tries to steer the state process into a prescribed target set with certainty. The state is assumed to follow stochastic dynamics while the target is deterministic and this miss-match renders the problem difficult. One exploits the degeneracies and/or the correlations of the noise process to determine the initial positions from which this goal is feasible. These problems appear naturally in several applications in quantitative finance providing robust hedging strategies. As a convenient solution technique, we use the geometric dynamic programming principle that we will describe in this talk. Then, this characterization of the reachability sets will be discussed in several examples.

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IP2

A Convex Optimization Approach to Infinite-Dimensional Systems

Time-delay appears naturally in many control systems. It is frequently a source of instability although, in some systems, it may have a stabilizing effect. A time-delay approach to sampled-data control, which models the closed-loop system as continuous-time with delayed input/output, has become popular in the networked control systems (where the plant and the controller exchange data via communication network). Many important plants (e.g. flexible manipulators and heat transfer processes) are governed by PDEs and are described by uncertain nonlinear models. In this talk Lyapunov-based methods for time-delay and distributed parameter systems leading to finite-dimensional Linear Matrix Inequalities (LMIs) will be presented. The LMI approach provides an effective and simple tool for robust control of uncertain infinite-dimensional systems.

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IP3

Simple Distributed Control of Networked Systems: Learning, Direct and Indirect Communications

We consider collaborative decision making and control in multi-agent systems. The emphasis is to derive simple distributed algorithms that work provably very well, while having minimal knowledge of the system and its parameters; thus the need for learning. We consider a behavior learning algorithm for a class of behavior functions and study its effects on the emergence of agent collaboration. Next we consider systems, with each agent picking actions from a finite set and receiving a payoff depending on the actions of all agents. The exact form of the payoffs is unknown and only their values can be measured by the respective agents. We develop a decentralized algorithm that leads to the agents picking welfare optimizing actions utilizing the impact of agents actions on their payoffs, and if needed very simple bit-valued information exchanges between the agents. We next consider the continuous time and continuous state space version of the problem based on ideas from extremum seeking control. Our results show how indirect communications (signaling between the agents via their interactions through the system) and direct communications (direct messages sent between the agents) can complement each other and lead to simple distributed control algorithms with remarkably good performance. We close by discussing the role of communication and influence connectivities and the need for new non-commutative probability models to model and analyze humans in such networked systems.

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IP4

Irreversibility in Dynamic Optimization

Irreversibility is the property that characterizes evolutionary processes which do not allow for time inversion. In Dynamic Optimization, such a behavior is expected for noise-perturbed systems but it also takes place in the deterministic case: being able to solve the Hamilton-Jacobi equation forward in time from some initial data and then backward, resulting in the same data, often implies the solution is smooth. Analyzing these phenomena may help to exploit optimization techniques in their full strength. This talk will discuss irreversibility effects such as the gain of regularity of solutions, the loss of regularity due to the onset and persistance of singularities, and compactness estimates for the flow.

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IP5

Hybrid Processes for Controlling Manufacturing Systems

Revolutionary computing technologies are driving significant advances in the manufacturing domain. High-fidelity simulations and virtual design environments allow unprecedented opportunities to test and validate systems before they are built, reducing overall design time and cost. Torrents of data streaming from the factory floor can be collected over high-speed networks, and stored in large-scale server farms (such as cloud-based systems), enabling improved analytics and increased performance. This talk will describe how the integration of simulation and plant-floor data can enable new control approaches that are able to optimize the overall performance of manufacturing system operations.

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IP6

Averaged Control

This lecture is devoted to address the problem of controlling uncertain systems submitted to parametrized perturbations. We introduce the notion of averaged control according to which the average of the states with respect to the uncertainty parameter is the quantity of interest. We observe that this property is equivalent to a suitable averaged observability one, according to which the initial datum of the uncertain dynamics is to be determined by means of averages of the observations done. We will first discuss this property in the context of finite-dimensional systems to later consider Partial Differential Equations, mainly, of wave and parabolic nature. This analysis will lead to unexpected results on the robustness of observability estimates with respect to additive perturbations. We shall also highlight that the averaging process with respect to the unknown parameter may lead a change of type on the PDE under consideration from hyperbolic to parabolic, for instance, significantly affecting the expected control theoretical properties. We shall link these results to well-known phenomena on regularisation by averaging. We will also present some open problems and perspectives of future developments. This work has been developed in collaboration with J. Lohac, M. Lazar and Q. Lu.

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SP1

W.T. and Idalia Reid Prize in Mathematics Lecture: Definitions and Hypotheses and All That Stuff

There are times when a satisfactory analysis of a problem in control requires certain abstract tools which may appear somewhat esoteric at first. In this non technical talk, we illustrate this proposition with some examples in which lack of existence, non smooth behavior, and discontinuous feedback are involved.

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SP2

SIAG/CST Prize Lecture - Control of Higher Order PDEs: KdV and KS Equations

Higher-order PDEs appear to model different nonlinear propagation phenomena. This class of equations includes the Korteweg-de Vries (KdV) and the Kuramoto-Sivahinsky (KS) equations. The first one is dispersive while the second one is parabolic. In despite of this great difference, they have in common some important features. For instance, both of them present critical spatial domains for which the boundary controllability does not hold. In this talk we aim at explaining the main results and methods concerning the control and stabilization of these nonlinear one-dimensional PDEs.

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CP1

Approximate Controllability of Second Order Semilinear Stochastic System with Variable Delay in Control and with Nonlocal Conditions

This paper deals with the approximate controllability of second Order semilinear stochastic system with variable delay in control and with nonlocal conditions. The result is obtained by using Banach fixed point theorem. At the end, an example is given to show the effectiveness of the result.

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CP1

Controlled Invariance and Dynamic Feedback for Systems over Semirings

The concept of (A, B)-invariant subspace is the fundamental concept of the geometric approach of control design. It has been extended by many authors to that of (A, B)-invariant module or semimodule, for the sake of extending the solution of various control problems to the case of systems over rings or semi rings. In this paper is discussed the use of dynamic feedback control laws for systems over semirings, and it is shown that an (A, B)-invariant semimodule over a commutative semiring can be made invariant for the closed-loop system by dynamic feedback.

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CP1

Normal Forms of Linear Multivariable Square Systems and Their Application

Normal forms called by Byrnes-Isidori are useful to study properties of zeros of controlled systems in continuous-time and sampled-data domain for the design of feedback controllers. This paper investigates how transfer function matrices and state-space equations of linear square systems are transformed to normal forms, and applies the results to analysis of zeros of sampled-data models corresponding to continuous-time linear square systems nondecouplable by static state feedback.

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CP1

Differential Controllability and Observability Functions with Applications to Model Reduction

In this talk, we aim at constructing a nonlinear balancing method in the contraction framework. We introduce the notion of differnetial controllability and observability functions, and we provide characterizations for them. Then, we define the differential balanced realization and study model reduction for such a realization.

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CP1

Relative Controllabilty Properties

For nonlinear systems described by ordinary differential equations, we present the notion of W-control sets which are defined as maximal subsets of complete approximate controllability within a safe region or world W in the state space. In articular, their relative invariance properties and their behavior under parameter variations are characterized. An application to invariance entropy shows that the information needed to keep a system in a subset of the state space is determined by the relatively invariant W-control sets.

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CP1

Nonlinear Unknown Input Observability: Analytical Expression of the Observable Codistribution in the Case of a Single Unknown Input

This paper investigates the unknown input observability for nonlinear systems characterized by a single unknown input and multiple known inputs. The goal is not to design new observers but to provide a simple analytic condition to check the observability of the state. In other words, the goal is to extend the observability rank condition to the case of unknown input. As in the case of only known inputs, the observable codistribution is obtained by recursively computing Lie derivatives along the vector fields that characterize the dynamics. However, in correspondence of the unknown input, the corresponding vector field must be rescaled. Additionally, the Lie derivatives must be also computed along a new set of vector fields that are obtained by recursively performing suitable Lie bracketing of the vector fields that define the dynamics. The analytic approach is illustrated by checking the weak local observability of several nonlinear systems driven by known and unknown inputs.

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CP2

Modelling and Stability for Interconnections of Hybrid Systems

Robustness and stability theory of hybrid systems is strongly developed recently, however interconnections of such systems are poorly studied. The existing few results hold under strong constraints on jump and flow sets of subsystems only. General type interconnections are not well developed and raise many modelling and mathematical problems. We will discuss these problems and possible solutions with emphasis on stability properties.

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CP2

On Reduced Order Observer for Radiative Conductive Heat Transfer Systems

This contribution deals with state observer design for a class of non-linear coupled partial differential equations that describe radiative-conductive heat transfer systems in 2D (two dimension). Observations are made though sensors placed at the upper boundary of the two dimensional domain. We explored the Galerkin method for a semi-discretization to obtain a large scale in finite dimensional. Thanks to the special structure of the obtained state system, we show through the Differential Mean Value Theorem that there always exists an observer gain matrix that assures asymptotic convergence. Both full order and reduced order state estimators are provided.

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CP2

Instability Characterizations for Differential Inclusions

Instability of an equilibrium point has typically been defined as “not stable” rather than as a standalone property. This is, in part, due to the fact that several unstable behaviors are possible. Furthermore, as the usual engineering goal is stability, all possible unstable behaviors are undesirable. In this talk, we present some specific definitions for unstable equilibrium points for differential inclusions. We also present Lyapunov characterizations and discuss their utility in a control design context.

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CP2

Characterizations of Input-to-State Stability for Infinite-Dimensional Systems

This talk is devoted to Lyapunov characterizations of the input-to-state stability (ISS) property for infinite-dimensional control systems. We discuss Lyapunov characterizations of uniform asymptotic stability for systems with disturbances and establish connections between the asymptotic gain property, uniform global asymptotic stability of undisturbed systems and ISS. Using the above criteria it is possible to characterize input-to-state stability in terms of ISS Lyapunov functions.

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CP2

Eigenvectors of Nonlinear Maps on the Cone of Positive Semidefinite Matrices and Application to Stability Analysis

We show that the problem of synthesis of a common Lyapunov function for some classes of switched linear systems can be approached by solving an eigenproblem involving a nonlinear map on the cone of positive semidefinite matrices. This map involves the selection of a maximal lower bound of a family of matrices in this cone. We present some variants of the power algorithm, allowing one to solve the nonlinear eigenproblem in a scalable way.

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CP3

A New Inverse Optimal Control Method for Discrete-Time Systems

This paper presents a new approach based on extended kalman filter to construct a control lyapunov function. This function will be used in establishing the inverse optimal controller. The main aim of the inverse optimal control method is to avoid the solution of HamiltonJacobiBellman equation resulted from the traditional solution of nonlinear optimal control problem. The relevance of the proposed scheme is illustrated through simulations. Results show the effectiveness of the proposed method.

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CP3

The Energy Czar's Problem

Consider an island economy powered in part by renewable energy, and in part by a single deposit of fossil fuel. The islands energy czar, who wishes to make the best possible use of the endowment, faces an optimal control problem not unlike the one confronting the proprietor of an extractive firm. The latter problem has an extensive history, which will be summarized. Existing results shed light on, but do not completely solve, the energy czars problem.

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CP3

Trajectory Optimization and Performance-Based Vehicle Guidance in Spatiotemporally Varying Fields

We discuss planar trajectory optimization where the cost functional is the integral along the trajectory of the intensity of a spatiotemporally-varying scalar field. We assume that this spatial field is described by an advection-diffusion parabolic PDE or a Poisson-type elliptic PDE. Multiresolution spatiotemporal discretization is employed for numerical trajectory optimization and for concurrent estimation of the field by a mobile sensor. Single- and twin-agent scenarios will be considered.

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CP3

On the Optimal Control of the Rigid Body Precise Movement: Is Energy Optimality the Same as Time Optimality?

For optimal control problems of rigid body precise movement minimal time optimality and minimal energy optimality are considered as competing approaches for trajectory planning. We investigate here theoretical and simulation results showing that, with appropriate choice of constraints, these approaches are equivalent in the sense that they produce the same trajectory. The optimal control solver DIDO was used as a numerical tool.

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CP3

Optimal Control of Landfills

We tackle landfill optimization when the re-circulation leachate is the control. We propose a scheme to construct the minimal time strategy by dividing the state space into three subsets. On two of them the optimal control is constant until reaching target, while it can exhibit a singular arc on their complementary. The singular arc could have

a barrier, and we prove the existence of a switching curve that passes through a point of prior saturation.

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CP3

Minimal-Time Bioremediation of Water Resources with Two Patches

We study the bioremediation, in minimal time, of a water resource using a single continuous bioreactor connected to two pumps at different locations in the resource. This leads to a minimal-time optimal control problem whose control variables are the inflow rates of both pumps, obtaining a non-convex problem. We solve the problem by applying Pontryagin's principle to the associated generalized control problem and obtain explicit bounds on its value function via Hamilton-Jacobi-Bellman techniques.

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CP4

Stochastic Control Problem for Delayed Switching Systems with Restrictions

In this talk we consider optimal control problem for stochastic systems. Dynamic of the system is described by the collection of stochastic differential equations with delay. We have investigated the stochastic control system which consist of several subsystems and a switching law indicating the active subsystem at each time instantly. The restrictions is defined by the functional inclusions in the right ends of each time interval. Firstly, optimality condition for control system without constraints is established. Then using Ekelands Variational Principle, the necessary condition of optimality for restricted stochastic systems is obtained .

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CP4

Geometric Methods for Optimal Sensor Design

Optimal estimation and control of linear systems are fundamental to many areas of engineering and beyond. It is well-known that the optimal estimator in the MSE sense is the Kalman filter., the performance of which depends on the observation matrix (C matrix) of the system. In this presentation, we address the problem of finding the observation matrix that yields the lowest estimation error. This problem is non-convex, but we show almost global convergence to a global minimum in an appropriate regime.

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CP4

On Discrete Time Optimal Portfolio for Continuous Time Market Models

We present an algorithm of optimal multistock portfolio selection in the class of piecewise constant portfolios that can be restructured at a sequence of random times. We suggest to separate selection of an optimal redistribution of the risky stocks and the optimal distribution of funds between risk free investment and the risky portfolio, This leads to a discrete time myopic optimal portfolio strategy.

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CP4

Stochastic Optimal Control with Delay in the Control: Solution Through Partial Smoothing

Stochastic optimal control problems governed by delay equations with delay in the control are more difficult to study than the the ones when the delay appears only in the state. The associated HJB equation does not satisfy the so-called "structure condition' which means that "the noise enter the system with the control'. The absence of such condition, together with the lack of smoothing properties which is a common feature of problems with delay, prevents the use of the known techniques to prove the existence of regular solutions. In this paper we provide a result on existence of regular solutions of such kind of HJB equations and we use it to solve completely the corresponding control problem finding optimal feedback controls. The main tool used is a partial smoothing property that we prove for the transition semigroup associated to the uncontrolled problem. Such results holds for a specific class of equations and data which arises naturally in many applied problems.

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CP4

Optimal Resource Extraction in Regime Switching Lévy Markets

This paper studies the problem of optimally extracting nonrenewable natural resources in light of various financial and economical restrictions and constraints. Taking into account the fact that the market values of the main natural resources i.e. oil, natural gas, copper, gold, fluctuate randomly following global and seasonal macro-economic parameters, these values are modeled using Markov switching Lévy processes. We formulate this problem as a finite-time horizon combined optimal stopping and optimal control problem. We prove that the value function is the unique viscosity solution of the corresponding Hamilton-Jacobi-Bellman equations, and derive optimal extraction policies. Moreover, we prove the convergence of a finite difference approximation of the value function. Numerical examples are presented to illustrate these results.

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CP4

Stochastic Markov Decision Subject to Ambiguity

In this presentation we address optimality of stochastic control strategies for infinite-horizon Markov decision problems with discounted pay-off, when the controlled process conditional distribution belongs to a ball of radius R with respect to total variation distance, centered at the nominal conditional distribution. The stochastic control problem is formulated using minimax theory and the following dynamic programming equation is obtained

$$v(x) = \inf_{u \in \mathcal{U}(x)} \left\{ f(x,u) + \alpha \int_{\mathcal{X}} v(z) Q^o(dz|x,u) + \alpha \frac{R}{2} \Big(\sup_{z \in \mathcal{X}} v(z) - \inf_{z \in \mathcal{X}} v(z) \Big) \right\}.$$

Here, $v(x)$ is the value function, $\mathcal{U}(x)$ is the feasible control set, f is the one stage cost, $Q^o(\cdot|x,u)$ is the nominal controlled process conditional distribution and, $\alpha \in (0,1)$ is the discounting factor.

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CP5

Computing the Hamiltonian Triangular Forms of Hamiltonian Pencils

This paper presents a new method for computing the Hamiltonian triangular form of a Hamiltonian pencil $\lambda E - A$ with $E, A \in R^{2n \times 2n}$ without purely imaginary eigenvalues. The algorithm is of computational complexity $O(n^3)$, and it is based on orthogonal-symplectic transformations and thus preserves the Hamiltonian structure of the pencil $\lambda E - A$. Problems in the existing benchmark collection for the discrete-time algebraic Riccati equations are used to illustrate the performance of the proposed algorithm.

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CP5

Multigrid Preconditioning for Space-Time Distributed Optimal Control Problems Constrained by Parabolic Equations

We present some recent results regarding multigrid preconditioning of the linear systems arising in the solution process of space-time distributed optimal control problems constrained by parabolic equations. While the construction of the preconditioners is based on ideas extracted from optimal control problems constrained by elliptic equations, in the parabolic-constrained case the multigrid preconditioners exhibit a suboptimal behavior, namely they approximate the operators to be inverted by half an order less than optimal.

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CP5

A Semi-Analytical Solution for the Helmholtz Problem in Three-Dimensional Case

This paper develops an analytical solution for sound, electromagnetic or any other wave propagation described by the Helmholtz equation. First, a theoretical investigation based on Multipole Expansion method was established. Then, we evaluate numerically the theoretical solution of scattering problem by an ideal rigid sphere. Finally, we made a numerical study to present the variation of surface potential with respect to different physical parameters of the problem.

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CP5

Comparison between the MINC and MRMT Configurations: The n-dimensional Case

The models MINC (Multiple INteracting Continua) and MRMT (Multiple Rate Mass Transfer) are extensively used in transport phenomena. We believe that these models are also relevant to describe flows in soil or in porous media. In the same way, these models can be used to describe connections between bioreactors. The goal of this manuscript is determine conditions for the input-output equivalence of these configurations for n compartments using some results of the linear system theory.

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CP5

Extracting Motion Primitives Toward Planning Human-Like Motions

The motions of entities can be thought of as either short- or long-term motion primitives: fragments of movements that embody one or more significant actions. We present a means of quickly and automatically extracting these prominent actions from long sequences of human movement and pose data. We show that dynamical-systems-based characterizations of these primitives can be used to efficiently plan paths for a highly articulated humanoid platform.

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CP5

Regulation Pitch Angle of Wind Turbine Using Reference Model Adaptive Controller

The conversion of wind energy to electrical energy with wind turbine is one of the best ways for reduction of harmful effects of fossil fuels. The renewable energy is growing rapidly in all over the world. Controlling blade pitch angle is a suitable way to achieve desired power of the turbine at low speed winds and in order to prevent damages in strong wind conditions. In this paper, pitch angle control in different wind conditions by using Reference Model Adaptive (RMA) Controller is proposed. Simulations and numerical results show that the output power control and pitch angle based on RMAC has faster nominal value with less error.

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CP6

Frequency Identification of Wiener-Hammerstein Systems.

The problem of identifying Wiener-Hammerstein systems is addressed in the presence of two linear subsystems of structure totally unknown. Presently, the nonlinear element is allowed to be noninvertible. The system identification problem is dealt by developing a two-stage frequency identification method such a set of points of the nonlinearity are estimated first. Then, the frequency gains of the two linear subsystems are determined at a number of frequencies. The method involves Fourier series decomposition and only requires periodic excitation signals. All involved estimators are shown to be consistent.

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CP6

Frequency-Domain Performance Analysis of Distributed-Parameter Systems under Periodic Sampled-Data Feedback Control

The stability and performance of distributed-parameter systems operating under periodic sampled-data feedback control is studied via integral-quadratic constraint (IQC) based analysis. Sufficient frequency-domain conditions are derived for verifying a specified bound on the L_2-gain of the feedback interconnection of a plant with (irrational) Callier-Desoer class transfer function and a feedback controller obtained via the periodic sample-and-hold discretization of a finite-dimensional LTI controller. The analysis is underpinned by a time-varying delay model of the sample-and-hold operation and IQC characterizations of a related system. An illustrative numerical example involving the control of a linear system of hyperbolic conservation laws is presented.

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CP6

Optimization of Synchronization Gains in Networked Distributed Parameter Systems

We consider networked distributed parameter systems that are tasked with synchronization. Synchronization controllers based on static output feedback are used to ensure synchronization. Using both tracking and synchronization metrics, the gain optimization problem is formulated as a minimization of a quadratic performance index. The optimal gains are then found as the ones that minimize the trace to the solution of a parameter-dependent operator Lyapunov equation for the aggregate system.

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CP6

Right Coprime Factorizations for Fractional Systems with Input Delays

The design of robust control laws lies in the computation of left and right coprime factorizations over the ring of complex functions that are analytic in the right complex plane. In her recent thesis, the third author (by alphabetic order) described a method to compute left coprime factorizations for a class of fractional systems with input delays. Here is proposed a method to compute right coprime factorizations. The method is based on the concept of column-reduced matrix, that already proved to be useful to solve this problem in the case of finite dimensional systems.

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CP6

Flow Sensing and Control for Aerospace Vehicles

Aerospace vehicles move in a fluid such as water or air, which can be moving relative to an inertial frame. The movement of fluid over the vehicle impacts the dynamics and control of translational and rotational motion. To improve control performance, the flow can be characterized in real time by assimilating spatially distributed measurements of pressure and/or velocity. The design and use of flow sensing arrays for underwater and aerial vehicles will be described.

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CP6

On Robust Output Regulation for Continuous-Time Periodic Systems

We construct a controller to solve robust output tracking problem for a stable linear continuous-time periodic system on a finite-dimensional space. We begin by transforming the time-dependent plant to a time-invariant discrete-time system using the "lifting technique'. The controller is then designed to achieve robust output tracking for the lifted system. We show that the solution of the control problem for a continuous-time periodic system necessarily requires an error feedback controller with an infinite-dimensional internal model. The results are illustrated with an example where robust output tracking is considered for a stable periodic scalar system.

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CP7

Parameter Estimation for Nonlinear Immune Response Model Using Em

The problem of parameter estimation of reduced mathematical model of the acute inflammatory response is considered for the discrete case in the presence of disturbances and measurement noise. A method combining expectation maximization and particle filter is introduced. the parameters that characterize each virtual patient are of interest. We begin with a study of nonlinear observability of the system to justify the use of state estimation and finally we present some simulation and discuss the obtained results.

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CP7

Characterization of the Hemodynamic Response in the Brain using Observer

Cerebral blood flow (CBF) is a key physiological variable in understanding the hemodynamic response in the brain which gives a deep insight into the underlying dynamics of brain activation. We propose an observer-based approach to estimate CBF from blood oxygen level dependent (BOLD) signal measured using functional magnetic resonance imaging. The model describing the pathway from CBF to BOLD is a coupled system of partial and ordinary differential equations (PDE/ODE). Numerical results will be presented to show the accuracy of the estimation method.

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CP7

Optimal Dosing Strategies Against Susceptible and Resistant Bacteria

Antibiotic modelling is concerned with the problem of finding efficient and successful dosing techniques against bacterial infections. In this study, we model the problem of treating a bacterial infection where the bacteria is divided into two sub-populations: susceptible and resistant. The susceptible type may acquire the resistance gene via the process of conjugation with a resistant bacterium cell. Efficient treatment strategies are devised that ensure bacteria elimination while minimizing the quantity of antibiotic used. Such treatments are necessary to decrease the chances of further development of resistance in bacteria and to minimize the overall treatment cost. We consider the cases of varying antibiotic costs, different initial bacterial densities and bacterial attachment to solid surfaces, and obtain the optimal strategies for all the cases. The results show that the optimal treatments ensure disinfection for a wide range of scenarios.

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CP7

A Mathematical Analog of Muscular Hydrostats and Similar Tissues

Muscular hydrostats (tongues, trunks, and tentacles) are composed almost of muscles which can shorten themselves but require a force external to the muscle to lengthen. This external force is supplied by the internal pressure that maintains the constant volume of the structure. A very simplified mathematical description of such a system is proposed and its response to various controls is computed

and displayed. Curling a tentacle, a trunk, or a tongue is demonstrated.

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CP7

A Variable Reference Trajectory for Model-Free Glycemia Regulation

The control design of an artificial pancreas, which is a hot research topic for diabetes studies, is tackled via the newly introduced model-free control and its corresponding intelligent proportional controller, which were already quite successful in many concrete and diverse situations. It results in an insulin injection for type 1 diabetes which displays via constant references a good nocturnal/fasting response, but unfortunately poor postprandial behavior due to long hyperglycemia. When a variable reference is introduced, that switches between a constant one, when glycemia is more or less normal or moderate, and an exponential decay reference path, when a high glycemia rate indicates a meal intake, the results *in silico*, which employ real clinical data, become excellent. We obtain a bolus-shaped insulin injection rate during postprandial phases. The hyperglycemic peaks are therefore lowered a lot.

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CP8

Diffusive Realization of a Lyapunov Equation Solution, and Parallel Algorithms Implementation

In a previous work, a theoretical framework of diffusive realization for state-realizations of some linear operators have been developed. Those are solutions to certain linear operator differential equations posed in one-dimensional bounded domains. They illustrate the theory on a Lyapunov equation arising from optimal control theory of the heat equation. In principle their method might be very efficient for real-time computation, however it is suffering from strong limitations. Here, we present significant improvements and report numerical results. A method of contour optimization is provided. It is based on a theoretical error estimate of the solution. Finally, we discuss expected gains if the method is implemented on different parallel computer topologies. The envisioned applications are for real-time distributed control on distributed computing architectures.

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CP8

On Controllability of a Two-Dimensional Network of Ferromagnetic Ellipsoidal Samples

In this article, we address the problem of stability and controllability of two-dimensional network of ferromagnetic particles of ellipsoidal shapes. The control is the magnetic field generated by a dipole whose position and amplitude can be selected. In the absence of control, first we prove the exponential stability of the relevant configurations of the network. Then, we investigate the controllability by the means of external magnetic field induced by the magnetic dipole.

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CP8

Analysis of the Push-Sum Algorithm for Unreliable Networks

In multi-agent systems, the push-sum algorithm allows computing the average of values held by the agents in a decentralized way. Unlike classical methods, push-sum also works when communications are directed or asynchronous. When the network is unreliable, the computed value will deviate from the true average. We analyze the error of the final common value obtained, both theoretically and numerically, and compare it with the standard consensus algorithm.

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CP8

Minimal Data Rates and Entropy in Digitally Networked Systems

In digitally networked control systems the assumption of classical control theory that information can be transmitted instantaneously, lossless and with arbitrary precision is violated. This raises the question about the smallest data rate above which a given control task can be solved. For the problem to render a subset Q of the state space invariant, the minimal data rate can be described by an entropy-like quantity, the so-called invariance entropy. If one considers a single feedback loop and assumes that the system is completely controllable and uniformly hyperbolic on Q, the invariance entropy can be expressed in terms of Lyapunov exponents. For networks with several subsystems there are different possibilities to formulate the question about the smallest data rate for the invariance problem, but also in this setting entropy-like quantities can be introduced to solve the problem.

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CP8

Real-Time Decentralized and Robust Voltage Control in Distribution Networks

Voltage control plays an important role in the operation of electricity distribution networks, especially when there is a large penetration of renewable energy resources. In this paper, we focus on voltage control through reactive power compensation and study how different information structures affect the control performance. In particular, we first show that using only voltage measurements to determine reactive power compensation is insufficient to maintain voltage in the acceptable range. Then we propose two fully decentralized and robust algorithms by adding additional information, which can stabilize the voltage in the acceptable range. The one with higher complexity can further minimize a cost of reactive power compensation in a particular form. Both of the two algorithms use only local measurements and local variables and require no communication. In addition, the two algorithms are robust against heterogeneous update rates and delays.

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CP8

Topological Obstructions to Distributed Feedback Stabilization to a Submanifold

We consider the problem of local asymptotic feedback stabilization – via a C^1 feedback law – of a control system $\dot{\mathbf{x}} = f(\mathbf{x}, \mathbf{u})$ defined in Euclidean space R^n (with $f \in C^1$) to a compact, connected, oriented $p-$dimensional submanifold P of R^n, subject to the constraint that the scalar entries of the system function f and of the feedback law u depend only on selected subsets of the state variables. Such constraints arise naturally in the context of distributed control systems, typically consisting of multiple agents with only local communication between the various agents. We obtain topological necessary conditions for the existence of such a stabilizing feedback control law; these topological conditions are expressed in terms of the generators of the homology groups of certain topological spaces naturally associated with the control problem, as well as the topology of the submanifold to which stabilization is to be performed.

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CP9

Sampling Intervals Enlargement for a Class of Parabolic Sampled-Data Observers

Enlarging the sampling intervals in the networked control-estimation is a hot topic. Presently, we seek sampling interval enlargement for sampled-data observers designed for a class of parabolic systems. This purpose is shown to be achievable by using inter-sample output predictor based observers. Sufficient conditions for global exponential convergence are derived in terms of LMIs via Lyapunov-Krasvoskii functionals. It is checked through simple examples that the proposed observers considerably enlarge the sampling interval. The results are illustrated by some examples from the literature.

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CP9

Reduced Order Modelling for Optimal Cancer Treatment

We study reduced order modelling for optimal treatment planning. Boltzmann transport equation is used to model the interaction between radiative particles with tissue. At first, we solve optimization problems: minimizing the deviation from desired dose distribution. Then we consider a parameterized geometry. In offline stage we solve a problem for sampled parameter values. The online phase then consists of solving the reduced problem for the actual set of parameters. Theoretical and numerical results are presented.

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CP9

Some Numerical Extension for the LOI/BOI Approach for the Control of de Saint-Venant Equations in Infinite Dimension

This paper considers the control design of a nonlinear distributed parameter system in infinite dimension, described by PDEs of de Saint-Venant. The nonlinear system dynamic is formulated by a Multi-Models approach over a wide operating range, where each local model is defined around a set of operating regimes. A PI feedback was designed and performed through Bilinear Operator Inequality and Linear Operator Inequality techniques for infinite dimensional systems. The authors propose in this paper to improve the numerical part by introducing weight μ_i not only equal to {0,1}, but $\mu_i \in [0, 1]$.

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CP9

Optimal Damping Coefficient of a Slowly Rotating Timoshenko Beam

This paper continues the authors previous investigations of stability of the slowly rotating Timoshenko beam whose movement is controlled by the angular acceleration of the disk of the driving motor into which the beam is rigidly clamped. We consider the problem of optimal value of damping coefficient of a particular type of viscoelastic damping operator. To determine location of spectrum of an appropriate operator we use a transfer function method.

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CP9

Asymptotic Behavior for Coupled Abstract Evolution Equations with One In?nite Memory

In this work, we consider two coupled abstract linear evolution equations with one in?nite memory acting on the ?rst equation. Under a boundeness condition on the past history data, we prove that the stability of our abstract system holds for convolution kernels having much weak decays than the exponential one considered in the literature. The general and precise decay estimate of solution we obtain depends on the growth of the convolution kernel at in?nity and the regularity of the initial data. We also present various applications to some hyperbolic distributed coupled systems such as wave-wave, Petrovsky-Petrovsky, wave-Petrovsky and elasticity-elasticity. These results have been published in Applicable Analysis, 2014.

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CP9

Observer-based Bilinear Control of First-order Hyperbolic PDEs

We investigate the problem of bilinear control of a solar collector plant using available boundary and solar irradiance measurements. The solar collector is described by a first-order 1D hyperbolic partial differential equation where the pump volumetric flow rate acts as the control input. By combining a boundary state observer and an internal energy-based control law, a nonlinear observer based feedback controller is proposed. The effect of solar radiation is cancelled using a feed-forward control term.

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CP10

Rigorous Numerical Method for Irrigation Canal System Dynamics and Control

Water canals for water delivery or irrigation provide a challenging system dynamics and control problem for distributed parameter plants. Water pool dynamics are derived from the shallow water equations (also called Saint-Venant equations in its one-dimensional form) that are a set of hyperbolic partial differential nonlinear equations. Rigorous numerical methods that are able to capture water wave dynamics in canals are difficult to achieve. In this case a numerical routine was designed from a finite volume method for hyperbolic systems of conservation laws with source terms using a semi-discrete MUSCL flux reconstruction linear well-balanced scheme. Time integration was done with a Runge-Kutta method. The numerical method was used to simulate water dynamics in the first two pools with withdraws of an existing irrigation canal in Vila Nova de Mil-Fontes, Portugal, including PI controlled gates movement to compensate for wave disturbances.

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CP10

Preconditioned Continuation Model Predictive Control

Model predictive control (MPC) anticipates future events to take appropriate control actions. Nonlinear MPC (NMPC) describes systems with nonlinear models and/or constraints. A Continuation/GMRES Method for NMPC, suggested by T. Ohtsuka in 2004, uses GMRES iterative algorithm to solve a forward difference approximation $Ax = b$ of the Continuation NMPC (CNMPC) equations on every time step. The coefficient matrix A of the linear system is often ill-conditioned, resulting in poor GMRES convergence, slowing down the on-line computation of the control by CNMPC, and reducing control quality. We adopt CNMPC for challenging minimum-time problems, and improve performance by introducing efficient preconditioning, utilizing parallel computing, and substituting MINRES for GMRES.

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CP10

Anfis Based Software Development for Nonlinear with Time Delay Dynamic Systems Identification

This article aims to show a software that was developed to identify nonlinear dynamical systems with time delay using the ANFIS. Therefore, we conducted two tests in the software, a simulated test uses a benchmark function, the Mackey-Glass, for making the prediction of future values of time series. The second test was performed using a real system coupled tanks with a smooth nonlinearity and time delay for the purpose to identify the dynamics of the system. The results shown in this paper confirm the capability of the developed software to identify nonlinear, with time delay, dynamic systems on a simple and intuitive way, as it was proposed.

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CP10

New Approach to Implicit Systems and Applications in Control Methods for Optimal Design Problems

Implicit representations of domains are at the core of fixed domain methods in shape optimization, like control methods or the fictitious domain approach. When the governing equation has Dirichlet boundary conditions, there are already known results in this respect. In the case of Neumann boundary conditions or of boundary observation, a more detailed knowledge of the properties of the unknown (implicitly defined) boundaries is necessary. We shall present a new approach based on implicit parametrizations of the boundaries. It also allows the handling of the critical case via the generalized solutions. We consider a class of variations of the unknown shapes, called functional variations, similar to the Dirichlet case and show how to compute directional derivatives of the unknown geometry.

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CP10

Accelerated Gradient Methods for Elliptic Optimal Control Problems with Tv-Regularised Cost

Over the past years, first order gradient methods have regained significant attention. Algorithms like FISTA are applicable to a broad range of scenarios, converge quickly and are ideally suited for large-scale problems. In this talk, we consider optimal control problems governed by elliptic equations, with a focus on non-smooth cost functionals. We will demonstrate how fast or accelerated gradient methods can be advantageously employed to solve these problems very efficiently.

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CP10

A Kind of Formula For Computing the Matrix Function

In this paper we employ the symbolic computation to derive a kind of formula for computing the matrix function f(A).

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CP11

New Results on Stochastic Consensus Networks

We revisit the genera linear time varying consensus problem and provide new conditions for asymptotic agreement on the agents' states on two distinct types of stochastic versions of the distributed algorithm. The first type is a linear discrete time dynamic evolution with connectivity signals driven by a measure preserving dynamical system. Our result highlights the fact that the probabilistic nature of the connections among agents that imposes almost sure convergence to consensus actually reproduces the deterministic recurrent connectivity condition known in the literature. The second type, is a linear continuous time flocking model with multiple time-varying diffusion coefficients. Via a stability in variation argument we establish sufficient conditions for asymptotic flocking with coordination around around a random-variable. Our analysis is based on rate at which the diffusion compartment vanishes. We argue, by example, that our results treat a number of related models proposed in the literature, as special cases.

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CP11

A Projection-Based Dual Algorithm for Fast Computation of Control in Microgrids

We present a novel algorithm for the distributed computation of optimal predictive storage and reactive power control in microgrids. This algorithm uses a dual decomposition approach to deal with coupling constraints, and a primal projection procedure to handle local constraints. This significantly decreases the amount of iterations needed for practical convergence, as compared to the dual decomposition algorithm involving all constraints. Simulations compare the algorithm with the dual decomposition approach in four different testbeds, to show how the speed of convergence is improved.

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CP11

Nullspace Design of Configuration Matrices for Lyapunov-Based, Multi-Vehicle Control

Lyapunov potential functions are common in multi-vehicle control algorithms because they ensure vehicle coordination while incorporating inter-vehicle communication topologies. However, this control approach often requires all vehicles to converge to a desired phase or shape variable. This talk will present recent results toward the design of novel quadratic functions for prescribed coordination. By designing quadratic terms based on matrices with a desired nullspace, we derive multi-vehicle control algorithms steering vehicles to any relative configuration.

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CP11

Convergence of Iterative Co-Learning Control

This talk discusses iterative co-learning where multiple linear subsystems update their input simultaneously based on the error in a common desired output. A challenge is that convergence of iterative learning for each individual subsystem (when the other subsystems are not learning) may not guarantee convergence under co-learning. Co learning with an update-partitioning approach will be presented that guarantees convergence whenever the individual, iterative learning for each subsystem is convergent.

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CP11

Role of Structured Noise in Emergence of Fundamental Tradeoffs in Linear Dynamical Networks

We deal with a network of multiple agents with dynamics described by a continuous time linear consensus algorithm. The performance of the network in presence of various types of noise inputs is investigated. We adopt the expected steady-state dispersion of the states of the network as a performance measure. The relationship between this performance measure and characteristics of the underlying graph of the network is explored. Specifically, we quantify how the asymptotic behavior of a linear consensus network is influenced by the existence of structured noises in different elements of the network, such as noise in sensors, emitters, channels, receivers, and the computational unit. In the next step, a class of centrality measures is introduced in order to assess the role of each agent and channel within a network. Finally, we discuss the emergence of fundamental tradeoffs on the performance measure with respect to the effects of structured noises in different elements of the network.

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CP11

Robust Dynamic Tolls for Self-Interested Traffic Routing

We consider the problem of designing robust taxation-mechanisms for influencing self-interested behavior in routing-problems where users have unknown sensitivities to taxes. Classical results are not sufficient for addressing this question due to unrealistic assumptions on either the system condition (i.e., homogeneous known sensitivities) or available information (i.e., network demands and users sensitivities). Accordingly, we present a dynamic tolling mechanism that, using local feedback, provably guarantees system-wide optimal behavior for a well-studied class of routing-problems.

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CP12

Optimal Inventory in Failure-Prone Manufacturing Systems with Monomial Holding Costs

The optimal policy for the production plan for a single commodity in a failure-prone parallel machine system is determined by solving the corresponding Hamilton-Jacobi-Bellman (HJB) equation. The system is assumed to possess two levels of operation capacity and the surplus holding cost is a monomial function. In this paper the analytical method based on Akella and Kumar (1986) is developed to solve the HJB equation using the derived boundary conditions of the value function. The effect of different operating parameters, such as failure rate, repair rate, maximal capacity level, et. al., on the optimal inventory level and the value function are numerically computed by using our analytical formula. For an arbitrary hold cost with the analytical or empirical formula which can be approximated by the sum of monomial functions, thus this paper provides a way to construct the corresponding optimal production plan.

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CP12

Performance Bound for Approximate Dynamic

Programming in Borel Spaces

We consider discrete-time constrained Markov control processes (MCPs) for Borel state and action spaces. We present a two-stage method to approximate the optimal value of the constrained MCPs via finite-dimensional convex optimization programs. The main contribution of this study is to provide explicit error bounds for the proposed solution under mild assumptions which are investigated for the long-run discounted as well as average cost. Finally, we also discuss the performance of the approximated control policy.

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CP12

Improvements to Optimal Control Problem Solvers on the Example of a Reachable Set Algorithm

The reachable set at a given time T of a nonlinear control system is the union of endpoints of all feasible solutions. The talk illustrates how an OCP-solver can be applied to calculate discrete reachable sets and shows some strategies to increase the stability of the OCP-solver for this class of problems. Furthermore a subdivision approach to improve the performance of the algorithm will be introduced.

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CP12

Convex Methods for Rank-Constrained Optimization Problems

Consider a rank-constrained optimization problem, which is otherwise convex. Penalizing the nuclear norm of the matrix minimizes its rank. We introduce a convex constraint, which, when used in conjunction with the above penalty, results in a convex problem that usually yields solutions of exactly desired rank. A modified dual program finds the "best" value of the parameter used with the nuclear norm. It is shown that allowing negative valued parameters (rewarding the nuclear norm) can result in better performance. The methods are demonstrated on SDPs.

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CP12

Distributed Optimization Based on Multi-Agent Systems

First, a continuous-time multi-agent system with nonlinear coupling is proposed to solve distributed optimization problems. Sufficient conditions are derived to ascertain the convergence to optimal solutions. The nonlinear coupling can deal with bounded inputs for agents and limited bandwidth for communication among agents. Furthermore, the nonlinear coupling has a superior property of robustness against additive noise than the linear case. Next, communication delays are considered on multi-agent systems for distributed optimization. Based on optimality conditions, it is revealed that optimal solutions are corresponding to the equilibrium points in a positive invariant set of the time-delay system. Both delay-dependent and delay-independent sufficient conditions are derived for ascertaining convergence to optimal solutions in the case of slow-varying delay. Delay-dependent conditions are also presented for the case of fast-varying delays.

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CP13

Output Feedback H-infinity Control for Discrete-Time Singular Systems: A Strict LMI Approach

This paper deals with the problem of the output feedback H_∞ control for discrete-time singular systems. Our goal is to develop a numerically tractable controller design method for output feedback H_∞ control of discrete-time singular systems. First, a new sufficient condition for H_∞ performance is derived. Then, a sufficient condition for the existence of the desired output feedback H_∞ controller is established. The proposed controller design method is formulated under the strict LMI framework. Finally, a numerical example is used to demonstrate the effectiveness of presented method.

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CP13

Parameterization of Positively Stabilizing Feedbacks for Single-Input Positive Systems

For unstable positive finite-difference systems approximating a diffusion PDE system with Neumann boundary conditions and scalar boundary input, parameterizations of all positively stabilizing state feedbacks are derived.They are based on characterizations of stable Metzler matrices by LMIs and of polyhedral sets as finitely generated cones, respectively.With well-chosen parameter values, this process generates a Dirac sequence of feedback functionals yielding a limit feedback such that the resulting closed-loop PDE system is positive and stable.

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CP13

On the Construction of Continuous Suboptimal Feedback Laws

It is well known that optimal feedback laws are usually discontinuous functions on the state, which yields to ill-posed closed loop systems and robustness issues. In this talk we show a procedure for the construction of a continuous suboptimal feedback law that allows overcoming the aforesaid problems. The construction we exhibit depends exclusively on the initial data that could be obtained from the optimal feedback.

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CP13

A Topological Method for Finding Positive Invariant Sets

A usual way to find invariant sets of a differential system is to impose that the flow goes inward on the border of the set. Using a topological approach (and in particular Wazewskis property) we present an algorithm that is based on a sufficient and weaker combinatorial condition of the flow on the border. We start from a template polyhedron and prove the positive invariance of a subset in the interior of this template.

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CP13

A Graph-Related Sufficient Condition for the Exact Computation of the Joint Spectral Radius

Our talk relates to the stability analysis of discrete-time switching systems, with and without logical switching constraints. We present an efficiently checkable sufficient condition under which a quadratic multiple Lyapunov function has a contractivity factor equal to the joint spectral radius of a system. This allows us to exactly compute its joint spectral radius in finite time. We put our work in relation with the previously introduced finite-time algorithm of Guglielmi and Protasov.

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CP13

Convexity + Curvature: Tools for the Global Stabilization of Nonlinear Systems with Control Inputs Subject to Magnitude and Rate Bounds

The aim of this paper is to address the global asymptotic stabilization (GAS) of affine systems with control inputs subject to magnitude and rate bounds, in the framework of Artstein-Sontag's control Lyapunov function (CLF) approach. These bounds are defined by compact (convex) control value sets (CVS) U with $0 \in intU$. Convex Analysis together with Differential Geometry allow us to reveal the intrinsic geometry involved in the CLF stabilization problem, and to solve it, if an optimal control $\overline{\omega}(x)$ exists. The existence and uniqueness of $\overline{\omega}(x)$ depends on convexity properties of CVS U; whereas its regularity and boundedness of its differential is achieved in terms of the curvature of U. However, in view that control $\overline{\omega}(x)$ is singular, we redesign it to derive an explicit formula for regular damping feedback controls fulfilling magnitude and rate bounds that render GAS a class of affine systems.

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CP14

Thermostatic Approximation of Optimal Control Problems on Multi-Domains

We study an optimal control problem with two controlled different dynamics in two half-spaces, in the framework of HJB equations. We introduce an approximation by the use of switching rules of the delayed-relay type, and study the passage to the limit when the parameter of the approximation (i.e. the thresholds distance) goes to zero. We then compare our result with other ones from the recent literature. Finally, we briefly sketch a one-dimensional threefold junction problem.

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CP14

Necessary Optimality Conditions for the Time of Crisis Control Problem.

We consider a non-smooth optimal control problem where the cost functional represents the time of crisis, that is, the time spent by a solution of a control system outside a given set. A regularization scheme of the problem based on the Moreau-Yosida approximation is proposed. We prove the convergence of an optimal sequence for the approximated problem to an optimal solution of the original one. We derive optimality conditions on the original and regularized problem.

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CP14

Optimal Control Methods for Solving Laser Parameter Extraction Problem

There are a wide range of applications involving laser propagation through a scattering medium. Very often, a measurement of the scattered light will be taken with the intent of learning some information about the medium. On the contrary, the present work seeks to extract a description of the source of light and its location. A phenomenological model for off-axis intensity is presented which employs a Mie scattering aerosol database. The model is extended to predict the off-axis polarized light described by the Stokes vector. Several inversion techniques are given and analyzed as well as example problems detailed which can recover the range, direction, power and polarization of the laser source. Current work on solving off-axis laser detection problem as an optimal control problem for the Radiative Transfer Equation is also discussed.

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CP14

New Sufficient Condition for the Proto-Lipschitz Continuity of the State Constrained Bilateral Minimal Time Function

We provide a sufficient condition for the proto-Lipschitz continuity of the state constrained bilateral minimal time function. Compared with the sufficient conditions given in C. Nour and R. J. Stern, *The state constrained bilateral minimal time function*, Nonlinear Anal., 69, no. 10, 3549-3558, (2008), our new condition does not impose any geometric assumption on the constraint set S and does not involve points exterior to S.

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CP14

Eigenvalue Assignment for Systems with Multiple Time-Delays

We consider the problem of pole assignment for a linear time invariant plant with state feedback subject to multiple time delays in the control input. For systems with a known time delay, we offer a parametric formula for the feedback gain matrix that will assign a desired set of closed-loop eigenvalues to the time-delay system. We consider some well-established pole placement methods for systems without delay that utilise pole placement via state feedback in order to achieve their desired performance objective. We explore the extent to which their desired control performance objective may be successfully achieved for a time-delay system by placing the primary poles of the delayed system at the same locations as for the system without delay. The role of the secondary poles of the time-delay system will also be investigated since they are known to affect both the stability and performance.

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CP14

Optimal Boundary Control of Process Described by the System of Telegraph Equation

In the present paper we study the problem boundary control of oscillations described by the system of telegraph equations:

$$\{\ u_x + Li_t + Ri = 0,\ i_x + Cv_t + Gu = 0$$

in rectangle $Q_T = [0 \leq x \leq l] \times [0 \leq t \leq T]$. Where $i(x,t)$-current strength, $u(x-t)$ – voltage in a two-wire transmission line with distributed parameters: resistance(R),capacity(C), charge leakage(G),self-induction(L). Will be found the explicit form of boundary control

$$u(0,t) = \mu(t), \quad u(l,t) = 0$$

which transfers the system from a given initial state

$$u(x,0) = \phi_1(x), \quad i(x,0) = \psi_1(x)$$

to a given final state

$$u(x,T) = \phi_2(x), \quad i(x,T) = \psi 2(x)$$

for a predetermined period of time T. Boundary control provides a minimum the following energy functional

$$\int_0^T i_t(0,t)u_t(0,t)dt$$

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CP15

Dynamic Risk Measures for Finite-State Partially Observable Markov Decision Problems

We provide a theory of time-consistent dynamic risk measures for finite-state partially observable Markov decision problems. By employing our new concept of stochastic conditional time consistency, we show that such dynamic risk measures have a special structure, given by transition risk mappings as risk measures on the space of functionals on the observable state space only. Moreover, these mappings enjoy a strong law invariance property.

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CP15

The Sakawa-Shindo Algorithm in Stochastic Control

In this work, J.F. Bonnans, J. Gianatti and F.J. Silva. The Sakawa-Shindo Algorithm in stochastic control. Preprint, to appear, we study the extension to the stochastic case of a first order algorithm for solving deterministic optimal control problems proposed by Y. Sakawa and Y. Shindo. On global convergence of an algorithm for optimal control. IEEE Trans Aut. Control. vAC-25. 1149, 1980, and analyzed in J.F. Bonnans. On an algorithm for optimal control using Pontryagin's maximum principle. SIAM J. Control and Optimization, 24, 1986. We need to assume that either the cost functional is Lipschitz and the volatility term is not controlled, or that the dynamics is an affine function of the state and the control. We prove that the iterates of the algorithm are well defined and the cost function decreases. Moreover, for convex problems we obtain the convergence of the iterates in the weak topology.

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CP15

An $(\underline{s}, \overline{s}, S)$ Optimal Maintenance Policy for Systems Subject to Shocks and Progressive Deterioration

We define a model of a system that deteriorates as a result of (i) shocks, modeled as a compound Poisson process and (ii) deterministic, state dependent progressive rate, with variable and fixed maintenance cost. We define maintenance strategies based on an impulse control model where time and size of interventions are executed according the system state. We characterize the value function as the unique viscosity solution of the HJB equation and prove that an $(\underline{s}, \overline{s}, S)$ policy is optimal. We also provide numerical examples. Finally, a singular control problem is proposed where there is no fixed cost, which study and relation with the former problem is open for future discussion.

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CP15

Two End Points Boundary Value Problems on Stochastic Optimal Transportation and Fokker-Planck Equation

We give a sufficient condition under which stochastic optimal transportation problem is finite, by the finiteness of the supremum in the duality theorem, which implies the existence of a semimartingale with given initial and terminal distributions. It also gives a new approach for h-path processes with given initial and terminal distributions. We also consider the similar problem to above for a class of optimal control problems for a family of solutions to Fokker-Planck equations.

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CP15

An Application of Functional Ito's Formula to Stochastic Portfolio Optimization with Bounded Memory

We consider a stochastic portfolio optimization model in which the returns of risky asset depend on its past performance. The price of the risky asset is described by a stochastic delay differential equation. The investor's goal is to maximize the expected discounted utility by choosing optimal investment and consumption as controls. We use the functional Ito's formula to derived the associated Hamilton-Jacobi-Bellman equation. For logarithmic and exponential utility functions, we can obtain explicit solutions in a finite dimensional space.

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CP15

Zubov's Method for Controlled Diffusions with State Constraints

We consider a controlled stochastic system in presence of state-constraints. Under the assumption of exponential stabilizability of the system near a target set, we aim to characterize the set of points which can be asymptotically driven by an admissible control to the target with positive probability. We show that this set can be characterized as a level set of the optimal value function of a suitable unconstrained optimal control problem which in turn is the unique viscosity solution of a second order PDE which can thus be interpreted as a generalized Zubov equation.

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CP16

Resolution-Directed Optimization-Based Distributed Sensing

In this paper we study the problem of optimal zone coverage, using distributed sensing, i.e., a group of collaborating sensors. We formulate the problem as an optimization problem with time-varying cost function. We examine the case where a group of elevated imaging sensors look down to and form the map of a 2-dimensional environment at a pre-specified resolution. The sensors solve an optimization problem that attempts to optimize a time-varying cost function. The cost at any time instance measures the distance between the desired resolution function and the achieved resolution until the previous time instant. We discuss the numerical implementation challenges of this approach and demonstrate its performance on a numerical example.

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CP16

A Localized Proper Symplectic Decomposition Technique for Model Reduction of Parameterized Hamiltonian Systems

Recently, a symplectic model reduction technique, proper symplectic decomposition (PSD), is proposed to achieve computational savings for a large-scale Hamiltonian system while preserving the symplectic structure [arXiv:1407.6118]. As an empirical approach, PSD preserves system energy and stability, thus, PSD is better suited than the classical POD for model reduction. In this talk, we combine PSD with the idea of parameter domain partition, and propose a localized PSD technique for model reduction of parameterized Hamiltonian systems.

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CP16

Numerical Analysis of a Family of Optimal Distributed Control Problems Governed by An Elliptic Variational Inequality

The numerical analysis of a family of distributed optimal control problems governed by elliptic variational inequalities (for each $\alpha > 0$) is obtained through the finite element method when its parameter $h \to 0$. We also obtain the limit of the discrete optimal solutions when $\alpha \to \infty$ (for each $h > 0$) and a commutative diagram for two continuous and two discrete optimal solutions are obtained when $h \to 0$ and $\alpha \to \infty$.

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CP16

Uniform Boundary Observability for Polynomial Approximations of the Wave Equation

The boundary observability of the second order wave equation is not preserved uniformly with respect to the discretization parameter after application of classical approximation methods like finite differences, finite elements or spectral elements. Here we consider a spectral Legendre-Galerkin (polynomial) space-discretization of the 1-d wave equation. We show that the uniform observability can be recovered using spectral filtering, mixed formulations or a weak imposition of the boundary conditions.

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CP16

Identification of Optimum Parameters in Mathematical Model of Temperature Measuring Device

We propose the mathematical model describing the dependence of the temperature on the resistances for self-test of temperature transducer, which is represented as system of equation with unknown degrees and coefficients. Method to identification of unknown parameters based on regularization technique is proposed. We obtain the error estimates of the solutions to this problem which allows to calculate the temperature values with guaranteed accuracy and to develop the criteria to self-test of device.

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CP16

An Application of Global Sensitivity Analysis to Large Scale Power System Small Signal Stability

We propose an application of the variance-based global sensitivity analysis to determine impact of variation of selected parameters and their interactions on power system small-signal stability. In practice, such analysis becomes essential when studying impact of increased penetration of renewable energy sources on stability. Computation is performed via Tensor-Train cross interpolation to map high-dimensional parameter space to system eigenvalues. For each interpolation point, eigenvalues are computed using small-signal stability software commonly used in industry.

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CP17

Approximate Controllability of a Second-Order Neutral Stochastic Differential Equation with State Dependent Delay

In this paper the conditions for approximate controllability are investigated for a distributed second order neutral stochastic differential system with respect to the approximate controllability of the corresponding linear system in a Hilbert space X. Our hypothesis is described as a geometrical relation in $L^2(0, T : X)$ between the range of the operator B and the subspace $N^{\perp}$ related with the sine function S(t). Thereby, we remove the need to assume the invertibility of a controllability operator, which fails to exist in infinite dimensional spaces if the associated semigroup is compact. Our approach also removes the need to check the invertibility of the controllability Gramian operator and the associated limit condition, which are practically difficult to verify and apply. An example is provided to illustrate the presented theory. Specifically we study the following second order equations modelled in the form

$$\begin{aligned} d(x'(t) + g(t, x_t)) &= [Ax(t) + f(t, x_{\rho(t,x_t)}) + Bu(t)]dt \\ &+ G(t, x_t)dW(t), \ a.e. \ on \ t \in J = [0, a] \\ x_0 = \phi \in \mathcal{B}, \ x'(0) &= \psi \in X \end{aligned} \quad (1)$$

where A is the infinitesimal generator of a strongly continuous cosine family $\{C(t) : t \in \mathsf{R}\}$ of bounded linear operators on a Hilbert space X. The state space $x(t) \in X$ and the control $u(t) \in L_2^{\mathcal{F}}(J, U)$, where X and U are separable Hilbert spaces and d is the stochastic differentiation. Let $(\Omega, \mathcal{F}, P)$ be a probability space together with a normal filtration $\mathcal{F}_t,\ t \geq 0$. Let K be a separable Hilbert space and $\{W(t)\}_{t\geq 0}$ is a given $K-$ valued Brownian motion or Wiener process with finite trace nuclear covariance operator $Q > 0$. The functions $f, g : J \times \mathcal{B} \to X$ are measurable mappings in X norm and $G : J \times \mathcal{B} \to L_Q(K, X)$ is a measurable mapping in $L_Q(J, X)$ norm.

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CP17

Resolving the Pattern of Akt Activation by Variational Parameter Estimation

Ordinary differential equation models have become one of the pillars for understanding complex biological systems. The equations typically contain many unknown parameters such as reaction rates and initial conditions, but also input functions driving the system. Both are *a priori* unknown and need to be estimated from experimental data. Here, we introduce variational calculus and adjoint sensitivities to apply it for input- and parameter estimation in mammalian target of rapamycin (mTOR) signaling. Whereas the direct identification and quantification of different active mTOR complexes is only possible by highly challenging experiments, the mathematical framework allows to reconstruct its dynamics by solving an appropriate Euler-Lagrange equation. The inherently large search space underlying this approach allows to test specific biological hypotheses about the activation of protein kinase B (AKT) by mTORC2 and to reject an alternative model with high statistical power.

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CP17

Polynomial Approximations and Controllability of Time-Invariant Linear Ensemble Systems

Robust manipulation of an ensemble of structurally identical dynamical systems is imperative for wide-ranging applications from quantum control to neuroscience. We study ensemble control of finite-dimensional time-invariant linear systems and develop explicit ensemble controllability conditions. Our derivation is based on the notion of polynomial approximation and the spectra properties of the system matrices. Practical examples and numerical simulations for optimal control of such ensemble systems are presented to demonstrate the applicability of the theoretical results.

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CP17

Continuous-Discrete Observers for Time-Varying Nonlinear Systems: A Tutorial on Recent Results

Continuous-discrete systems occur when the plant state evolves in continuous time but where the output values are only available at discrete time instants. Continuous-discrete observers have the valuable property that the observation error between the true state of the system and the observer state converges to zero in a uniform way. The design of continuous-discrete observers can often be done by building framers, which provide componentwise upper and lower bounds for the plant state. This paper is a tutorial on these approaches, highlighting recent results in the literature, and also providing previously unpublished, original results which are not being simultaneously submitted elsewhere.

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CP17

Exact Null Controllability of Evolution Equations by Smooth Scalar Controls and Applications to Controllability of Interconnected Systems

The most of papers devoted to controllability problems are mainly considering square integrable or piecewise-continuous controls as a set of admissible controls. However some mechanical systems, for example, cars or aircrafts, require smooth controls. Exact null-controllability conditions for abstract linear control equations in the class of smooth controls are presented. One of applications of these results is the exact null-controllability conditions for a series of interconnected equations, governed by a control of the last one. These conditions allow us to use the presented abstract approach for a series contained equations of a different structure. For example, the first one may be a parabolic control equation, and the second one may be a linear differential control system with delays, governed by scalar control, and so on. The exact null-controllability for interconnected heat–wave equations is considered as illustrative example.

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CP17

Approximate Controllability of Semilinear Fractional Control Systems of Order $\alpha \in (1, 2]$

The objective of this paper is to present some sufficient conditions for approximate controllability of semilinear delay control systems of fractional order $\alpha \in (1, 2]$. The

results are obtained by the theory of strongly continuous α-order cosine family and sequential approach under the natural assumption that the linear system is approximate controllable. At the end, an example is given to illustrate the theory.

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CP18

On the Finite-Time Stabilization of Strings Connected by Point Mass

In this paper, the problem of finite-time boundary stabilization of two strings connected by point mass is investigated. Based on the so-called Riemann invariant transformation, the vibrating strings are transformed in two hybrid-hyperbolic systems, and leads to the posedness of our system. In order to act in the system, it is desirable to choose boundary feedbacks, in this case, Hölderien stabilizing feedback laws to vanish in finite-time the right and the left of the solutions are considered.

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CP18

Metzler Matrix Transform Determination Using a Nonsmooth Optimization Technique with An Application to Interval Observers

The paper deals with the design of cooperative observers which formulates as computing a state coordinate transform such that the resulting observer dynamics are both stable and cooperative. The design of cooperative observers is a key problem to determine interval observers. Solutions are provided in the literature to transform any system into a cooperative system. A novel approach is proposed which reformulates into a stabilization problem. A solution is found using nonsmooth optimization techniques.

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CP18

Delay-Independent Closed-Loop Stabilization of Neutral Systems with Infinite Delay

Abstract: In this paper, the problem of stability and stabilization for neutral delay-differential systems with infinite delay is investigated. Using Lyapunov method, new sufficient condition for the stability of neutral systems with infinite delay is obtained in terms of linear matrix inequality (LMI). Memory-less state feedback controllers are then designed for the stabilization of the system using the feasible solution of the resulting LMI, which are easily solved using any optimization algorithms. Numerical examples are given to illustrate the results of the proposed methods.

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CP18

Observer Based Control for a Class of Coupled Parabolic Hyperbolic Systems

This paper investigates the control problem for nonlinear-coupled partial differential equations that describe radiative-conductive heat transfer systems. Thanks to the special structure of the obtained state system, using the Galerkin method for the semi-discretization of PDE and to the differential mean value theorem, a new linear matrix inequality condition is provided for the observer-based controller design. The observer and controller gain are computed simultaneously by solving LMI, i.e a convex problem. Also we provide a reduced order observer based controller that assures global asymptotic stability.

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CP18

On Some System-Theoretic Properties of Hamiltonian Systems Defined on Contact Manifolds

The intrinsic description of open irreversible thermodynamic systems has given rise to the definition of control Hamiltonian systems defined on contact manifolds which has been call input-output contact systems. In this communication, we shall analyze some system-theoretic properties of such systems. We shall, in particular, analyze the structure preserving feedback of these systems, characterize a class of contact forms achievable in closed-loop and consider the stabilization of thse systems.

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CP18

Lyapunov-Razumikhin Methods for Stabilization in the Sample-and-Hold Sense of Retarded Nonlinear Systems

A new methodology for the design of stabilizers in the sample-and-hold sense for nonlinear retarded systems is provided. It is shown that, if there exist a control Lyapunov- Razumikhin function and an induced steepest descent state feedback, uniformly in time bounded on bounded subsets of the state space, then such feedback, applied by suitably fast sampling and holding, guarantees practical semiglobal stability, with arbitrary small final target ball of the origin.

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CP19

A Certified Reduced Basis Approach for Parametrized Linear-Quadratic Optimal Control Problems with Control Constraints

We focus at a parameter dependent PDE constrained Optimal Control Problem with two-sided control constraints. For that problem we derive a model order reduction technique that not only is capable of reducing the optimality conditions of the problem but also the control constraints. The reduction ensures the strict feasibility for one of the two-sided control constraints and enables us to compute an approximation and its error bound independently of the original dimension of the problem.

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CP19

Maximum Principle for Optimal Control Problems with Integral Equations Subject to State and Mixed Constraints

We consider an optimal control problem with a Volterra type integral equation subject to endpoint equality and inequality constraints, mixed state-control constraints of inequality and equality type, and pure state inequality constraints. The gradients of active mixed constraints with respect to the control are assumed to be linear–positively independent. We prove necessary optimality conditions which generalize Maximum Principle for similar problems with ODEs. The proof is based on an extension of the control system by introducing sliding mode controls and using a relaxation theorem that allows one to approximate solutions of the extended system by solutions of the original system. We thus obtain a family of optimal control problems with extended systems, for each of which we apply the stationarity condition (Euler–Lagrange equation, obtained earlier in our joint work with N.P. Osmolovskii), and then compress these conditions into a universal condition that has the form of MP.

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CP19

On-Line Model Predictive Control for Constrained Image Based Visual Servoing of a Manipulator

This paper presents an on–line image based visual servoing (IBVS) controller subject to the constraints based on the robust model predictive control (RMPC) method. A controller is designed for the robotic visual servoing system subject to input and output constraints, such as robot physical limitations and visibility constraints. To verify the effectiveness of the proposed algorithm, real-time experimental results on a 6 Degrees-of-Freedom robot manipulator with eye-in-hand configuration are presented and discussed.

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CP19

Analysis of Floating Offshore Wind Turbine Model Considering Gyro Moment

A floating offshore wind turbine system is analyzed. First we develop the floating offshore wind turbine model and the provide analysis for the dynamics considering the gyro moment based on the multi-body dynamics analysis. Specifically, regarding the blade pitch angle of the rotor as the control input, we derive control laws for the power output regulation, floating sway suppression, and gyro-moment suppression at the same time. Furthermore, we provide numerical simulation to show tradeoff relationship between floating sway suppression and gyro-moment suppression.

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CP19

Flat Systems of Minimal Differential Weight: Comparison Between the Two-Input and the Multi-Input Case

We study flatness of control-affine systems, defined on an n-dimensional state-space. In [F. Nicolau and W. Respondek, *Flatness of two-inputs control-affine systems linearizable via one-fold prolongation*, Nolcos 2013], [F. Nicolau and W. Respondek, *Multi-Input Control-Affine Systems Linearizable via One-Fold Prolongation and Their Flatness*, CDC 2013], we gave a complete geometric characterization of systems that become static feedback linearizable after a one-fold prolongation of a suitably chosen control. They form a particular class of flat systems, that is of differential weight $n + m + 1$, where m is the number of controls. We distinguished the two-input case, i.e., $m = 2$ and the multi-input case, i.e., $m \geq 3$. They have slightly different geometries and have to be treated separately. The aim of

this talk is to give a comparison between these two cases.

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CP19

Tracking Control of An Underactuated Autonomous Ship

In this paper, we will construct a control that forces position and orientation of the underactuated autonomous ship moves according to a reference feasible trajectory. To achieve this objective, we use as a design tool of inputs the Backtepping methodology and Lyapunov function. Experimental results are given to show the tracking performance. we will illustrate trajectories with time varying velocity (sinusoidal path). Then, we will test the tracking robustness in presence of drag forces disturbances.

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CP20

HJB Approach to Dynamic Mean-Variance Stochastic Control

We consider a general continuous mean-variance problem where the cost functional has an integral and a terminal-time component. We transform the problem into a superposition of a static and a dynamic optimization problem. The value function of the latter can be considered as the solution to a degenerate HJB equation either in viscosity or in Sobolev sense (after regularization) under suitable assumptions and with implications with regards to the optimality of strategies.

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CP20

On Using Spectral Graph Theory to Infer the Structure of Multiscale Markov Processes

Multiscale Markov processes are used to model and control stochastic dynamics across different scales in many applications areas such as electrical engineering, finance, and material science. A commonly used mathematical representation that captures multiscale stochastic dynamics is that of singularly perturbed Markov processes. Dimensionality reductions techniques for this class of stochastic optimal control problems have been studied for many years. However, it is typically assumed that the structure of perturbed process and its dynamics are known. In this paper, we show how to infer the structure of a singularly perturbed Markov process from data. We propose a measure of similarity for the different states of the Markov process and then use techniques from spectral graph theory to show that the perturbed structure can be obtained by looking at the spectrum of a graph defined on the proposed similarity matrix.

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CP20

Robust Optimal Control for Pdes with Uncertainty in Its Input Data

We shall review on recent results obtained by the authors ([Martínez-Kessler-Periago, Robust optimal shape design for an elliptic PDE with uncertainty in its input data, to appear in ESAIM:COCV (2015)] and [Munch-Martínez-Kessler-Periago, in preparation]) concerning robust optimal control problems for elliptic and parabolic partial differential equations with uncertainty in its input data. Robustness is modelled by including the variance (and semi-variance) of the physical quantity to be optimized in the cost functional. For the numerical resolution of the problems, the adjoint method is used. Both the direct and adjoint (non-local in the probabilistic space) equations are solved by using a sparse grid stochastic collocation method. A number of numerical experiments in 2D will illustrate the theoretical results and will show the computational issues which arise when uncertainty is quantified through random fields.

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CP20

Application of Sufficient Optimality Conditions in Analysis of Stochastic Models of Illiquid Markets

The purpose of this work is to study the optimal control problem of an agent in the market with random trade delays. In this article we present a stylized model of optimal saving and purchases of durable goods in which the moments of time when an agent makes purchases are random and are described by Poisson flow. We find the optimal behavior of the agent using the sufficient optimality conditions. We prove existence of the solution. In the case of high intensity of the random process of trade the explicit form of optimal strategy is presented.

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CP21

Towards a Minimum L2-Norm Exact Control of the Pauli Equation

A computational framework for the exact-control of the magnetic state and the spin of an electron is presented. The evolution of this quantum system is governed by the Pauli equation, that is a system of Schrödinger equations coupled by the action of magnetic fields. The magnetic fields are used as controls in order to steer the quantum system from an initial state to a desired target state at a given final time. This control framework is based on a minimum norm optimization formulation of exact-controllability quantum problems, that allows the application of efficient Krylov-Newton optimization techniques. Furthermore, in order to provide this framework with an adequate initialization, a continuation procedure is discussed. Results of numerical experiments demonstrate the effectiveness of the proposed framework.

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CP21

Optimal Control Via Occupation Measures and Interval Analysis

In this lecture, we present a method based on occupation measures to compute a guaranteed lower bound to an optimal control problem. Following Vinter approach, the optimal control problem is formulate into a linear programming problem of infinite dimension. Thank to Interval arithmetic, this linear programming problem can be approximate, in a reliable way. Finally, its solution gives a lower bound to the optimal cost. Examples will illustrate the principle of the methodology.

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CP21

On Approximate Solution of Mobile (scanning) Control Problems

We describe an approximate technique for solving the so-called mobile control problems. The method is based on the Bubnov-Galerkin procedure and allows to reduce the control problem to a finite-dimensional nonlinear system of integral constraints of equality type. An efficient numerical scheme is described reducing the solution of the nonlinear system to a problem of nonlinear programming. The proposed method is described for nonlinear equations with linear boundary conditions. Two particular problems of heating by a moving source and vibration damping by a moving absorber are considered. The system of necessary and sufficient conditions for controllability are obtained in both cases. Main points of numerical implementations are discussed.

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CP21

Towards Optimal Feedback Control of the Wave Equation Using Adaptive Sparse Grids

An approach to solve optimal feedback control problems for the wave equation using adaptive sparse grids is considered. A semi-discrete optimal control problem is introduced and the feedback control is derived from the corresponding value function. The value function can be characterized as the solution of a Hamilton-Jacobi Bellman (HJB) equation. Besides a low dimensional semi-discretization of the underlying wave equation it is important to solve the HJB equation efficiently to address the curse of dimensionality. We propose to apply a semi-Lagrangian scheme using spatially adaptive sparse grids. Sparse grids allow the discretization of the high(er) dimensional value functions arising in the numerical scheme since the curse of dimensionality of full grid methods arises to a much smaller extent. Several numerical examples are presented. This is joint work with J. Garcke (University of Bonn).

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CP21

Optimal Motion Planning for Multi-Agent Systems with Uncertainty

Using a computational optimal control approach, a scalable parallel algorithm is developed for optimal motion planning involving a large number of interacting heterogeneous agents under uncertainty. The algorithm is tested on designing trajectories of multiple vehicles collectively defending a high-value-unit from hundreds of uncertain attackers. Simulation results demonstrate the efficiency and generality of the algorithm for different initial formations, and under different probability distributions for uncertainty. Extension of the interacting scenarios utilizing Monte Carlo and Quasi Monte Carlo simulations are discussed.

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CP21

Fast EM Clustering For Large Data Using an Integrated Approach Rough-Fuzzy Granulation And Fisher Discriminate Analysis

A new fast EM clustering methodology is introduced, based on a combined rough-fuzzy granulation and fisher discriminate analysis (FDA). The proposed algorithm is suitable for mining data sets, which are large both in dimension and size, in case generation. It utilizes FDA specification and an granular computing method for obtaining crude initial values of the parameters of the mixture of Gaussians used to model the data . Rough set theory is used for feature extraction and solving superfluous attributes issue. Upper and lower approximations of rough set is calculated based on fuzzy membership functions. Features of a pattern can hence be described in terms of three fuzzy membership values in the linguistic property sets as low (L), medium (M) and high (H). FDA provides an optimal lower dimensional representation in terms of discriminating among classes of data.

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CP22

Distributed Controllability of the Wave Equation Using Moving Controls

This talk aims to address the inner controllability of the one dimensional wave equation using controls with supports which may vary with respect to the time variable. Theoretical and numerical aspects are considered. A generalized observability inequality for the homogeneous wave equation is proven and this implies the well-posedness of a mixed formulation that characterizes the controls of minimal L^2 norm. A numerical approximation of this formulation is presented and several numerical experiments are reported.

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CP22

Lpv Control of a Water Delivery Canal with Reduced Complexity Models

The problem of designing a LPV controller for a water delivery canal using models with a priori imposed order that approximate plant dynamics is addressed. A water delivery canal is an infinite dynamical system that is modelled by the Saint-Venant equations, a pair of hyperbolic partial differential equations that embed mass and momentum conservation for one-dimensional shallow water streams. Using a method based on the Laplace transform, these equations are approximated by a finite dimensional system with a priori imposed order. The fact that the linear approximation relies on a physical description of the plant allows the quantification of the model uncertainty in terms of the physical parameters and the order. An LPV controller based on H_∞ control is then designed. This work extends recent results of other authors for LPV based on PID laws and the Muskingum model, by allowing the controller order to be imposed and by providing a direct link with physical parameters.

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CP22

Predetermined Time Constant Approximation for Model Identification Search Space Boundary by Standard Genetic Algorithm

A new predetermined time constant approximation (Tsp) method for optimising the search space boundaries for an optimal model is proposed and presented. Using the dynamic response period and desired settling time offered a better suggestion for initial Tsp values of the transfer function coefficients. Furthermore, an extension on boundaries derived from the initial Tsp values and the consecutive execution, brought the elite groups within feasible boundary regions for better exploration. This enhanced the locating of the optimal values of time constant for identified transfer function. The Tsp method is investigated on two processes; raw data of excess oxygen and a third order transfer function model with and without random disturbance. The simulation results assured the Tsp methods effectiveness and flexibility in assisting SGAs to find optimal transfer function model parameters in their explorations.

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CP22

Approximate Optimal Control in Feedback Form for Parabolic System with Quickly-Oscillating Coefficients

In this research, the optimal control in feedback form (synthesis) was found for linear-quadratic problem that consists of semi-defined performance criterion and a parabolic lumped control system with quickly-oscillating coefficients. The exact formula for the synthesis was found and its approximate form that lies in substitution of quickly-oscillating parameters with average and all infinite sums with finite was justified.
References: EGOROV, A. I. Optimal Control of Linear Systems. Kiev: Vishha shkola, 1988.

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CP22

Stabilization of Positive Infinite Dimensional Systems by State Feedback with Cone Constraints on the Inputs

For positive unstable infinite-dimensional linear systems, conditions are established for positive stabilizability and a method is described for computing a positively stabilizing state feedback, which guarantees that the stable closed loop dynamics are nonnegative for specific initial states. A feedback control is designed such that the unstable finite-dimensional spectrum of the dynamics generator is replaced by the eigenvalues of the stable input dynamics and such that the resulting input trajectory remains in an affine cone.

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CP22

Stability of the Axially Moving Kirchhoff String with the Sector Boundary Feedback Control

In this study, the stability problem for the axially moving Kirchhoff string with nonlinear boundary feedback control has been investigated. The proposed boundary control, which satisfies a sector constraint condition, is a negative feedback of the transverse velocity at the right end of string. Applying the integral-type multiplier method, the absolute stability of the axially moving Kirchhoff system is established. To validate the proposed theoretical results, numerical simulations are expressed by the finite element method.

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CP23

Convergence Analysis of Hybrid ACO/Nelder-Mead Tuning Method for PID Controller Structures with Anti-Windup

A statistical analysis of the system response quality found by Ant Colony Optimization (ACO) based algorithm with respect to search space discretization and the ants number is presented for tuning 4 nonlinear controller structures. The resulting sensitivity curves permit to determine ACO parameter values to initiate Nelder-Mead (NM) algorithm which has permitted to reduce the average computation time by up to 7 times for an equivalent quality response as compare to the previous ACO-NM algorithm.

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CP23

Optimal Control of Combined Chemotherapies in Phenotype-Structured Populations

We consider a system of two scalar integro-differential equations modelling a structured population for healthy and tumor cells under the effects of cytotoxic and cytostatic drugs. After having introduced the model and a natural optimal control problem, where the drugs are the controls to be optimized, we give numerical and analytical results.

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CP23

Simultaneous Null Controllability of a Semilinear System of Parabolic Equations

In this paper, we consider a coupled system of two semilinear heat equations. We prove the null controllability of the system with a finite number of contraints on the state. First, we show the equivalence with a null controllability problem with constrained control. The latter problem was solved in a previous work, mainly thanks to a crucial observability estimate. Then we use a fixed point theorem to achieve the result.

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CP23

The Ribosome Flow Model: Theory and Applications

The Ribosome Flow Model (RFM) is a nonlinear model describing the movement of ribosomes along the mRNA strand. We describe the analysis of the RFM using tools from systems and control theory including contraction theory, monotone systems theory, and convex analysis. Joint work with Tamir Tuller (Tel Aviv University) and Eduardo D. Sontag (Rutgers University).

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CP23

Studies on Epidemic Control in Structured Populations with Applications to Influenza

This work focuses on the dynamics and control of epidemics in age-structured populations over short timescales (i.e. single Influenza outbreaks). We study the impact of contact structure (i.e. who mixes with whom) and compare the results of a well known empirical study to results generated under the assumption of proportionate mixing. Finally, we use optimal control theory to identify solutions in the presence of limited vaccine resources.

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CP23

Adaptive Polynomial Identification and Optimal Tracking Control for Nonlinear Systems

The paper proposes an adaptive polynomial identifier and a robust nonlinear optimal tracking control scheme for polynomial systems. The identifier approximates an uncertain nonlinear system, where its parameters are on-line adapted

using a Kalman-Bucy filter. Then, based on the identifier an optimal tracking controller is synthesized, including an integral term to provide it robustness. The identification and control scheme is illustrated via simulations for the control of the blood glucose level in diabetic patients.

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CP24

Using Piecewise-Constant Congestion Taxing Policy in Repeated Routing Games

We consider repeated routing games with piecewise-constant congestion taxing in which a central planner sets and announces the congestion taxes for fixed windows of time in advance. Specifically, congestion taxes are calculated using marginal congestion pricing based on the flow of the vehicles on each road prior to the beginning of the taxing window. The piecewise-constant taxing policy in motivated by that users or drivers may dislike fast-changing prices and that they also prefer prior knowledge of the prices. We prove that the multiplicative update rule converges to a socially optimal flow when using vanishing step sizes. Considering that the algorithm cannot adapt itself to a changing environment when using vanishing step sizes, we propose using constant step sizes in this case. Then, however, we can only prove the convergence of the dynamics to a neighborhood of the socially optimal flow (with its size being of the order of the selected step size).

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CP24

Zero-Sum Stopping Games with Asymmetric Information

We study a model of a two-player, zero-sum, stopping game with asymmetric information. We assume that the payoff depends on two continuous-time Markov chains (X, Y), where X is only observed by player 1 and Y only by player 2, implying that the players have access to stopping times with respect to different filtrations. We show the existence of a value in mixed stopping times and provide a variational characterization for the value as a function of the initial distribution of the Markov chains. We also prove a verification theorem for optimal stopping rules in the case where only one player has information. (preprint: http://arxiv.org/abs/1412.1412)

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CP24

Generic Uniqueness of the Bias Vector of Mean-Payoff Zero-Sum Games

Under some ergodicity conditions, finite state space mean payoff zero-sum games can be solved using a nonlinear fixed point problem, involving a vector (bias or potential), which determines the optimal strategies. A basic issue is to check when the bias is unique. We show that this is always the case for generic values of the payments of the game. We also discuss the application of this result to the perturbation analysis of policy iteration.

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CP24

On Asymptotic Value for Dynamic Games with Saddle Point

We consider two-person dynamic games with zero-sum. We investigate the limit of value functions of finite horizon games with long run average cost as the time horizon tends to infinity, and the limit of value functions of discounted games as the discount tends to zero. Under quite weak assumptions on the game, we prove the Uniform Tauberian Theorem: existence of a uniform limit for one of the value functions implies the uniform convergence of the other one to the same limit. The key roles in the proof were played by Bellmans optimality principle and the closedness of strategies under concatenation.

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CP24

A Fractional Mean-Field Game: Existence, Uniqueness, and Fast Equilibrium Seeking Algorithm

In this work, we study a fractional mean-field game problem given by a fractional controlled state dynamics and payoff that measures the gap between a mean-field term and the fractional integral of the state. First, we prove that the problem is well-posed. Second, we show that, given the mean-field term, each decision-maker has a unique mean-field response in the space of square integrable functions. We show that a mean-field equilibrium exists and propose a fast learning algorithm that converges to mean-field equilibria.

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CP24

A Variational Approach to Second Order Mean Field Games with Density Constraints: the Stationary Case

In this work we study the existence of solutions of a stationary Mean Field Game (MFG) system with a density constraint on the distribution of the agents. We prove the existence of a solution for both, the subquadratic and the superquadratic cases. Our approach is based on the interpretation of the MFG system as the optimality condition of the optimal problem of a stationary Fokker-Planck equation. Using tools from convex analysis and some sharp results in the theory of elliptic equations with measure data, we derive first the optimality system for the qualified problem, i.e. when the Slater condition for the density constraint is satisfied. For non qualified problems, we proceed by using an approximation argument.

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CP25

Non-Commutative Least Mean Squares Estimators and Coherent Observers for Linear Quantum Systems

Quantum versions of control problems are often more difficult than their classical counterparts. To make further progress, new methods need to be devoloped to estimate the internal state of plants. In this talk, we consider plants whose internal states are governed by non-commutative linear quantum stochastic differential equations. We obtain non-commutative least mean squares estimators, and give conditions which make them physically realizable. Also, some algorithms for designing coherent quantum observers will be presented.

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CP25

Convergence of Caratheodory Solutions for Primal-Dual Dynamics in Constrained Concave Optimization

This paper characterizes the asymptotic convergence properties of the primal-dual dynamics to the solutions of a constrained concave optimization problem using classical notions from stability analysis. We motivate our study by providing an example which rules out the possibility of employing the invariance principle for hybrid automata to analyze the asymptotic convergence. We understand the solutions of the primal-dual dynamics in the Caratheodory sense and establish their existence, uniqueness, and continuity with respect to the initial conditions. We employ the invariance principle for Caratheodory solutions of a discontinuous dynamical system to show that the primal-dual optimizers are globally asymptotically stable under the primal-dual dynamics and that each solution of the dynamics converges to an optimizer.

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CP25

Analysis of Uncertain Systems to Compute Their Approximate Models

Mathematical modelling of practical available systems resulted in higher order models along with the uncertainty within making their study and analysis difficult. As a solution, emerged model order reduction. An effective procedure to derive a reduced model for an uncertain systems using Routh approximant is discussed here. The proposed methodology is an extension of an existing technique for continuous-time uncertain systems. The algorithm is justified and strengthened by various available examples from the literature.

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CP25

Time Averaged and Spatial Averaged Convergence for a Direct Coupled Distributed Coherent Quan-

tum Observer

This presentation considers the convergence properties of a distributed direct coupling quantum observer for a closed linear quantum system. The proposed distributed observer consists of a network of quantum harmonic oscillators and it is shown that the distributed observer converges in a time averaged sense in which each component of the observer estimates the specified output of the quantum plant. Simulation results also indicate that if the observer is suitably constructed then the spatial average of the observer outputs will converge to the plant variable of interest on a finite time interval.

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CP25

Model Calibration and Control Design in the Presence of Model Discrepancy

Measurement and model errors produce uncertainty in model parameters estimated through least squares fits to data or Bayesian model calibration techniques. In many cases, model errors or discrepancies are neglected during model calibration. However, this can yield nonphysical parameter values for applications in which the effects of unmodeled dynamics are significant. It can also produce prediction intervals that are inaccurate in the sense that they do not include the correct percentage of future observations. In this presentation, we discuss techniques to quantify model discrepancy terms in a manner that yields physical parameters and correct prediction intervals. We illustrate aspects of the framework in the context of distributed structural models with highly nonlinear parameter dependencies. Finally, we will discuss the impact of model discrepancy and uncertainty quantification on robust control design.

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CP25

Aircraft Preliminary Design Using Nonlinear Inverse Dynamics

The question: What shape should an aircraft have to give certain desirable properties? An answer is given by applying Nonlinear Inverse Dynamics. In general this approach is used to define flight trajectories calculations and flight control systems design. Nonlinear model matching is applied to obtain the preliminary design of aircraft. Given a set of customer flight specifications the parameters which define the shape and size of the required aircraft are determined.

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CP26

Extremum Seeking-Based Indirect Adaptive Control for Nonlinear Systems with State-Dependent Uncertainties

We study in this paper the problem of adaptive trajectory tracking for nonlinear systems affine in the control with bounded state-dependent uncertainties. We propose to use a modular approach, in the sense that we first design a robust nonlinear state feedback which renders the closed loop input to state stable (ISS) between an estimation error of the uncertain parameters and an output tracking error. Next, we complement this robust ISS controller with a model-free multiparametric extremum seeking (MES) algorithm to estimate the model uncertainties. The combination of the ISS feedback and the MES algorithm gives an indirect adaptive controller. We show the efficiency of this approach on a two-link robot manipulator example.

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CP26

Tracking Optimal Trajectories in the Restricted Three-Body Problem Using Lqr Feedback

Existing literature has presented optimal trajectories in the circular-restricted three-body problem (CRTBP) for ballistic capture and orbit transfers. However, there has been only a limited discussion thus far of how to stabilize such trajectories in the presence of noise; e.g. navigation errors, thrust resolution and misalignment. This work addresses stability concerns by introducing an LQR-based feedback strategy that tracks an optimal trajectory in the Earth-Moon system. Stability margins are assessed using Lyapunov-based methods.

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CP26

Predicting Time Series Outputs and Time-to-Failure for An Aircraft Controller Using Bayesian Modeling

The determination of system stability and time before loss of control (time-to-failure) is important for aircraft safety. We describe a hierarchical statistical model using Treed Gaussian Processes to predict stability, time-to-failure, and output time series. We first classify the data into success and failure, then use separate models for prediction. A basis representation for curves allows us to model variable length curves. We demonstrate our prediction method with a neuro-adaptive flight control system.

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CP26

Robust Regulation of Siso Systems: The Fractional Ideal Approach

We solve the robust regulation problem for single-input single-output plants by using fractional ideals and without using coprime factorizations. We are able to formulate the famous internal model principle in a form suitable for general factorizations. By using it we are able to give a necessary and sufficient solvability condition for the robust regulation problem, which leads to a design method for a robustly regulating controller. The theory is illustrated by examples.

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CP26

The Complexity of Uncertainty in Markov Decision Processes

We consider Markov decision processes with uncertain transition probabilities and two optimization problems in this context: the *finite horizon problem* which asks to find an optimal policy for a finite number of transitions and the *percentile optimization problem* for a wide class of uncertain Markov decision processes which asks to find a policy with the optimal probability to reach a given reward objective. To the best of our knowledge, unlike other optimality criteria, the finite horizon problem has not been considered for the case of bounded-parameter Markov decision processes, and the percentile optimization problem has only been considered for very special cases. We establish NP-hardness results for these problems by showing appropriate reductions.

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CP26

Finite Step Algorithms for the Solution of Robust Control Problems with Application to Hydraulic and Pneumatic Control Systems

In this paper a unification of robust control stabilizability algorithms solving many control problems will be presented. The convergence of the algorithm is guaranteed under solvability conditions depending upon the particular robust control problem. A main algorithm with minor modifications is presented for solving many robust control problems of linear systems with nonlinear uncertain structure, such as robust output asymptotic tracking or robust PID design. The main algorithm is based on the respective results of Hurwitz invariability (robust stabilizability) of uncertain gained controlled polynomials. The applicability of the proposed algorithms will be illustrated to various hydraulic and pneumatic uncertain systems such as hydraulic pneumatic actuators, hydraulic motors and pumps. The algorithms will be implemented in micro controller based platforms and PLC platforms providing a helpful tool for controlling many industrial processes. Acknowledgment This research has been co-financed by the European Union (European Social Fund ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) - Research Funding Program: ARCHIMEDES III. Investing in knowledge society through the European Social Fund. (ARCHIMEDES III-STRENGHTENING RESERCH GROUPS IN TECHNOLOGICAL EDUCATION, NSRF 2007-2015).

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CP27

A Decentralized Team Routing Strategy among Telecom Operators in an Energy-Aware Network

We consider a networking infrastructure, upon which various "large" users (e.g., Telecom Operators, data centers, etc.) have multiple paths to deliver an aggregated entry flow to a certain destination. The flow of each user can be split among the different paths that traverse energy-aware routers. The routers adopt a specific strategy to minimize the power–delay product for each link, which gives rise to quadratic link (in the aggregated link flows) cost functions. We seek person–by–person satisfactory (p.b.p.s.) strategies stemming from a team optimal control problem of the users. The team optimization problem is defined among Decision Makers (DMs – one for each user) that try to minimize a common aggregate cost function of their routes, each one acting solely on the basis of the knowledge of the amount of flow to be routed. We derive piecewise linear p.b.p.s. solutions, which are characterized by a set of parameters. The latter can be found by solving a set of nonlinear fixed point equations.

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CP27

Estimating the Relative Position of Mobile Agents on Jordan Curves from Ambiguous Proximity Data

We consider the problem of estimating the relative positions of an ensemble of agents, moving along a Jordan curve. When two of them get sufficiently close, they can measure their Euclidean distance. Based on the knowl-

edge of agent dynamics, a prediction-correction algorithm described is proposed to recursively estimate the relative position along the Jordan curve for each pair of agents. Exploiting these position estimates, decentralized formation control strategy can be implemented on the curve.

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CP27

An Inversion-Based Fault Reconstruction Approach in Nonlinear Systems

This paper presents an inversion-based fault reconstruction approach for a wide class of nonlinear systems subject to an actuator or plant fault. If the nonlinear system has finite relative order with respect to the fault signal, the inverse system as an observer-based filter, reproduces the fault at its output. A simulation for a continuous-stirred tank reactor (CSTR) model include flow rate fault is used to illustrate the effectiveness of the proposed method.

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CP27

Image Compression and Signal Transform Designs Based on Fast and Stable Discrete Cosine and Sine Transformation Algorithms

Discrete Fourier Transformation is engaged in image processing, signal processing, speech processing, feature extraction, convolution etc. In this talk we elaborate image compression results based on stable, fast, and recursive radix-2 Discrete Cosine Transformation (DCT) and Discrete Sine Transformation (DST) algorithms having sparse and orthogonal factors. We also propose signal transform designs constructed solely via variants of DCT and DST respect to decimation in time and frequency algorithms having sparse, orthogonal, rotation/rotation-reflection, and butterfly matrices.

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CP27

A Collocation Method for Zakai Equations

We propose a new numerical method for Zakai equations in nonlinear filtering. The method constructs a numerical solution by the quasi-interpolation in a recursive way. We provide the rigorous bound of the approximation error defined by Sobolev norm, which is consisting of the time-discretization errors and the interpolation ones that are accumulated over time steps.

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CP27

The Cauchy Attitude Estimator for Planetary Flyby in An Intense Radiation Background

There are many estimation problems where both impulsive measurement and/or process noise occurs. Handling outliers in the data has been a heuristic process. Recently, a recursive estimator for heavy tailed Cauchy probability density functions that model the measurement and process noise into a discrete-time linear system has been developed. This new scheme directly handles impulsive noise. In fact, for Cauchy noise, this estimator produces the conditional mean and is thereby a minimum variance estimator. To demonstrate the improvement that is obtained, this new estimator is applied to a planetary flyby, where the star-tracker measurements are impulsive due to the electromagnetic radiation characteristics of the planet.

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CP28

Metric Invariance Entropy and Conditionally Invariant Measures

A notion of measure-theoretic invariance entropy is constructed with respect to a conditionally invariant measure for control systems in discrete time. It is shown that the metric invariance entropy is invariant under conjugacies, the power rule holds, and the (topological) invariance entropy provides an upper bound.

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CP28

Controlling Spatiotemporal Chaos in Active Dissipative-Dispersive Nonlinear Systems

We develop a novel generic methodology for the stabilization and control of infinite-dimensional dynamical systems exhibiting low-dimensional spatiotemporal chaos. The methodology is exemplified with the generalized Kuramoto-Sivashinsky equation, the simplest possible prototype that retains that fundamental elements of any nonlinear process involving wave evolution. We show that with an appropriate choice of time-dependent feedback controls we are able to stabilize and/or control all stable or unstable solutions, including steady solutions, travelling waves and spatiotemporal chaos. We also show that the proposed methodology, appropriately modified, can be used to control the stochastic Kuramoto-Sivashinsky equation and related models.

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CP28

Optimal Control of Passive Particles Advected by Two-Dimensional Point Vortices

The objective of this work is to develop a mathematical framework for the modeling, control and optimization of dynamic control systems whose state variable is driven by interacting ODE's and PDE's, which should provide a sound basis for the design and control of new advanced engineering systems. We are applying necessary conditions of optimality to the two-dimensional incompressible Navier-Stokes flow, which can be reduced to a problem with ODE dynamics, by using vortex and multiprocess methods, to study the position of a particle subject to this flow.

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CP28

Optimal Control of Managed Aquifer Recharge (mar) From Infiltration Trenches With Objective of Minimal Waterlogging: Revisiting the Polubarinova-Kochina and Pontryagin Legacy

In MAR, surface water infiltration perturbs water table (moving free boundary). Three phases of transient MAR are analytically investigated using Green-Ampts ODE, Boussinesqs linearized PDE and Laplaces PDE with the volume of wetted soil at a specified instance and free surface depth above substratum as criteria. Hydrogeological parameters and total annual volume of injected water are constraints. The controls are: time schedule, filling depth-size-shape of trench, number of trenches. Optimal MAR scenarios are found.

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CP28

Subdifferential Inclusions and Tracking Problems

The evolution of the state of a system can be usually described by a differential inclusion

$$x'(t) \in F(t, x(t)). \tag{2}$$

Moreover, in many systems admissible states have to satisfy additional viability constraints

$$x(t) \in K(t) \tag{3}$$

where $K(\cdot)$ is a family of moving subsets (a *tube*). In this lecture we address a control problem that concerns (2)-(3). In fact, given an initial state x_0, we are interested in finding a control $u(t)$ such that there exits (at least) a solution of

$$\begin{cases} x'(t) \in u(t) + F(t, x(t)) \\ x(0) = x_0 \end{cases} \tag{4}$$

reaching the tube $K(\cdot)$ at a finite time t^* and remaining thereafter, that is, such that (3) is satisfied whenever $t \geq t^*$.

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CP28

Swirling Flow Stabilisation and the KdV Equation

Asymptotic analysis of swirling flow through a pipe leads to the Korteweg de Vries equation. We discuss what this tells us about the stability of the flow and what it suggests about ways to stabilise the flow.

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MS1

Dynamic Programming in Mathematical Finance

Mathematical Finance has introduced new type of stochastic control problems. In this context, the martingale method has been used to solve them. This gives the impression that probabilistic techniques are the only way to obtain a solution. We want to show that purely analytical techniques can be used for the same result. Not only it is useful to have additional techniques, but also analytical techniques allow for more constructive solutions. In particular, one does not need to rely on the martingale representation theorem to construct optimal stochastic controls. We will discuss the concepts and the main techniques. Two models will be considered, the classical consumer-investor model and a model describing the choice of projects for an entrepreneur. A credit risk problem will be solved in this framework. Do not include references or citations separately at the end of the abstract. Instead, all citations must be in text in the general form [Authorname, Title, etc]

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MS1

Optimal Control of Piecewise Deterministic Markov Processes

The main goal of this talk is to study the infinite-horizon expected discounted continuous-time optimal control problem of piecewise deterministic Markov processes (PDMPs) with the control acting continuously on the jump intensity λ and on the transition measure Q of the process but not on the deterministic flow ϕ. The set of admissible control strategies is assumed to be formed by policies, possibly randomized and depending on the past-history of the process, taking values in a set valued action space. We provide sufficient conditions based on the three local characteristics of the process ϕ, λ, Q, and the semi-continuity properties of the set valued action space, to guarantee the existence and uniqueness of the integro-differential optimality equation (the so called, Bellman-Hamilton-Jacobi equation) as well as the existence of an optimal (and δ-optimal, as well) deterministic stationary control strategy for the problem.

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MS1

Controlling Lvy Processes by Absolutely Continuous Processes

Given a spectrally negative Lévy process in the real line, we consider the problem of controlling its direction (and intensity) using in an additive way absolutely continuous processes, adapted to the information generated by the Lévy process. Using the fluctuation theory of processes, it is possible to describe the functional that we aim to minimize in terms of the scale function associated with the process, and prove that an optimal solution has a refracted form, described in terms of the frontier of some set.

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MS1

A Measure Approach for Continuous Inventory Models: Long-Term Average Criterion

This paper examines a single-item inventory process, modelled by a one-dimensional SDE, which incurs long-term average costs. The manager may increase the current inventory level but not reduce the inventory level. This paper provides minimal conditions which imply that an optimal ordering policy exists in the class of (s, S) processes. The value is obtained over a restricted class of policies and then shown to be optimal in general. Both linear and nonlinear optimization is involved.

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MS2

Reference Tracking of Depth of Anesthesia Using Optimal Control

Optimal control theory has gained increasing importance in biomedical applications, e.g., in the automatic administration of anesthetics during general anesthesia. One example of a monitored state is the depth of anesthesia, which is usually achieved by the joint administration of hypnotics and analgesics. This state is quantified by the bispectral index (BIS) that varies between 97.7% and 0%. On the other hand, the amount of drug to be administered should be optimized both for patient health and for economical reasons. This motivates the use of optimal control in this field of application. In this contribution a static state-feedback control law is considered. In order to determine a suitable feedback gain, a nonlinear optimal control problem (OCP) is formulated and solved using direct methods. These methods have become increasingly useful when computing the numerical solution of the OCP. Moreover, they are known to provide a very robust and general approach.

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MS2

Identification of the Fragmentation Role in the Amyloid Assembling Processes and Optimization of Current Amplification Protocols

The goal is to establish a kinetic model of amyloid formation which will take into account the contribution of fragmentation to the de novo creation of templating interfaces. We propose a new, more comprehensive mathematical model which takes into account previously neglected phenomena potentially occurring during the templating and fragmentation processes. In particular, we try to capture a potential effect of the topology and geometry of prion folding on the elongation and fragmentation properties of a polymer of a given length by separating polymers of the same length into several compartments. Additionally, we apply techniques from geometric control to the new model to design optimal strategies for accelerating the current amplification protocols, such as the Protein Misfolding Cyclic Amplification (PMCA).

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MS2

Slow Invariant Manifold Reduced Models for Stiff Chemical Kinetics ODE in Optimal Control

Model reduction in the context of numerical optimal control using a multiple shooting approach is a useful way to decrease the computational complexity. Mathematical models for chemical kinetics based on stiff ordinary differential equations can often be reduced for example by using a trajectory-based optimization approach to compute a slow invariant manifold within the state space. This seems to be a profitable approach because on the one hand a optimal control problem has to be solved and on the other hand the model reduction is performed via optimization as well. As an example, we discuss the Michaelis-Menten enzyme kintetics in singularly perturbed form and demonstrate the applicability of our model reduction method for singularly perturbed optimal control problems.

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MS2

On the Significance of Singular Controls in Optimal Solutions to Biomedical Problems

Optimal control problems for mathematical models of biomedical problems often can be described by control-affine nonlinear systems with an L1-type objective. Typically the controls are bounded, for example as dose rates or concentrations of therapeutic agents in cancer treatments or as vaccination rates in epidemiology. In solutions, bang-bang controls represent administrations of agents at full dose with rest periods while singular controls typically are time-varying solutions at intermediate and thus lower than maximum dose values. There exists mounting medical evidence that "more is not necessarily better" in cancer treatments and this has generated significant research interest in what could be called the biologically optimal dose (BOD). From an optimization perspective, singular controls stand out as the prime candidates in this context. Although in few problems a full synthesis of optimal controlled trajectories can be established, it becomes of interest, both theoretically and from an application point of view, to analyze problems in which singular controls appear as extremals. In this talk, challenges related to finding optimal solutions, like establishing optimality of singular controls, bang-singular junctions and synthesis of controlled trajectories will be addressed. The connections between the types of solutions and medical concepts including metronomic chemotherapy, chemo-switch protocols and adaptive therapy will be discussed.

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MS3

Minimax Solutions for First Order Mean Field Games

We consider first order mean field game system with non-smooth Hamiltonian enjoying the sublinear growth. Proposed definition of minimax solution means that the graph of value function is viable under certain differential inclusion, when the measure on the state space is determined by a measure on the set of viable trajectories. We prove the existence theorem, and the consistency of minimax and classical solutions. Additionally, we construct a near-Nash equilibrium for finite-player game.

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MS3

Risk-Sensitive Optimal Control for Mean-Field Dynamics under Partial Observation

We establish a stochastic maximum principle (SMP) for control problems of partially observed diffusions of mean-

field type with risk-sensitive performance functionals.

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MS3

Mean Field Games: New Results and New Perspectives

Abstract not available.

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MS3

Mean Field Inspection Games

In this talk we present a new model of mean field inspection games with one major player and a large number of inspectees on a discrete state space.

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MS4

Optimal Control of Phase Field Equations with Dynamic Boundary Conditions

This talk deals with an optimal control problems for the Allen-Cahn equation with a nonlinear dynamic boundary condition involving the Laplace-Beltrami operator. The nonlinearities both in the bulk and on the boundary can be singular, i.e., they may range from the derivative of logarithmic potentials confined in $[-1, 1]$ to the subdifferential of the indicator function of the interval $[-1, 1]$ up to a concave perturbation. We first examine the case of logarithmic nonlinearities: in a recent paper by Colli and Sprekels the corresponding control problems were studied, and results concerning existence and first-order necessary and second-order sufficient optimality conditions were shown. Then, in the case of double obstacle potentials, a joint research with M. H. Farshbaf-Shaker and J. Sprekels focused on the "deep quench" approximation (i.e., approximating the indicator function by logarithmic nonlinearities) and led us to establish both the existence of optimal control and first-order necessary optimality conditions. Extensions of these results to the viscous Cahn-Hilliard and Cahn-Hilliard equation with dynamic boundary condition will be outlined.

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MS4

Optimal Control of the Cahn-Hilliard Variational Inequality

Abstract not available.

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MS4

Optimal Distributed Control of Nonlocal Cahn-Hilliard/Navier-Stokes Systems in 2D

In this talk, we report on joint work with S. Frigeri and E. Rocca (both WIAS Berlin). We study the distributed optimal control of nonlocal Cahn-Hilliard/Navier-Stokes systems in the two-dimensional case under box constraints for the controls. The nonlocal contribution to the chemical potential has the form of a convolution integral with an integral kernel having certain smoothness properties; for instance, potentials of Newton or Bessel type are admitted. Upon showing sufficiently strong regularity and stability properties for the solutions to the state system, the Frechet differentiability of the control-to-state mapping in suitable function spaces can be established, and first-order optimality conditions in terms of an adjoint System and a variational inequality can be derived.

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MS4

Optimal Control of Electromagnetic Fields Governed by the Full Time-Dependent Maxwell Equations

In this talk, we present recent results in the optimal control of the full time-dependent Maxwell equations. Our goal is to find an optimal current density and its time-dependent amplitude which steer the electric and magnetic fields to the desired ones. The main difficulty of the optimal control problem arises from the complexity of the Maxwell equations, featuring a first-order hyperbolic structure. We present a rigorous mathematical analysis for the optimal control problem. Here, the semigroup theory and the Helmholtz decomposition theory are the key tools in the analysis. Our theoretical findings include existence, strong regularity, and KKT theory. The corresponding optimality system consists of forward-backward Maxwell equations for the optimal electromagnetic and adjoint fields, magnetostatic saddle point equations for the optimal current density, and a projection formula for the optimal time-dependent amplitude. A semismooth Newton algorithm in a function space is established for solving the nonlinear and nonsmooth optimality system. The paper is concluded by numerical results, where mixed finite elements and Crank-Nicholson schema are used.

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MS5

Some Results on the Stability of 1-D Nonlinear Hyperbolic Systems on a Finite Interval

This talk deals with the control of systems modeled by hyperbolic systems in one space dimension. These systems appear in various real life applications (navigable rivers and irrigation channels, heat exchangers, plug flow chemical reactors, gas pipe lines, chromatography,...). On these systems we show methods to construct stabilizing feedback laws. We also show the importance of the choice of functional spaces for the stabilization issue in the nonlinear case.

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MS5

Performance Estimates for Model Predictive Control of Pdes

Model Predictive Control (MPC) is a control technique which synthesizes an infinite horizon control function from pieces of finite horizon optimal control functions. It can thus be seen as a model reduction technique in time. Often, the goal of MPC is to obtain a tracking control steering the system state to a desired reference. In this talk, we explore for various types of PDEs how the cost functional in the finite horizon PDE optimization in the MPC scheme must be chosen in order to obtain the desired tracking behaviour and good performance in the sense of an infinite horizon objective.

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MS5

Optimal Control for the Wave Equation: Infinite Versus Finite Horizon

We consider a vibrating string that is fixed at one end with Neumann control action at the other end. We study a problem of optimal control where the deviation from the desired state is penalized on the whole time interval and analyze the asymptotic properties as the time horizon tends to infinity. Due to the structure of the objective function, most of the optimal control action is concentrated at the beginning of the time interval.

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MS5

PBDW: Real-Time State Estimation for Parametrized PDEs

We present the parametrized-background data-weak (PBDW) formulation, a real-time and in-situ data assimilation (state estimation) framework for physical systems modeled by parametrized PDEs. The formulation addresses anticipated uncertainty through a background (prior) space associated with the parametrized PDE, incorporates unanticipated uncertainty through a representation update space, identifies stability-informed choices of experimental observations, and incorporates elements of model reduction to provide real-time computational efficiency. We demonstrate the effectiveness of the formulation using a real physical system.

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MS6

Output Regulation for Linear Hybrid Systems with Unpredictable Jumps: the Case with Dwell Time

The problem of output regulation for hybrid systems having linear flow and jump maps is considered, under the assumption that the relevant time domain satisfies a dwell time condition but is otherwise unknown. A characterization of the steady-state motions achieving regulation is provided in terms of hybrid generalizations both of the invariant subspace algorithm and of the Francis equations. The two proposed approaches are compared, and relations with the case without dwell time are highlighted.

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MS6

Stabilization of Switched Affine Systems by Means of State Dependent Switching Laws

This presentations addresses the stabilization problem for a class of switched affine systems. Qualitative conditions for the existence of stabilizing switching laws dependent on the systems state will be presented. The proposed methodology is based on the use of an equivalent bilinear model of the original switched system. Furthermore, constructive conditions for local stabilization will presented by emulating locally classical controllers. The proposed conditions can be easily reformulated as numerically tractable linear matrix inequalities.

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MS6

Geometric Methods for Switching Systems

This contribution reviews the basic aspects of the geometric approach to control and regulation problems in linear switching systems. It is shown that the geometric approach provides tools and methods for characterizing, in a structural sense, the solvability of non interacting control problems, as well as of regulation problems, for different classes of switching systems. Both the cases in which the switching signal is measurable and that in which it is not measurable are considered.

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MS6

Stability Issues in Disturbance Decoupling for Switching Linear Systems

Disturbance decoupling – i.e., the problem of making the output insensitive to undesired inputs – is a classical problem of control theory and a main concern in control applications. Hence, it has been solved for many classes of dynamical systems, considering both structural and stability requirements. As to decoupling in linear switching systems, several stability formulations apply. The aim of this contribution is pointing out different definitions of stability and devising corresponding synthesis algorithms.

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MS7

Max-Plus Fundamental Solution Semigroups for Optimal Control Problems

Recent work concerning the development of fundamental solution semigroups for specific classes of optimal control and related problems is unified and generalized. By exploiting max-plus linearity, semiconvexity, and semigroup properties of the corresponding dynamic programming evolution operator, two types of max-plus fundamental solution semigroup are presented. These semigroups, referred to as max-plus primal and max-plus dual space fundamental solution semigroups (respectively), consist of horizon indexed max-plus linear max-plus integral operators. They facilitate the propagation of value functions, and hence the solution of Hamilton-Jacobi-Bellman equations, to longer time horizons via max-plus convolutions. Their application to specific classes of optimal control problem is also summarised.

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MS7

On Average Control Generating Families for Singularly Perturbed Optimal Control Problems

It is known that, under certain conditions, the dynamics of the slow components of a singularly perturbed (SP) control system is approximated by solutions of the averaged system, in which the role of controls is played by measure-valued functions. A family of controls and the corresponding solutions of the fast subsystem is called average control generating (ACG) if it generates a state-control trajectory of the averaged system. We will state sufficient and necessary conditions of optimality of ACG families in problems of optimal control considered on the solutions of the averaged system, and we will discuss a linear programming based approach to numerical construction of near optimal ACG families. The theoretical results will be illustrated with numerical examples.

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MS7

High-Order Schemes for Stationary Hamilton-Jacobi-Bellman Equations

In this talk we consider stationary Hamilton-Jacobi-Bellman equations related to infinite horizon optimal control problems or dynamic games. Our goal is to solve these equations numerically using semi-Lagrangian schemes with high-order discretization in space. While for low order discretizations monotonicity ensures convergence of the value iteration, i.e., termination of the numerical computation, this is in general no longer the case for high-order methods. Main contribution of the talk is to show how ε-monotonicity can be used in order to re-establish convergence and to present a selection of high-order schemes to which this theory applies.

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MS7

Deterministic Control of Randomly-Terminated Processes

We will describe an efficient (noniterative) numerical method for a class of static HJB problems with free boundary. Such equations arise in optimal control of deterministic-up-to-termination finite-horizon processes, when the terminal time T is an exponentially distributed random variable. A part of this talk will be based on joint work with J. Andrews.

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MS8

Reconstruction of Independent Sub-Domains for a Class of Hamilton-Jacobi Equations and Application to Parallel Computing

A previous knowledge of the domains of dependence of a Hamilton-Jacobi equation can be useful in its study and approximation. Information of this nature is, in general, difficult to obtain directly from the data of the problem. In this talk we introduce formally the concept of *independent sub-domain* discussing its main properties and we provide a constructive implicit representation formula. Using such results we propose an algorithm for the approximation of these sets that is shown to be relevant in the numerical resolution via parallel computing.

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MS8

Dynamic Programming for Path-Dependent Deterministic Control and Idempotent Expansion Methods

It is often seen in control problems that the status of a system is affected by not only a current state but also a past history of a trajectory. In this presentation, we will talk about dynamic programming arguments for optimal deterministic control under path-dependent dynamics and costs. We show that the path-dependent continuous-time value function defined on an infinite-dimensional space can be approximated by time-discretized path-dependent value functions which, on the other hand, are given on finite-dimensional spaces. To compute the discrete-time path-dependent value function, we use idempotent expansion methods. We will discuss particular cases where idempotent expansions work.

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MS8

Staticization and Associated Hamilton-Jacobi and Riccati Equations

The use of stationary-action formulations for dynamical systems allows one to generate fundamental solutions for classes of two-point boundary-value problems (TPBVPs). One solves for stationary points of the payoff as a function of inputs, a task which is significantly different from that in optimal control problems. Both a dynamic programming principle (DPP) and a Hamilton-Jacobi partial differential equation (HJ PDE) are obtained for a class of problems subsuming the stationary-action formulation. Although convexity (or concavity) of the payoff may be lost as one propagates forward, stationary points continue to exist, and one must be able to use the DPP and/or HJ PDE to solve forward to such time horizons. In linear/quadratic models, this leads to a requirement for propagation of solutions of differential Riccati equations past finite escape times.

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MS8

On the Use of Non-Stationary Policies for Stationary Infinite-Horizon Markov Decision Processes

We consider infinite-horizon stationary γ-discounted Markov Decision Processes, for which it is known that there exists a stationary optimal policy. Using Value and Policy Iteration with some error ϵ at each iteration, it is well-known that one can compute stationary policies that are $\frac{2\gamma}{(1-\gamma)^2}\epsilon$-optimal. After arguing that this guarantee is tight, we develop variations of Value and Policy Iteration for computing non-stationary policies that can be up to $\frac{2\gamma}{1-\gamma}\epsilon$-optimal.

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MS9

Yield-Analysis of Different Coupling Schemes for Interconnected Bio-Reactors

Bio-chemical reaction networks are more and more adapted to be used for the production of fine chemicals. Due to the appearance of intermediate species which influence the single reaction steps, a single compartment approach for the implementation of such a reaction may not be optimal. Multi-compartment approaches however might have the potential to increase the yield of desired product if the coupling of the compartments is chosen appropriately. A model based approach is presented to identify and analyze such coupling schemes for a specific enzyme cascade as an example system.

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MS9

A Simulation-based Approach for Solving Optimisation Problems with Steady State Constraints

Ordinary differential equations (ODEs) are widely used to model biological, (bio-)chemical and technical processes. The parameters of these ODEs are often estimated from experimental data using ODE-constrained optimisation. This article proposes a simple simulation-based approach for solving optimisation problems with steady state constraints. This simulation-based optimisation method is tailored to the problem structure and exploits the local geometry of the steady state manifold and its stability properties. A parameterisation of the steady state manifold is not required. We prove local convergence of the method for locally strictly convex objective functions. Efficiency and reliability of the proposed method are demonstrated in two examples.

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MS9

A Control Theory for Stochastic Biomolecular Regulation

The tight regulation of the abundance of cellular constituents in the noisy environment of the cell is a critical requirement for several biotechnology and therapeutic applications. Here we present elements of a new regulation theory at the molecular level that accounts for the noisy nature of biochemical reactions and provides tools for the analysis and design of robust control circuits at the molecular level. Using these ideas, we propose a new regulation motif that implements an integral feedback strategy that robustly regulates a wide class of reaction networks. Tools from probability and control theory are then used to show that the proposed control motif preserves the stability of the overall network, while steering the population of any regulated species to a desired set point.

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MS10

Impulse Control of Non-Uniformly Ergodic Processes with Average Cost Criterion

We study a problem of impulse control of a Markov process that maximises the average cost per unit time criterion:

$$\liminf_{T\to\infty} \frac{1}{T} E^x \bigg\{ \int_0^T f(X_s)ds - \sum_{i=1}^{\infty} 1_{\tau_i \le T} c(X_{\tau_i -}, \xi_i) \bigg\},$$

where f is a running reward and $c \geq 0$ is an impulse cost. We characterise optimal strategies via a solution to an auxiliary Bellman equation. The novelty of the paper is a general treatment of models in which (X_t) is supported on unbounded space and not uniformly ergodic. Our results have applications in balancing of energy systems and in managing inventories. Based on a joint work with Łukasz Stettner.

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MS10

Ergodic Stopping Problems

The lecture is devoted stopping problems of Markov processes with functional without discount rate. We show continuity of the value function and existence of optimal stopping time. For this purpose we have to impose various ergodic conditions on Markov processes. In general we are interested in the case when we don't have uniform ergodicity. We show the above results under different sets of assumptions and consider also the case with general discount rate. The talk is based on a joint paper with J. Palczewski.

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MS10

A Measure Approach for Continuous Inventory Models: Discounted Cost Criterion

This paper examines a single-item inventory process, modelled by a one-dimensional SDE, which incurs discounted costs. The manager may increase the current inventory level but not reduce the inventory level. This paper provides very minimal conditions which imply that an optimal ordering policy exists in the class of (s, S) processes. The stochastic problem is imbedded in two different linear programs over a space of measures. The ultimate solution relies on duality theory in linear programming.

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MS10

Representation Formulas for Solutions of Isaacs Integro-PDE and Construction of Almost Optimal Strategies

We will present sub- and super-optimality inequalities of dynamic programming for viscosity solutions of Isaacs integro-PDE associated with two-player, zero-sum stochastic differential game driven by a Lévy type noise. This implies that the lower and upper value functions of the game satisfy the dynamic programming principle and they are the unique viscosity solutions of the lower and upper Isaacs integro-PDE. Our method uses PDE techniques and is based on regularization of viscosity sub- and super-solutions of Isaacs equations to smooth sub- and super-solutions of slightly slightly perturbed equations, and approximate optimal synthesis. It is constructive and provides a fairly explicit way to produce almost optimal controls and strategies.

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MS11

Viability Radius and Robustness for a class of Linear Systems

We consider the problem of robust viability and viability radius for a class of linear disturbed systems. The problem consists in the determination of the smallest disturbance f, for which a given viable state z_0 do not remains viable. We also consider the problem of the determination of the smallest disturbance f for which the viability set $Viab^f_{\mathcal{K}}$ is empty, which we call the Minimal Lethal Disturbance (MLD). This work is motivated by the problem of Minimal Lethal Dose in toxicology.

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MS11

Constrained Optimal Control of Bilinear Systems: Application to An HVAC System

We investigate the constrained optimal control problem of bilinear systems. We minimize a quadratic cost functional over a set of admissible controls given by $U_{ad} = \{u \in L^2(0,T,R^m) \ : \ u_{min} \leq u \leq u_{max}$ and $\alpha \leq \langle v,u\rangle_{L^2(0,T,R^m)} \leq \beta\}$, using functional analysis tools. We develop algorithms that allow to compute the optimal control, and we apply our approach to an HVAC (Heating Ventilating and Air Conditioning) system, where the total consumed energy must not exceed a given ceiling.

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MS11

A Viability Analysis for Structured Model of Fishing Problem

In this work we study a structured fishing model, basically displaying the two stages of the ages of a fish population, which are in our case juvenile, and adults. We associate to this model two constraints: one of ecological type ensuring a minimum stock level, the other one of economic type ensuring a minimum income for fishermen. The analytical study focuses on the compatibility between the state constraints and the controlled dynamics. Using the mathematical concept of viability kernel, we define a set of constraints combining the guarantee of consumption and a stock of resources to be preserved at all times.

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MS11

A Viability Analysis of Fishery Controlled by Investment Rate

This work presents a stock/effort model describing both harvested fish population and fishing effort dynamics. The fishing effort dynamic is controlled by investment which corresponds to the revenue proportion generated by the activity. The dynamics are subject to a set of economic and biological state constraints. The analytical study focuses on the compatibility between state constraints and controlled dynamics. By using the mathematical concept of viability kernel, we reveal situations and management options that guarantee a sustainable system.

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MS12

Dynamic Programming Using Radial Basis Functions

We propose a discretization of the time-discrete Hamilton-Jacobi-Bellman equation in optimal control in space by radial basis functions in combination with a moving least squares projection type operator (aka 'Shepards method').

We show convergence of the associated fixed point iteration, demonstrate the simplicity of the implementation by a corresponding Matlab code and present several numerical experiments from optimal control.

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MS12

A Spectral Assignment Approach for the Graph Isomorphism Problem

In this presentation, we will propose a heuristic for the graph isomorphism problem that is based on the eigendecomposition of the adjacency matrices. If the graphs possess repeated eigenvalues, which typically correspond to graph symmetries, finding isomorphisms is challenging. By repeatedly perturbing the adjacency matrices, it is possible to break symmetries of the graphs without changing the isomorphism. This heuristic approach can be used to construct a permutation which transforms G_A into G_B.

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MS12

Graphical Model Based Representation of Dynamical Systems

Bayesian Networks are widely used to characterize the joint dependence between random variables in multivariate problems due to their compactness and availability of efficient learning/ inference algorithms. This talk highlights the incorporation of deterministic relations, which may either be learned or explicitly embedded, within the framework of Bayesian networks to improve model fidelity while reducing complexity. Further, we motivate the need of this work by presenting concrete practical examples from engineering domain.

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MS12

From Geometry to Topology in Mobile Robotics: Localization and Planning

In this talk, I will provide an overview of some recent work on localization and planning for mobile agents in a unknown/partially known environment using qualitative information abstracted from dense metric data. By modeling the problem from a topological perspective and using recent advances in the area of algebraic topology, we will derive methods for localization as well as planning strategies.

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MS13

Discrete-time Control for Systems of Interacting Objects with Unknown Random Disturbance Distributions: A Mean Field Approach

We are concerned with stochastic control systems composed of a large number N of interacting objects sharing a common environment. The dynamic of each object is determined by a stochastic difference equation, where the random disturbance density is unknown to the controller. The system is modeled as a Markov control process and is analyzed according to the mean field theory. Then, combining the mean field limit with a suitable statistical estimation method of the density, we construct control policies which are nearly asymptotically optimal for the N-system, under a discounted optimality criterion.

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MS13

Stationary Almost Markov Perfect Equilibria in Discounted Stochastic Games

We study discounted stochastic games with Borel state and compact action spaces depending on the state variable. The transition probability is a convex combination of finitely many probability measures depending on states and it is dominated by some finite measure on the state space. Our main result establishes the existence of subgame perfect equilibria, which are stationary (the equilibrium strategy is determined by a single function of the current and previous states of the game).

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MS13

On Risk Processes Controlled by Investment and Reinsurance

This contribution investigates insurance models for which the risk/reserve process can be controlled by reinsurance and investment in the financial market. Assuming that the company can control its wealth process over time in two different ways: the reinsurance level and the amount of capital invested in the risky asset, the main objectives of these works are to search the probability that the company eventually becomes insolvent. A recent innovative approach uses continuous time Semi-Markov processes to unify the time of events that produce changes in the risk process, say claim arrivals and price changes of the risky asset. Additional capital injection elements may be considered by the company in order to maintain its wealth over a desired level. The finite horizon problem is faced and partial solutions are presented.

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MS13

On the Vanishing Discount Factor Approach for Markov Decision Processes with Weakly Continuous Transition Probabilities

This note deals with average cost Markov decision processes with Borel state and control spaces, possibly unbounded costs and non-compact action subsets, and weak continuous transition law. Based on recent results of Feinberg, Kasyanov and Zadoianchuk (MOR 37, 591-607, 2012), this note provides an elementary proof of the existence of average cost optimal stationary policies using the vanishing discount factor approach.

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MS14

Non-degenerate Forms of the Extended Euler-Lagrange Condition for State Constrained Optimal Control Problems

We consider state constrained optimal control problems in which the dynamic is represented in terms of a differential inclusion, and the state and the end-point constraints are closed sets. We shall discuss simple examples which illustrate how the interplay among the state constraint, the left-end point constraint and the velocity set might influence the possibility to apply the necessary conditions for optimality in the non-degenerate form. We show that this is actually a common feature for general state constrained optimal control problems.

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MS14

Analytical Study of Optimal Control Intervention Strategies for Ebola Epidemic Model

Abstract not available.

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MS14

Budget-Constrained Infinite Horizon Optimal Control Problem

In this talk a class of infinite horizon optimal control problems with an isoperimetric constraint, also interpreted as a budget constraint, is considered. The problem setting includes a weighted Sobolev space as the state space. We investigate the question of existence of an optimal solution and establish a Pontryagins Type Maximum Principle as a necessary optimality condition including a transversality condition. Which influence the isoperimetric constraint may have on the feasible set and on the existence of an optimal solution is illustrated in details on examples.

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MS14

Optimal Control of Epidemiological Seir Models with L1-Objectives and Control-State Constraints

Optimal control is an important tool to determine vaccination policies for infectious diseases. For diseases transmitted horizontally, SEIR compartment models have been used. Most of the literature on SEIR models deals with cost functions that are quadratic with respect to the control variable, the rate of vaccination. In this paper, we consider L1-type objectives that are linear with respect to the control variable. Various pure control, mixed control–state and pure state constraints are imposed. For all constraints, we discuss the necessary optimality conditions of the Maximum Principle and determine optimal control strategies that satisfy the necessary optimality conditions with high accuracy. Since the control variable appears linearly in the Hamiltonian, the optimal control is a concatenation of bang-bang arcs, singular arcs and boundary arcs. For pure bang-bang controls, we are able to check second-order sufficient conditions.

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MS15

Robust Mean-Field Games to Model Emulation in Opinion Dynamics

Abstract not available.

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MS15

Monotonicity Methods for Mean-Field Games

Abstract not available.

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MS15

Continuous Time Mean Field Consumption-Accumulation Modeling

We consider continuous time mean field consumption-accumulation games. The capital stock evolution of each agent is based on the Cobb-Douglas production function and takes into account stochastic depreciation. The individual HARA-type utility depends on both the own consumption and relative consumption. We analyze the fixed point problem of the mean field game. The individual strategy is obtained as a linear feedback with the gain reflecting the collective behaviour of the population.

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MS15

The Evolutionary Game of Pressure and Resistance

We extend the framework of evolutionary inspection game (put forward recently by the authors and his co-workers) to a large class of conflict interactions between a major player and a large group of small players. The results are applied to the analysis of the processes of inspection, corruption, cyber-security, counter-terrorism, epidemiology, interaction of humans with their environment and many other. The contribution will develop the ideas expressed in the author's preprint 'The evolutionary game of pressure (or interference), resistance and collaboration' (2014), http://arxiv.org/abs/1412.1269

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MS16

Numerics and Optimal Control for Phase-Field Models of Multiphase Flow

Flow of mixtures of incompressible fluids with complex fluid interactions (surface tensions, contact angles) can be described by a system of (multicomponent) Cahn-Hilliard-Navier-Stokes equations. We propose finite element based numerical approximations of non-smooth phase-field models for mixtures of incompressible fluids with variable densities and viscosities. We discuss theoretical and practical issues related to the proposed numerical approximations. We also discuss numerical approaches for optimal control of the models.

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MS16

Model Predictive Control of Two-Phase Flow Using a Diffuse-Interface Approach

We present a nonlinear model predictive control framework for closed-loop control of two-phase flows. The fluid is modeled by a thermodynamically consistent diffuse interface model proposed in [H. Abels, H. Garcke, G. Grün, Thermodynamically consistent, frame indifferent diffuse interface models for incompressible two-phase flows with different densities, M3AN, 22(3), 2012] and allows for fluids of different densities and viscosities. We adapt the concept of instantaneous control to construct finite dimensional closed-loop control strategies for two-phase flows. We provide numerical investigations which indicate that finite dimensional instantaneous control is well suited to stabilize two-phase flows.

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MS16

Drag Optimisation in a Stationary Navier-Stokes Flow Using a Phase Field Approach

We present a phase field formulation for boundary objective functionals in shape optimisation with stationary Navier-Stokes flow. With an additional Ginburg-Landau regularisation, we prove existence of a minimiser and derive first order necessary optimality conditions for a general functional. The same results can be deduced for the drag functional, and via a formal asymptotic analysis, we show that the sharp interface description of the drag optimisation problem can be recovered from the phase field model.

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MS16

Optimal Control of a Semidiscrete Cahn-Hilliard/Navier-Stokes System with Variable Densities

In this talk we consider a time discretization of the Cahn-Hilliard/Navier-Stokes system with variable densities by Abels-Garcke-Grün and study an associated optimal control problem. It focus is on the non-smooth double-obstacle potential and distributed control action. Existence of minimizers are shown and first-order optimality conditions are derived by a Yosida type approximation. The resulting stationarity system corresponds to a function space version of C-stationarity.

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MS17

Feedback Control of Vortex Shedding Using Interpolatory Model Reduction

We demonstrate the linear feedback control of vortex shedding in flows with one or two circular cylinders where rotation is used as the actuation mechanism. Reduced-order models of the linearized system are computed using interpolatory model reduction and the computed feedback control laws are shown to be effective in stabilizing both steady-state and time-averaged flows for low-Reynolds number flows. The feedback control designs are also used to determine the effective placement of sensors.

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MS17

Model Reduction Based Feedback Control of the Monodomain Equations

Optimal control of reaction-diffusion systems arising in electric cardiophysiology has become an important research topic. The monodomain equations represent a reasonably accurate model for the electric potential of the human heart. In view of terminating cardiac arrhythmia, feedback methodologies are of particular interest. In this talk, it is shown that the PDE-ODE structure of the linearized monodomain equations leads to a system that is not null controllable but that can still be stabilized by finite dimensional controllers. This allows for constructing the controller based on model reduction techniques. While the reduced model is obtained from the linearized system, it is shown that it locally stabilizes the nonlinear system as well.

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MS17

Balanced POD Model Reduction for Parabolic PDE Systems with Unbounded Input and Output Operators

Balanced POD is a data-based model reduction algorithm that has been widely used for linearized fluid flows and other linear parabolic PDE systems with inputs and outputs. We consider balanced POD algorithms for such systems when the input and output operators are unbounded, as can occur when control actuators and sensors are located on the boundary of the physical domain. We discuss computational challenges, standard and modified algorithms, and convergence theory.

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MS17

Reduced-Order Surrogate Models for Closed-Loop Control

A stabilizing feedback control is computed for a semilinear parabolic PDE utilizing a nonlinear model predictive (NMPC) method. In each level of the NMPC algorithm the finite time horizon open loop problem is solved by a reduced-order strategy based on proper orthogonal decomposition. A stability analysis is derived for the combined algorithm so that the lengths of the finite time horizons are chosen in order to ensure the asymptotic stability of the computed feedback controls.

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MS18

Gamkrelidze-Like Maximum Principle for Optimal Control Problems with State Constraints

This report addresses necessary conditions of optimality for optimal control problem with state constraints in the form of the Pontryagin's Maximum Principle (MP). For such problems, these conditions were first obtained by R.V. Gamkrelidze in 1959 and subsequently published in the classic monograph by the four authors. His MP was obtained under a certain regularity assumption on the optimal trajectory. Somewhat later, in 1963, A.Ya. Dubovitskii and A.A. Milyutin proved another MP for problems with state constraints. In contrast with the MP of R.V. Gamkrelidze, this MP was obtained without a priori regularity assumptions, and, thereby, it degenerates in many cases of interest. Later, under an additional assumption of controllability of the optimal trajectory, other versions of the MP have been obtained so that they no longer degenerate. Here, we suggest a MP in a form close to the one proposed by R.V. Gamkrelidze but without any a priori regularity assumptions on the optimal trajectory. However, the absence of regularity assumptions does not ensure the nondegeneracy of this MP. Therefore, we prove that, under certain additional conditions of controllability relatively to the state constraints at the end-points, or regularity of the reference control process, degeneracy will not occur, since an appropriate non-triviality condition will be satisfied.

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MS18

Pontryagin Principle in Infinite-Dimensional Discrete-Times Problems

We present Pontryagin principle in infinite-dimensional infinite-horizon discrete-times optimal control for systems which are governed by difference equations or by difference inequations. We use techniques of optimization in Banach ordered spaces.

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MS18

The Euler Lagrange Equation and the Regularity of Solutions to Variational Problems

In this talk we will consider the problem of minimizing

$$\int_\Omega [L(\nabla v(x)) + g(x, v(x))]dx$$

with boundary conditions $v \in u^0 + W^{1,1}(\Omega)$ and, assuming a solution u to exist, we will focus on the problem of the validity of the Euler-Lagrange equation for the solution and on the main application of this equation, namely to prove the regularity of the solution itself. We will present an overview of the state of the art with respect to the validity of the Euler-Lagrange equation, as well as some recent results and some open problems. We shall then consider the problem of the regularity of the solution: we minimize an integral functional over a space of functions having first order weak derivatives and, under some reasonable conditions, it turns out the the solution has *second order* derivatives. We shall try to clarify the mechanism of this phenomenon and present some recent results in this direction.

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MS18

Subdifferentials of Nonconvex Integral Functionals in Banach Spaces: A Gelfand Integral Representation

We investigate subdifferential calculus for integral functionals on nonseparable Banach spaces. To this end, we present a new approach in which the Clarke and Mordukhovich subdifferentials of an integral functional are regraded as a Gelfand integral of the subdifferential mapping of an integrand. Main results are applied to stochastic DP with discrete time, and the differentiability of the value function is demonstrated without any convexity assumption.

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MS19

A Cubature Based Algorithm to Solve Decoupled McKean-Vlasov Forward-Backward SDEs

As shown by Carmona, Delarue and Lachapelle (2012), the solution of a Mean-Field Game problem (and also the one of the related optimization of McKean-Vlasov type dynamics problem) is linked to a system of forwardbackward stochastic differential equations with coefficients depending on the marginal distributions of the solutions. We call those types of equations McKean Vlasov Forward-Backward SDEs (MKV-FBSDE). In this talk, I will introduce an algorithm to solve decoupled MKV-FBSDEs, which appear in some stochastic control problems in a mean field environment. We will start by defining a deterministic algorithm to approximate weakly a MKV- Forward SDE, as an alternative to the usual approximation methods based on interacting particles. The algorithm is based on the cubature method of Lyons and Victoir (2004), and given enough regularity of the coefficients of the equation, it can be parametrized to obtain any given order of convergence. Then, we show how to construct implementable algorithms to solve decoupled MKV-FBSDEs. We give two algorithms and show that they have convergence of order one and two under appropriate regularity conditions. Finally, we proceed to illustrate our results by means of some numerical examples. This is a joint work with P.E. Chaudru de Raynal

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MS19

”Phase Diagram” of a Simple Mean Field Game

We present a detailed analysis about a simple mean field game model called “the seminar problem’ after [O. Gueant, J.-M. Lasry and P.-L. Lions, 2010]. This model is characterized by the fact that every agent optimizes his trajectory with respect to a simple random event (the seminar starting time) which derives from the collective behavior. In the mean field limit, this event becomes deterministic and a rather thorough understanding of the solutions can be achieved. In particular, for a sensible class of initial conditions, distinct behaviors can be associated to different domains of the parameter space.

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MS19

Mean Field Games Equilibrium in a SIR Vaccination Model

Recent debates concerning the innocuity of vaccines with respect to the risk of the epidemic itself lead to vaccination campaign failures. We analyze, in a SIR model, whether individuals driven by self interest can reach an equilibrium with the society. We show, in a Mean Field Games context, that an equilibrium exists and discuss the price of anarchy. Finally, we apply the theory to the 2009-2010 Influenza A (H1N1) vaccination campaign in France.

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MS19

Fokker-Planck Optimal Control Problems

The Fokker-Planck (FP) equations are partial differential equations describing the time evolution of the probability density function (PDF) of stochastic processes. These equations are of parabolic type corresponding to the PDF of Itō processes, and of hyperbolic type for the PDF of piecewise deterministic processes. For FP equations on bounded domains, we investigate the Chang-Cooper scheme for space discretization and first- and second-order backward time differencing. We prove that the resulting space-time discretization schemes are accurate, conditionally stable, conservative, and positivity-preserving. For the case of unbounded domains, the Hermite spectral discretization method is applied and analyzed as well. Next, two optimal control formulations based on the FP equations are discussed in order to control the corresponding PDFs. To approximate the solutions, the Hermite spectral discretization method is applied. Within the framework of Hermite discretization, we obtain sparse-band systems of ordinary differential equations. We analyze the accuracy of the discretization schemes by showing spectral convergence in approximating the state, the adjoint, and the control variables that appear in the FP optimality systems.

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MS19

On the Solvability of Risk-Sensitive Linear-Quadratic Mean-Field-Type Teams and Games

In this paper, we formulate and solve mean-field-type team and game problems described by a linear stochastic dynamics of McKean-Vlasov type and a quadratic or exponential-quadratic cost functional for each player. The optimal strategies of the players are given explicitly using a simple and direct method based on square completion and a Girsanov-type change of measure. This approach does not use the well-known solution methods such as the Stochastic Maximum Principle and the Dynamic Programming Principle. Sufficient conditions for existence and uniqueness of best response strategy to the mean of the state and the mean-field equilibrium, are provided.

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MS20

Long and Winding Central Paths

We disprove a continuous analog of the Hirsch conjecture proposed by Deza, Terlaky and Zinchenko, by constructing a family of linear programs with $3r + 4$ inequalities in dimension $2r + 2$ where the central path has a total curvature in $\Omega(2^r/r)$. Our method is to tropicalize the central path in linear programming. The tropical central path is the piecewise-linear limit of the central paths of parameterized families of linear programs viewed through logarithmic glasses.

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MS20

A Max-Plus Fundamental Solution Semigroup for a Class of Lossless Wave Equations

A new max-plus fundamental solution semigroup is presented for a class of lossless wave equations. This new semigroup is developed via formulation of the action principle as an optimal control problem for the wave equations of interest, followed by the construction of a max-plus fundamental solution semigroup for this optimal control problem using dynamic programming. An application of this semigroup to solving two-point boundary value problems is discussed via an example.

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MS20

Tropicalizing Semialgebraic Pivoting Rules, Or How to Solve Mean Payoff Games in Polynomial Time on Average

We introduce an algorithm which solves mean payoff games in polynomial time on average, assuming the distribution of the games satisfies a flip invariance property on the set of actions associated with every state. The algorithm is a tropical analogue of the shadow-vertex simplex algorithm, which solves mean payoff games via linear feasibility problems over the tropical semiring. The proof relies on the observation that certain semi-algebraic pivoting rules can be tropicalized.

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MS20

On the Regulation Problem for Tropical Linear Event Invariant Dynamical Systems

Tropical linear event-invariant systems describe the firing dynamics for timed event graphs with fixed times. In this context, the regulation problem can be defined as the problem of controlling the inputs so a given specification, described by a semimodule, is achieved. It will be shown that, under some technical assumptions, this regulation problem can be reduced to a two-sided eigenproblem, which in turn can be solved using parametric mean payoff games.

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MS21

Modeling and Estimation in Control of Immune Response to BK Virus Infection and Donor Kidney in Renal Transplant Recipients

In this presentation we discuss the feedback control problem that results from the involuntary immune-suppression that is a standard therapy for organ transplant patients. We develop and validate with bootstrapping techniques a mechanistic mathematical model of immune response to both BK virus infection and a donor kidney based on known and hypothesized mechanisms in the literature. The model presented does not capture all the details of the immune response but possesses key features that describe a very complex immunological process. We then estimate model parameters using a least squares approach with a typical set of available clinical data. Sensitivity analysis combined with asymptotic theory is used to determine the number of parameters that can be reliably estimated given the limited number of observations.

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MS21

Sensitivity Analysis and Control in the Lamina Cribrosa

We discuss sensitivity analysis with respect to important biological parameters (Lame coefficients, intra-ocular pressure and retrolaminar tissue pressure) for a poroelastic model describing the lamina cribrosa in the eye. It is believed that the biomechanics of the lamina cribrosa plays an important role in the retinal ganglion cell loss in glaucoma. Our goal is to reveal which parameters are most influential and need to be controlled in order to prevent the development of glaucoma.

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MS21

Approximation Methods for Feedback Stabilization of Boussinesq Equations

Pure Dirichlet boundary control of thermal fluids systems leads to technical issues of control compatibility for 3D problems. In this paper we replace the pure Dirichlet problem with an approximating Robin boundary condition which eliminates the compatibility condition. We show the resulting Neumann/Robin boundary control problem is well posed and can be used to locally exponential stabilize the Boussinesq equations. Numerical results are given to illustrate the method and convergence of the approximation scheme.

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MS21

Control of the Cardiovascular-Respiratory System under External Perturbations

Exploiting the fact that in the combined cardiovascular-respiratory system the partial pressure of CO_2 in arterial blood is regulated to 40 mm Hg we present results on the reaction of the system to external perturbations using the Euler-Lagrange formulation of the corresponding optimal control problem. Numerical issues concerning stiffness of the resulting two-point boundary value problem will be discussed.

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MS22

Lookback Option Pricing for Regime-Switching

Jump Diffusion Models

We will introduce a numerical method to price the European lookback floating strike put options where the underlying asset price is modeled by a generalized regime-switching jump diffusion process. In the Markov regime-switching model, the option value is a solution of a coupled system of nonlinear integro-differential partial differential equations. Due to the complexity of regime-switching model, the jump process involved, and the nonlinearity, closed-form solutions are virtually impossible to obtain. We use Markov chain approximation techniques to construct a discrete-time Markov chain to approximate the option value. Convergence of the approximation algorithms is proved. Examples are presented to demonstrate the applicability of the numerical methods.

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MS22

Approximation of Basket CDS Price on Default Sensitive Regime Switching Model

In this work, we derive the sufficient conditions for the convergence of the approximation of the basket CDS price via the weak convergence method. Particularly, the volatility of the underlying risk neutral price switches among finite many regimes driven by the default events occurred in the past.

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MS22

A Multi-Scale Approach to Limit Cycles with Random Perturbations Involving Fast Switching and Small Diffusion

This talk is devoted to multi-scale stochastic systems. The motivation is to treat limit cycles under random perturbations involving fast random switching and small diffusion, which are represented by the use of two small parameters. Associated with the underlying systems, there are averaged or limit systems. Suppose that for each pair of the parameters, the solution of the corresponding equation has an invariant probability measure $\mu^{\varepsilon,\delta}$, and that the averaged equation has a limit cycle in which there is an averaged occupation measure μ^0 for the averaged equation. Our main effort is to prove that $\mu^{\varepsilon,\delta}$ converges weakly to μ^0 as $\varepsilon \to 0$ and $\delta \to 0$ under suitable conditions. We also examine application to a stochastic predator-prey model. Moreover, some numerical examples will also be reported.

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MS22

An Optimal Mean-Reversion Trading Rule under a Markov Chain Model

This paper is concerned with a mean-reversion trading rule.In contrast to most market models treated in the literature, the underlying market is solely determined by a two-state Markov chain. The major advantage of such Markov chain model is its striking simplicity and yet its capability of capturing various market movements. The purpose of this paper is to study an optimal trading rule under such a model. The objective of the problem under consideration is to find a sequence stopping (buying and selling) times so as to maximize an expected return. Under some suitable conditions, explicit solutions to the associated HJB equations (variational inequalities) are obtained. The optimal stopping times are given in terms of a set of threshold levels. A verification theorem is provided to justify their optimality. Finally, a numerical example is provided to illustrate the results.

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MS23

Lmi Formulation of Analysis and Control Problems Involving Fractional Order Models

The aim of the talk is to present several methods based on Linear Matrix Inequalities (LMI) to analyze properties and to design control laws for systems modeled by fractional differential equations. First, model is written as a pseudo state space representation whose limitations are reminded. Then, LMI formulations for stability analysis, stabilization and H_∞ control are proposed. Finally, some perspectives are drawn in order to overcome the limitations induced by pseudo state space representation.

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MS23

Diffusive Representations for the Stability Analysis and Numerical Simulation of Fractional PDEs

Fractional integrals and derivatives can be equivalently transformed into Diffusive representations, allowing for well-posedness and stability analysis of fractional ODEs or PDEs, seen as coupled systems. Though a Lyapunov functional can be proposed explicitely, a lack of precompactness of the trajectories is to be found, we resort to Arendt-Batty theorem to conclude on asymptotic stability. Moreover, on a linear fractional wave equation with non-constant coefficients, a more general Integral representation is used to analyze and numerically simulate the system in low dimension.

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MS23

Stabilizability Properties of Fractional Delay Systems of Neutral Type

We consider the stabilizability of fractional delay systems of neutral type including the delicate case of systems which possess a chain of poles clustering the imaginary axis. Fractional rational controllers are investigated first and are shown to be very efficient for proper systems but not be well adapted for strictly proper systems with some parameter uncertainties. Second, the stabilizability by some classes of fractional controllers with delays is examined. Finally, some illustrative examples are given.

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MS23

On the Two Degree-of-Freedom Control of Fractional Systems

We propose a methodology to design a two-degree-of-freedom fractional control system. First, the feedback controller is obtained, for a class of fractional systems, by solving a weighted $\mathcal{H}_\infty$ model-matching problem to achieve some robustness specifications. Then, an optimal parametric feedforward signal is synthesized by input-output inversion of the fractional system dynamics. Finally, the weighting function and the feedforward signal parameters are optimized through a combined min-max problem.

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MS24

Sensing and Control in Symmetric Networks

We examine the relation between the symmetry structure of linear finite-dimensional systems and their controllability, where symmetry property indicates that the state transition matrix A commutes with a finite non-trivial group of matrices. We show that representation theory of finite groups constitutes a framework that allows generalization of some existing results on controllability of interconnected distributed systems. Computational aspects of optimal actuator placement are addressed. Main ideas are illustrated with several telling examples.

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MS24

Observation and Control of Ensembles of Linear Systems

Parameter dependent linear systems define natural classes of ensembles, i.e., infinite networks of systems. We apply methods from complex approximation theory to characterize controllability and observability for ensembles of linear systems, where the controls or observations are independent of the system parameters. By sampling at finitely many parameters, this leads to new tools for robust control and estimation of large scale networks.

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MS24

Dynamic Intrinsic Variables for Data Fusion and State Reconstruction

In this talk, we show how data-driven Koopman spectral analysis can be applied to the problem of data fusion and/or nonlinear state estimation. Our approach uses Extended Dynamic Mode Decomposition to approximate the leading Koopman eigenfunctions, which we use as a set of intrinsic coordinates that embed different sets of measurements in a common space. We apply our method to the FitzHugh-Nagumo PDE, and map point-wise measurements to principal component coefficients.

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MS24

A Chaotic Dynamical System That Paints and Samples

In this work, we develop a novel algorithm to reproduce paintings and photographs. Combining ideas from ergodic theory and control theory, we construct a chaotic dynamical system with predetermined statistical properties. Beyond reproducing paintings this approach is expected to have a wide variety of applications such as uncertainty quantification and sampling for efficient inference in machine learning. We then explore the use of this algorithm for assigning limited resources to nodes in a graph.

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MS25

Bang-Bang Type Nash Equilibrium Points for Nonzero-Sum Stochastic Differential Games

It is by now well known that non-zerosum differential games are connected to multi-dimensional BSDEs with, usually, non Lipschitz generators. In the case when the payoffs of the players of the game depend only on the terminal value of the controlled system, the generator of the associated BSDE could even be discontinuous. However we show that a Nash equilibrium point for this specific game exists in the Markovian framework. This Nash equilibrium point is of bang-bang type. This is a joint work by S.Hamadne and Rui MU.

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MS25

Credit Default Swaps with Bessel Bridges

In this work we propose the valuation of credit default swap using the so-called Bessel bridges to model the credit ndex process. The intuition behind this assumption is that Bessel bridges, by contruction, remain stricly positive until a fixed time T at which they hit zero for the first time.

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MS25

Evolutionary Inspection Games

In this talk, we present a few developments of inspection games with an evolutionary perspective and the properties of their equilibria.

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MS25

Study of Certain Stochastic Predator-Prey Models

Stochastic Predator-Prey models arise from many applications in ecological and biological applications. Recently such systems have drawn resurgent attentions. In this talk, we present some new perspective of study on such systems. We treat permanence and ergodicity for both nondegenerate and degenerate cases. One new feature of our result is the characterization of the support of a unique invariant probability measure. Convergence in total variation norm of transition probability to the invariant measure is also established. Related Kolmogorov systems with regime switching will also be investigated.

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MS26

Numerical Approaches for Bilevel Optimal Control Problems with Scheduling Tasks

Abstract not available.

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MS26

An Example of Solving Hjb Equations Using Sparse Grids

In this presentation, we show an example of solving the 6-D HJB equation for the optimal attitude control of a satellite equipped with momentum wheels. To mitigate the curse-of-dimensionality, a computational method on sparse grids is developed. The method is causality free, which enjoys the advantage of perfect parallelism. The problem is solved using several hundred CPUs in parallel. The accuracy of the numerical solution is verified at a set of randomly selected sample points.

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MS26

Optimal Control of a Hyperbolic Conservation Law Modeling Highly Re-Entrant Manufacturing Systems

Highly re-entrant manufacturing systems common in semiconductor manufacturing may be modeled by hyperbolic conservation laws with non-local velocity. We investigate the problem for L^1 and positive measure-valued data, whereas previous results [Coron, Kawski, and Wang (2010) MR 2679644] and [Colombo, Herty, and Mercier (2011) MR 2801323] established existence and uniqueness of solutions for the minimum-time optimal control problem and for L^2 data.

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MS26

The Role of the Objective in Optimal Control Problems Arising in Biomedical Applications

Mathematical models for biomedical problems generally are described by nonlinear systems, often affine in the controls that represent, for example, drug concentrations in models for cancer chemotherapy or vaccination and treatment rates in epidemiological problems. It is natural to consider these problems as optimization problems, for example, to minimize the tumor volume achievable with a given amount of chemotherapeutic agents. As much as biology offers insights into the dynamics of the underlying system, there generally is little guidance about the choice of the objective and this allows for considerable freedom. However, this choice strongly influences the structure of optimal solutions seen. For example, controls are continuous if quadratic, L2-type functionals are minimized, but generally have discontinuities if L1-type functionals are considered. Necessary conditions for optimality based on the Pontryagin maximum principle allow the computations of extremals, but even in the L2 case do not guarantee even local optimality of a numerically computed solution. Thus sufficient conditions for optimality need to be verified and these need to be customized to the problem under consideration. In this talk, we discuss the implications that the choice of the objective has on the mathematical procedures that need to be employed (e.g., differences in the associated flows of extremals) as well as relate the structure of solutions back to the biological background of the original problem.

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MS27

On the Interpretation of the Master Equation

Since its introduction by P.L.Lions in his lectures and seminars at the College de France, the Master equation has attracted a lot of interest, and various points of view have been expressed. There are several ways to introduce this type of equation. It involves an argument that is a probability measure, and Lions has proposed to work with the Hilbert space of square integrable random variables. So writing this equation is an issue. Its origin is another issue. In this talk we discuss these various aspects, and for the modeling we heavily rely on a seminar by P.L.Lions at the College de France on November 14, 2014; see http://www.college-de-france.fr

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MS27

On Nonlinear Filtering Theory for McKean-Vlasov SDEs

Partially observed stochastic dynamical systems whose state equations are of McKean-Vlasov (MV) SDE type (and hence contain a measure term) are considered. Nonlinear filtering equations are provided based on the classification that the measure term is stochastic or deterministic, and that either the state or the joint state and measure term is estimated. The filtering equations in both normalized and unnormalized forms and, for some cases, equations for conditional densities are obtained.

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MS27

From Kinetic to Macroscopic Models Through Local Nash Equlibria

We propose a mean field kinetic model for systems of rational agents interacting in a game theoretical framework. This model is inspired from non-cooperative anonymous games with a continuum of players and Mean-Field Games. The large time behavior of the system is given by a macroscopic closure with a Nash equilibrium serving as the local thermodynamic equilibrium. Applications of the presented theory to social and economical models will be given.

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MS27

Nonlinear Filtering Problems in Partially Observed MFG Control Theory

In Mean Field Games (MFG) with a major and many minor agents the best response policies of the minor agents depend on the major agents state and the stochastic mean field. The situation where the minor agents partially observe the major agent's state is considered and nonlinear filtering equations for the major agent's state when its dynamics depend upon the mean field are obtained. The results are then applied to the corresponding MFG problem.

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MS28

On Pod and Krylov Methods for Solution of Algebraic Riccati Equations

We propose a projection based method to solve large-scale algebraic Riccati equations based on proper orthogonal decomposition. The method can take advantage of existing simulation codes for linear systems, is easy to implement and produces very accurate solutions. We highlight connections to Krylov subspace methods and present a numerical example, where the matrices come from a high fidelity discretization of a two dimensional PDE.

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MS28

On Adi Approximate Balanced Truncation

Balanced truncation is a model reduction method for input-output-systems governed by ordinary differential equations which relies on the determination of the observability and controllability Gramian matrices and provides an error bound in the H_∞ norm. A variety of efficient numerical methods have been developed for balanced truncation. In particular, the ADI iteration for determining the Gramians has become very popular since it allows to determine reduced order models of large-scale systems. Since ADI iteration provides approximative solutions, it is natural to wonder the effect of this approximation in the overall model reduction process. This is subject the talk, where we aim to present a backward error analysis: We first show that ADI approximate balanced truncation in theory consists of exact balanced truncation of a certain artificial system, which is obtained from the original system via an L_2-orthogonal projection of the impulse response. Numerical consequences will be presented.

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MS28

Trust Region POD for Optimal Control of a Semilinear Heat Equation

An optimal control problem governed by a semilinear heat equation is solved using globalized inexact Newton methods. The Newton step is computed by a conjugate gradient algorithm. To reduce the computational effort a model order reduction approach based on proper orthogonal decomposition (POD) is applied. By utilizing POD in a trust region framework we can guarantee that the reduced-order approximation of the gradient is sufficiently accurate. Numerical results are presented and discussed.

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MS28

Rb-Based Optimization with Parameter Functions

We solve parabolic partial differential equations using a space-time variational formulation. We do not only allow parameters in the coefficients (for e.g. model calibration) but choose the initial condition as a parameter (function) as well. A reduced basis method is introduced that handles the parameter function and the corresponding infinite dimensional parameter space in a two-step Greedy procedure. In option pricing, this offers the possibility to use the same reduced basis for different types of options as they differ only by their initial value (assuming the same model approach). This is joint work with Antonia Mayerhofer (Univ. of Ulm).

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MS29

Acyclic Gambling Games

A gambling game is a two player zero stochastic game, played in discrete time, where each player controls a gambling house. A gambling house Γ^i of player i is a measurable function that assigns to each $x^i \in X^i$ a nonempty set $\Gamma^i(x^i)$ of probability measures defined on the Borel subsets of X^i, where X^i is a metric compact set. Think to two players in a Casino where x_i is the fortune of player i and $\Gamma^i(x^i)$ is the set of gambles available to player i when his fortune is x^i. The gambling game is played as follows. At stage $t = 1, ...,$ knowing the past history of states $(x_1^1, x_1^2, ..., x_t^1, x_t^2)$, each player i chooses simultaneously as his opponent a probability $\sigma_t^i \in \Gamma^i(x_t^i)$. The new states x_{t+1}^i, $i = 1, 2$, are selected according to σ_t^i. The pair (x_{t+1}^1, x_{t+1}^2) is publicly announced and the game moves to stage $t+1$. For each discount factor $\lambda \in]0, 1[$, one can associate a game with total payoff $\sum_{t=1}^{\infty} \lambda(1-\lambda)^{t-1} u(x_t^1, x_t^2)$, where u is some continuous utility function. A standard approach proves that this discounted game has a value v_λ, which is the unique fixed point of a λ-Shapley operator. We prove that, if the gambling houses are non-expensive and irreversible, the asymptotic value $\lim_{\lambda \to 0} v_\lambda$ exists and may be characterized as the unique fixed point of a pair of functional equations which extends the Mertens-Zamir system and the "Réduite' operator.

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MS29

Denjoy-Wolff Theorems for Hilbert's and Thompson's Metric Spaces

We shall discuss some recent results concerning the dynamics of fixed point free mappings on the interior of a normal, closed cone in a Banach space that are nonexpansive with respect to Hilbert's metric or Thompson's metric. Among other results, we show several Denjoy-Wolff type theorems that confirm conjectures by Karlsson and Nussbaum for an important class of nonexpansive mappings. We shall also see how one can extend, and put into a broader perspective, results by Gaubert and Vigeral concerning the linear escape rate of such nonexpansive mappings.

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MS29

The Operator Approach to Zero Sum Games; Applications to Games with short stage Duration

The operator approach to zero-sum repeated games consists in the study of the properties of the Shapley operators describing the recursive structure of the game, in order to infer asymptotic properties on its values. After recalling important results in the field, we will consider in particular the games with short stage duration defined by Neyman (Dynamic Games and Applications, 2013) and establish some of their asymptotic properties using the theory of nonexpansive operators in Banach spaces.

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MS29

Existence of Pure Optimal Uniform Strategies in Partially Observable Markov Decision Processe

We consider Partially Observable Markov Decision Processes. We prove that for any $\epsilon > 0$, there exists a pure strategy which is ϵ-optimal in any n-stage POMDP, provided that n is big enough. Moreover, under this strategy, the expectation of the liminf of the random mean of the stage rewards is close to the optimal reward.

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MS30

Conjugate Times and Regularity of the Minimum Time Function with Differential Inclusions

We study the regularity of the minimum time function, T, for a system with a general target, taking the state equation in the form of a differential inclusion. We first derive a sensitivity relation which guarantees the propagation of the proximal subdifferential of T along any optimal trajectory. Then, we obtain the local C^2 regularity of the minimum time function along optimal trajectories by using such a relation to exclude the presence of conjugate times.

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MS30

Second Order Sensitivity Relations for the Mayer Problem in Optimal Control

We investigate the value function, V, of a Mayer optimal control problem. The second order sensituivity relations are derived using solutions of the corresponding Riccati equation, the co-state of the maximum principle and second order sub/superjets of V along optimal trajectories. By applying sensitivity analysis to exclude the presence of conjugate points, we deduce that the value function is twice differentiable along any optimal trajectory starting at a point at which V is proximally subdifferentiable.

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MS30

Linear-Quadratic Optimal Control Probems with Infinite Horizon - Maximum Principle, Duality and Sensitivity

We consider a class of infinite horizon optimal control problems in Lagrange form involving the Lebesgue integral with a weight function in the objective. This special class of problems arises in the theory of economic growth, in processes where the time T is an exponentially distributed random variable and in problem of asymptotic feedback stabilization of a linear control system. The problem is for-

mulated as optimization problem in Hilbert Spaces. These considerations give us the possibility to extend the admissible set and simultaneously to be sure that the adjoint variable belongs to a Hilbert space. For the class of problems proposed, we can proof an existence result as well as Pontryagin type Maximum Principle including transversality conditions. The convex duality theory developed for this problem class provides sensitivity results.

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MS30

Necessary Conditions for Optimal Control Problems with Time Delays

We report on necessary conditions for free-time optimal control problems with time delay, recently derived by Boccia and Vinter. The conditions cover problems with general, non-smooth data and incorporate a new transversality-type condition associated with the free end-time. They are accompanied by sensitivity relations, which describe the effect of small parameter changes on the optimal cost. It is shown how the free-time conditions can be used to compute optimal controls.

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MS31

Demand Response-Enabled Optimal Control of HVAC Systems in Buildings

Optimized control of HVAC system can potentially reduce significant amount of energy consumption of buildings. In this work, we describe a model predicted control (MPC) framework that optimally computes the control profiles of the HVAC system considering the dynamic demand response signal, on-site storage of electricity, on-site generation of electricity, greenhouse gas emission as well as occupants comfort. The approach would determine how to power the HVAC system from the optimal combination of grid electricity, on-site stored electricity and on-site generated electricity.

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MS31

Energy Use Forecast and Model Predictive Control of Building Complexes

In this talk, we present a framework for forecasting and optimization of energy dynamics of building complexes. This framework integrates a physics-based model with a time-series model to forecast and optimally manage building energy. Physical characterization of the building is partially captured by a collection of energy balance equations estimated by a least squares technique and data generated from the EnergyPlus model. The model is then used in an MPC framework to control set points.

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MS31

A Binary Bilevel Algorithm: Application for Real Time Control of a Medium Voltage Electrical Network

Reporting from the SO-grid project: we present a new algorithm to solve binary bilevel programs. At each step of the algorithm, we solve a binary linear slave program, check the feasibility for the master problem, and add a cut if the solution is not feasible. As an application, we show how this algorithm can be used to solve a binary bilevel model for real time control of medium voltage electrical network.

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MS31

Real Time Control of Medium Voltage Electrical Distribution Networks

Several electrical measurement devices are designed, developed and deployed within the SO-grid project in order to monitor and control a medium voltage electrical network in real time. We present a mathematical model to determine the minimum number and location of these devices to be placed in the network and that ensure the convergence of the state estimation function. We also discuss some solution methods and preliminary computational results.

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MS32

Optimal Distributed Control for Continuum Power Systems

Large electrical power networks can be viewed as continuum systems which follow the dynamics of a second order nonlinear wave equation with constant voltage assumptions. In this talk we generalize to time and space variant voltages. Two optimal control problems are solved. The first problem is when the mechanical power is the control input, while the second problem is when the variant voltage magnitude is the control input under a generalized variant voltage PDE constraint. Numerical results are presented to illustrate the performance of the resulting closed loop control systems for large power networks.

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MS32

Decentralized Charging and Discharging Control of Plug-in Electric Vehicles for Peak Load Shifting

Plug-in electric vehicles (PEVs) are energy storage devices and distributed energy resources. Using advanced metering infrastructure and communication technologies, we can control PEVs for peak load shifting. In this paper, by allowing bidirectional power flow between PEVs and the grid, we study the load flattening problem by regulating PEVs' charging and discharging process. A decentralized algorithm using iterative water-filling is developed. The advantages of our algorithm include reduction in computational burden and privacy preserving.

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MS32

Incorporating Smart-Grid Operating Strategies into Off-Grid Electrification Planning

The introduction of smart meters with wireless communication and sophisticated technology for fine-grained monitoring and control has revolutionized the possibilities for deploying highly resilient and economically sustainable microgrids for off-grid electrification. Traditional planning tools lack the flexibility to explore implications of operating strategies that leverage these capabilities. A new method is presented for incorporating low-level, user-selected power management policies into comprehensive microgrid planning analysis to support comparative evaluation of alternative implementations for first-access energy systems.

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MS32

Randomized Policies for Demand Dispatch

The paper concerns automated demand response from on/off loads. It is assumed that there is one-way communication from the grid operator to each load. The loads are either on or off – their power consumption is not continuously variable. Local control at each load is defined by a family of *Markov transition matrices*, denoted $\{P_\zeta : \zeta \in \Re\}$. At time t, if the load receives the signal ζ_t from the grid operator, then it changes state to the value x' with probability defined by the transition matrix, $P_{\zeta_t}(x, x')$; the randomness is local, and hence independent of all other loads. A mean-field limit is used to obtain an input-output model, where the output is the aggregate power consumption. The main result is to show how these transition laws can be designed so that the linearized mean field model is minimum phase at any operating point. This is achieved through a variety of Markov chain analytical tricks based on Poisson's equation.

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MS33

Moreau Sweeping Processes on Banach Spaces

The sweeping process or Moreau's process in a Hilbert space (introduced and studied by J.J. Moreau in J.D.E. in 1977) is an interesting problem in both Analysis and Mechanics. In this talk I will present my last recent results on the existence of solutions for several extensions to Banach spaces of Moreau sweeping processes and its variants.

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MS33

Control of Moreau's Sweeping Process: Some Results and Open Problems

In this talk we discuss some recent results of the theory of Moreau's sweeping processes including necessary conditions for the dynamic case. As open problems we discuss the dynamic programming for the controlled sweeping process, which is currently being investigated and establishing a suitable version of Pontryagin Maximum principle.

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MS33

Differential and Difference Inclusions and the Filippov Theorem

This is a joint work with R. Baier and F. Lempio. We survey some results on the continuous and discrete Filippov theorem on approximate solutions of differential and difference inclusions and applications.

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MS33

Optimality Conditions for Optimal Control Problems with Interval-Valued Objective Functions

This work examines continuous time optimal control problems with interval-valued objective functions. For this, we consider three concepts of order relations in the interval space to obtain optimality conditions for these problems and obtain Pontryagin maximum principle type of optimality conditions for optimal control problems using the concept of generalized Hukuhara derivative (gH-derivative) for interval-valued functions. We also illustrate our method with numerical examples.

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MS33

Differential Inclusions and Applications

My talk will deal with differential inclusions. Such evolution problems appear when the state-variable is submitted to some constraints and therefore has to stay in an admissible set. Especially we will be interested in the study of sweeping processes and of second order differential inclusions involving proximal normal cones. We propose to detail some results about these different problems by pointing out the geometrical assumptions regarding the admissible sets. Furthermore we will consider some applications in crowd motion modelling and in granular media.

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MS34

A Dynamic Domain Decomposition for a Class of Second Order Hamilton-Jacobi Equations

We present a new parallel algorithm for the numerical solution of a class of second order Hamilton-Jacobi equations coming from stochastic optimal control problems. The new method is an extension of the patchy domain decomposition technique developed in the recent joint work of the author with E. Cristiani, M. Falcone, and A. Picarelli (2012). The original method is modified to solve quite general nonlinear problems with possibly degenerate and control driven diffusion. In particular, we show that, under suitable relations between the data and the discretization parameters, a remarkable acceleration of the parallel computation can be obtained. This is a joint work Maurizio Falcone.

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MS34

Convergence of An Hp-Collocation Method for Optimal Control

A convergence theory is introduced for approximations of continuous-time optimal control problems using an hp-collocation method based on Radau quadrature. Under assumptions of coercivity and smoothness, an hp discretization of an unconstrained control problem has a local minimizer and corresponding Lagrange multiplier that converge in the sup-norm to a local minimizer and costate of the continuous-time optimal control problem. The accuracy is improved either by increasing the degree of the polynomial within a mesh interval or by refining the mesh. The convergence theorem is presented along with a brief overview of the proof. This is a joint work with Hongyan Hou and

Anil V. Rao.

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MS34

Optimal Control for Irrigation Scheduling based on the AquaCrop Model

We present a methodology based on numerical optimal control to determine optimal irrigation scheduling under restricting water quotas. The objective function, which is nonlinear and non-smooth, is the expected seasonal yield calculated using the dynamic crop model AquaCrop. By gradually increasing the value of the water quota, the convex function describing yield as a function of irrigation water as obtained. Irrigated maize in the region of Lombardia, Italy, is presented as example.

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MS34

Computation of An Explicit Error Estimate for Optimal Control Problems of Odes

Error estimates for the local solution of an optimization problem typically depend on the fineness of the discretization and on the smallest eigenvalue of a certain quadratic form (related to second-order sufficient optimality conditions). In this talk, we will consider the case of optimal control problems of ODEs, discretized in time. The computation of the smallest eigenvalue, a delicate task, will be based on a "Riccati"-based approach, that we will explain with the help of Schur complements.

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MS34

Lie Brackets and Hamilton-Jacobi Inequalities

In relation with a control-affine system with a non negative Lagrangian, we embed the corresponding Hamilton-Jacobi-Bellman equation in a more general equation. In particular, the latter is built from Lie brackets of the vector fields involved in the dynamics. The supersolutions of this extended equation can be regarded as Liapunov-like functions (here called Minimum Restraint Functions), which, besides yielding global asymptotic controllability, provide an upper estimate on the minimum value.

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MS35

Parametric Robust Control Design

We present a new technique for tuning arbitrary linear control structures against multiple plant models subject to parametric uncertainties and against a variety of performance requirements. Our method is an inner relaxation. Worst-case parametric scenarios are computed and exploited to design robust controllers against parametric uncertainties. Our approach relies on two different nonsmooth optimization techniques which operate in controller and parameter spaces, respectively. Applications reveal a good balance between flexibility and effectiveness.

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MS35

Robust Interference Control for Networks with Link Uncertainty

In multi-cell communication networks, the end users suffer not only from intra-cell interference and noise, but also inter-cell interference. It is very important to control these interferences by precoding the transmitted signals to improve the quality of the received signals and maximize the network throughput. Signal precoding must use the link state information, which is obtained through training and thus subject of uncertainty. In this talk, we show that the robust interference control is a concave program, which can be solved effectively by very low-complexity iterations.

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MS35

Bilinear Constrained Programming for Robust PID Controller Design

A new design method of extended PID controllers achieving robust performance is developed. Both robust stabilization and performance conditions are losslessly expressed by bi-linear constraints in the proportional-double derivative gains (k_p, k_{dd}) and the derivative-integral gains (k_i, k_d). Therefore, the considered PID control design can be efficiently solved by alternating optimization between (k_p, k_{dd}) and (k_i, k_d), where each alternating iteration is an infinite linear or infinite convex program. Furthermore, the method works equally efficiently whenever even higher order differential or derivative terms are needed to be included in PID control to improve its robust stabilizability and performance capability. Numerical examples are provided to show the viability of the proposed development.

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MS35

Computing the Structured Distance to Instability

Analysis and control of systems with uncertain real parameters has been high on the agenda since the 1980s. In this talk we investigate the computation of quantities like the distance to instability of a nominally stable system with uncertain parameters, or the worst-case H-infinity norm of a system over a given range of uncertain parameters. Such criteria allow to assess the robustness of a system, but their computation is NP-hard. We therefore develop heuristic approaches, which are fast and reliable in practice, and which can a posteriori be certified when used in tandem with suitable global methods.

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MS36

Parameter Estimation in a Stochastic System Model for PageRank

The PageRank algorithm is used by Google as a way of hierarchically indexing web pages in order to ensure that it provides relevant and reputable search results. In this paper, we present a stochastic system reformulation of the PageRank problem and establish strong consistency of the least squares estimator of an unknown parameter in the system. Furthermore, we show that the least squares estimator remains strongly consistent within a distributed randomized framework for PageRank computation.

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MS36

Classification of Alzheimer's Disease Using Unsupervised Diffusion Component Analysis

The goal of this study is to classify magnetic resonance (MR) images of brains of patients with Alzheimers Disease (AD) and those without AD. An algorithm based on diffusion maps constructs coordinates that generate geometric representations using the MRI. Diffusion maps arise from modeling of data by stochastic differential equations. This method also accounts for variability in calibration for different patients. This is joint work with Thomas Strohmer from UC Davis.

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MS36

Empirical Characteristic Function Methods in System Identification

The objective of this talk is to extend the empirical characteristic function method to identify finite dimensional linear stochastic systems driven by an i.i.d. noise process, the characteristic function of which is known to belong to a parametric class of characteristic functions given in closed form. The proposed method is essentially as efficient as the maximum likelihood method. Our results will be supported by extensive numerical experiments.

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MS36

A Classification Based Perspective to Optimal Policy Design for a Markov Decision Process

Classical approximate dynamic programming techniques generally become impracticable in high-dimensions. Policy search copes with this issue by considering a parameterized policy space. Here, we focus on discrete actions and introduce a parameterization inspired by nearest-neighbor classification, each particle representing a state space region mapped into a certain action. Locations and actions are tuned via policy gradient with parameter-based exploration. The task of selecting an appropriately sized set of particles is solved through an iterative scheme.

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MS36

Shadow Price for General Discrete Time Models

In the case of market with proportional transaction costs (bid and ask price) we are looking for an artificial market with price without transaction costs such that optimal strategies and value functions on both markets are the same. In the talk we shall consider a number of problems arising in discrete time setting which lead first to so called weak shadow price, the price depending on current financial position, with the use of which we construct shadow price. The talk is based on o joint paper with T. Rogala.

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MS37

Partially Observable Markov Decision Processes with General State, Action and Observation Sets

We describe sufficient conditions for the existence of optimal policies, validity of optimality equations, and convergence of value iterations for discounted partially observable Markov decision processes with Borel state, action, and observation sets. These conditions are: (i) the one-step cost function is bounded below and K-inf-compact, (ii) the transition probability is weakly continuous, and (iii) the observation probability is continuous in total variation.

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MS37

Inverse Problems and Dynamic Potential Games

Dynamic potential games are, roughly speaking, noncooperative dynamic games whose equilibria can be found by solving certain optimal control problem. One way to characterize some classes of dynamic potential games is through inverse problems. In this talk we present some results about inverse problems in optimal control and dynamic potential games. In particular, we characterize a class of dynamic potential games whose Nash equilibria and Pareto solutions coincide.

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MS37

Equilibrium Characteristics of Default in a Currency Area

Hernandez-del-Valle and Martinez-Garcia (2015) find that default is the optimal decision of a sovereign government in a currency area after prolonged real exchange rate overvaluation. Our objective is to determine if default is Pareto optimal and/or Nash equilibrium.

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MS37

Approximation of Denumerable State Continuous-Time Markov Games: Discounted and Average Payoff Criteria

We consider a two-person zero-sum continuous-time Markov game with denumerable state space, general action spaces, and unbounded payoff and transition rates. We deal with noncooperative equilibria for the discounted and the average payoff criteria. We are interested in approximating numerically the value and the optimal strategies of the game. We construct finite state and actions truncated game models, that can be explicitly solved, which converge in a suitably defined sense to the original game model. We study the convergence rate for the value of the games and we illustrate our results with an application to a population system.

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MS38

No-Fold Conditions for Broken Extremals

We consider an optimal control problem whose extremals are given by the flows of two competing Hamiltonians, not necessarily equal to lifts of vector fields. We assume that there are only normal switching points (Kupka, 1987). Conjugacy for the resulting broken extremals may occur at or between switching times; we formulate a sufficient condition for strong optimality in terms of jumps on the Jacobi fields which is related to the no-fold condition of Noble and Schättler (2002). As an application, we consider L^1 minimization of the control of affine multi-input systems whose control is restricted to the Euclidean ball.

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MS38

On Sufficient Conditions for a Class of Constrained Problems with Indefinite Quadratic Functional

In [M.M.A. Ferreira, A.F. Ribeiro and G.V. Smirnov, *Local Minima of Quadratic Functionals and Control of Hydro-Electric Power Stations*, JOTA, july 2014] some new sufficient conditions for a local minimum of a possibly indefinite quadratic functional were developed. That work was motivated by the existence of non-isolated local minimizers associated to a certain class of optimal control problems. We will present some further analysis of such sufficient conditions as well as some other applications.

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MS38

On Strong Local Optimality of Concatenations of Bang and Singular Arcs

Abstract not available.

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MS38

The Turnpike Property in Optimal Control

The turnpike property emerged in the 50's, after the works by the Nobel prize Samuelson in econometry. It stands for the general behavior of an optimal trajectory solution of an optimal control problem in large time. This trajectory trends to behave as the concatenation of three pieces: the first and the last arc being rapid transition arcs, and the middle one being in large time, almost stationary, close to the optimal value of an associated static optimal control problem. In a recent work with Enrique Zuazua, we have established the turnpike property in a very general framework in finite dimensional nonlinear optimal control. We prove that not only the optimal trajectory is exponentially close so some (optimal) stationary state, but also the control and the adjoint vector coming from the Pontryagin maximum principle. Our analysis shows an hyperbolicity phenomenon which is intrinsic to the symplectic feature of the extremal equations. We infer a very simple and efficient numerical method to compute optimal trajectories in that framework, with an appropriate variant of the shooting method.

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MS39

A Physics Based Approach to Model Discrepancy and Model Form Uncertainty for Design and Control of Distributed Parameter Systems

Abstract not available.

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MS39

Optimal Boundary Control and Estimation of Parabolic PDEs Using Sum-of-Squares (SOS) Polynomials

We use SOS to design stabilizing and optimal controllers for scalar parabolic PDEs with spatially distributed coefficients. We use point actuation via Dirichlet, Neumann, Robin and mixed boundary conditions and point measurements of state. Our approach is based on solving LOIs using a convex parameterization of Lyapunov functions via positive matrices. Objectives include include both exponential stability and minimum L2 gain. Numerical examples show the accuracy is competitive with alternatives such as backstepping.

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MS39

Low-complexity Modeling of Partially Available Second-order Statistics via Matrix Completion

We study the problem of completing partially known state statistics of large-scale linear systems. The dynamical interaction between state variables is known while the directionality of input excitation is uncertain. In particular, we seek to explain the data with the least number of possible input disturbance channels. This can be formulated as a rank minimization problem, and for its solution, we employ a convex relaxation based on the nuclear norm.

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MS39

Boundary Estimation for Infinite Dimensional Elliptic Cauchy Problem Using Observers

We design and prove the convergence of an iterative observer for boundary estimation problem for an elliptic equation, namely, Cauchy problem for Laplace equation. The Laplace equation is formulated as a first order system in one of the space variables with state operator matrix. The convergence of proposed iterative observer is established using semigroup theory and the concepts of observability for infinite dimensional systems. Numerical simulations are provided to signify efficiency of the algorithm.

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MS40

Model Order Reduction Approaches for the Optimal Design of Permanent Magnets in Electro-Magnetic Machines

In an electromagnetic machine with permanent magnets the excitation field is provided by a permanent magnet instead of a coil. The center of the generator, the rotor, contains the magnet. Our optimization goal consists in finding the minimum volume of the magnet which gives a desired electromotive force. This results in an optimization problem for a parametrized partial differential equation (PDE). We propose a goal-oriented model order reduction approach to provide a reduced order surrogate model for the parametrized PDE which then is utilized in the numerical optimization. Numerical tests will be provided in order to show the effectiveness of the proposed method.

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MS40

Reduced Basis Method for Multiobjective Optimization

We present a reduced order technique for the numerical solution of PDE-constrained multiobjective optimization, where several objective functions have to be simultaneously optimized. The idea is to find a solution which does not penalize the optimization of any objective function and which is a good compromise for all the individual ones. In general, does not exist a single optimal solution, but there exists a (possibly infinite) number of Pareto optimal solutions. In the multiobjective optimization theory, the Pareto optimality allows to determine efficient optimal points for all the considered objective functions [C. Hillermeier. Nonlinear multiobjective optimization. A generalized homotopy approach. Birkhaeuser Verlag, Basel, 2001]. We apply the reduced basis method in this context where the constraints are given by parametric linear and semilinear PDEs [A.T. Patera and G. Rozza. Reduced basis approximation and a posteriori error estimation for parametrized partial differential equations Version 1.0. Copyright MIT, http://augustine.mit.edu, 2007], in order to propose a reduced-order techniques to handle the computational complexity and resolution times and to ensure a suitable level of accuracy.

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MS40

Reduced Order Models for Nonlinear PDE-Constrained Optimization and Control Problems

We review reduced basis methods for the efficient solution of parametric optimization and parametrized control problems dealing with nonlinear PDEs, by considering both a “reduce-then-optimize’ and an “optimize-then-reduce’ approach. A simultaneous reduction of state and control spaces is performed when dealing with parametrized control problems. Moreover, efficient a posteriori error bounds enable to certify the solution of the reduced optimization problem. We present some numerical test cases dealing with the optimal control of fluid flows.

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MS40

Application of Error Estimates for Nonlinear POD Reduced Order Models

We consider the use of reduced order models in the calibration of certain models in mathematical finance which lead to the identification of parameters of a highly nonlinear PDE. While the ROM fits the original system quite successfully, the nonlinear dependence is very strong and a frequent refitting of the ROM is necessary. We observed this numerically and try to find a theoretical justification for this behavior.

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MS41

Ergodicity Condition for Zero-Sum Games

For zero-sum repeated stochastic games, basic questions are whether the mean payoff per time unit is independent of the initial state, and whether this property is robust to perturbations of rewards. In the case of finite action spaces, we show that the answer to both questions is positive if and only if an ergodicity condition involving fixed points of the recession function of the Shapley operator or reachability in directed hypergraphs is satisfied.

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MS41

Strategically Enhanced Preferential Attachement, Coalition Building and Evolutionary Growth

We prove rigorous results on the convergence of various Markov decision models of interacting small agents to a deterministic evolution on the distributions of the state spaces of small players, paying the main attention to situations with an infinite state space of small players. These include the strategically enhanced extensions of the models of evolutionary growth, coalition building and preferential attachment. Applications include processes of banks or firms merging, as well as the processes of emerging cooperation.

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MS41

Target Defense Differential Game with a Closed-

Form Solution

A pursuit-evasion game in the plane is considered where an attacker (A) strives to come as close as possible to a Target set (T) before being intercepted by the Defender (D) whereas D tries to intercept A as far away from T as possible; the players A and D have simple motion a la Isaacs. The game terminates when A reaches T without having been intercepted by D, or A comes as close as possible to the target set T, at which time he is captured by D. We also comment on the case where the target T is a dynamic point target and the D and T team play cooperatively to defeat A.

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MS41

Development of An Idempotent Algorithm for a Network-Delay Game

A game is considered where the communication network of the first player is explicitly modeled. The second player may induce delays in this network, while the first player may counteract such actions. Costs are modeled through expectations over idempotent probability measures. Idempotent algebras are used to obtain an algorithm for solution of the game.

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MS42

Coupling MPC and DP Methods for the Numerical Solution of Optimal Control Problems

We consider the approximation of an infinite horizon optimal control problem which combines a first step based on Model Predictive Control (MPC) in order to have a quick guess of the optimal trajectory and a second step where we solve the Bellman equation in a neighborhood of the reference trajectory. In this way we obtain a local version of the classical DP approach. We present the main features of these new technique and illustrate its effectiveness by some numerical tests.

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MS42

Recent Computational Techniques for Dynamic Programming on Hybrid Systems

The notion of hybrid system has been recently introduced to give a unified framework for control systems mixing discrete and continuous control actions. In this talk, we review some recent researches on the approximation of Dynamic Programming equations for hybrid systems, including convergence and error estimates for numerical schemes, acceleration techniques based on policy iteration, and construction of a quasi-optimal feedback. Moreover, we show some numerical tests on real (although relatively simple) applications.

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MS42

Local Optimization Algorithms for the Approximation of Hamilton-Jacobi-Bellman Equations

We introduce local optimization strategies for Dynamic Programming-based approximations of Hamilton-Jacobi equations. In particular, semi-Lagrangian schemes require the local minimization of the Hamiltonian with respect to the control variable. For this purpose, we set a semismooth Newton method and a first-order primal-dual algorithm, both leading to accurate optimal control fields. We present different examples assessing the performance and accuracy of the proposed scheme.

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MS42

Speeding Up Model Predictive Control Via Al'brekht's Method and Its Extensions

The methods that we propose for speeding up MPC are based on Albrekhts method for solving HJB equations. Albrekht showed that the Taylor series around an operating point of the optimal cost and optimal feedback of an infinite horizon continuous time nonlinear optimal control problem could found degree by degree. We extend this method to discrete time nonlinear optimal control problems. The series provide a terminal cost and terminal feedback for MPC that is defined on a larger domain. This allows a shorter time horizon thereby speeding up MPC. We extend the series approach to find the Taylor series of the optimal cost and optimal feedback around a optimal trajectory. This speeds up MPC by yielding a longer interval for the real time computation.

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MS43

Second Order Analysis of State-Constrained Control-Affine Problems

In this talk we establish new second order necessary and sufficient optimality conditions for a class of control-affine problems with a scalar control and a scalar state constraint. These optimality conditions extend to the constrained state framework the Goh transform, which is the classical tool for obtaining a generalization of the Legendre condition. We propose a shooting algorithm to solve numerically this class of problems and we provide a sufficient condition for its local convergence. We present examples to illustrate the theory.

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MS43

Second-Order Necessary Conditions in Pontryagin Form for Optimal Control Problems

We say that optimality conditions for an optimal control problem are in Pontryagin form if they only involve Lagrange multipliers for which Pontryagin's minimum principle holds. This restriction to a subset of multipliers is a strengthening for necessary conditions, and enables sufficient conditions to give strong local minima [Milyutin, Osmolovskii]. We consider optimal control problems with pure state and mixed control-state constraints, and we present here first- and second-order necessary conditions in Pontryagin form, relying on a technique of partial relaxation [Dmitruk].

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MS43

Second-Order Necessary Optimality Conditions for the Mayer Problem Subject to a General Control Constraint

We discuss second order necessary optimality conditions for the Mayer optimal control problem with an arbitrary closed control set $U \subset R^m$. Using second order tangents, we show that if a control $\bar{u}(\cdot)$ is optimal, then an associated quadratic functional is nonnegative on elements in the second order jets to U along $\bar{u}(\cdot)$. Our proofs are straightforward and do not use embedding of the problem into a class of infinite dimensional problems.

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MS43

A Second-Order Maximum Principle for State-Constrained Control Problems

In this talk we present second-order necessary optimality conditions for control problems in the presence of pure state constraints, obtained using second-order tangents to the set of trajectories. Through a second-order variational differential inclusion we obtain a point-wise second-order maximum principle and a second-order necessary optimality condition in the form of an integral inequality which extends some earlier known results to the case of strong local minimizers.

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MS44

Toward Massive Deployment of Power Electronics in Future Electric Energy Systems: Modeling and Control Challenges and Opportunities

In this talk we pose the problem of fast digital control design for changing electric power systems. The underlying modeling, placing and tuning of minimal number of fast nonlinear digital controllers in both microgrids and EHV power plants is discussed in light of the state-of-the-art in nonlinear control for general large scale dynamical systems. We combine the rich structure of the underlying power system with general methods on the way to a systematic design framework.

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MS44

Balanced Control Strategies for Heterogeneous Battery Systems for Smart Grid Support

This paper introduces new balanced charge/discharge control strategies that distribute charge or discharge currents properly so that during operations battery pack balancing is continuously maintained. The strategies are targeted for serially interconnected heterogeneous battery systems to be used for power grid support. SOC-based balanced charge/discharge strategies are developed. Their convergence properties are rigorously established, and simulation examples demonstrate their convergence behavior under different charging current profiles. Also, robustness against parameter estimation errors is discussed.

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MS44

Is Consumer-Based Integration of Renewable and Storage Good for Consumers?

Two models of renewable integration and the use of storage in distribution networks are considered. The first is a centralized utility-based model in which the utility owns the renewable generation as part of its portfolio of energy resources. The second is a decentralized consumer-based model in which each consumer owns the renewable generation and is allowed to sell surplus electricity back to the utility in a net-metering setting. Similar models for storage are also considered: the utility owned and operated storage vs. consumer owned and operated one. The essential question is whether consumer owned and operated renewable generation or storage ultimately benefits the consumer under a profit regulated monopoly.

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MS44

Exploiting Energy Storage for Integration of Renewables in Low Voltage Networks

Electricity networks have witnessed the outgrowth of a huge number of uncertainty sources and constraints, mainly due to the rising amount of renewable generation and the increased sensitivity of customers to quality of service. We investigate optimal sizing and placement of an energy storage to address both over- and under-voltage problems in distribution networks. An optimal power flow is formulated where the total storage budget is minimized subject to power flow equations, energy storage dynamics and voltage quality constraints. A convex relaxation approach is exploited to provide a suboptimal solution.

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MS45

An Optimal Junction Solver for Traffic Flow

Abstract not available.

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MS45

On the Attainable Set for Scalar Conservation Laws and Its Application

Abstract not available.

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MS45

On the Uniform Controllability of the One-Dimensional Transport-Diffusion Equation in the Vanishing Viscosity Limit

Abstract not available.

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MS45

Exact Boundary Controllability of Nodal Profile for Quasilinear Wave Equations in a Planar Tree-Like Network of Strings

Abstract not available.

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MS46

Estimation of a Gaseous Release into the Atmosphere Using An Unmanned Aerial Vehicle

We propose a scheme based on controls and computational fluid dynamics to provide real-time estimates of the gas concentration released in the atmosphere from a moving source. The concentration is estimated numerically using an unmanned aerial vehicle equipped with a gas sensor.

The performance-based motion control of the sensing aerial vehicle is integrated into the performance state estimation scheme. The resulting guidance scheme couples the vehicle motion to the estimator performance.

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MS46

LQG Controller Equivalent to the Control by Interconnection for Infinite Dimensional Port Hamiltonian System

This paper proposes a method that combines LQG control design and structure preserving model reduction for the control of infinite dimensional port Hamiltonian systems (IDPHS). A modified LQG controller design equivalent to control of IDPHS by interconnection is first proposed. The method of Petrov-Galerkin is then used to approximate the balanced realization of the IDPHS by a finite dimensional port Hamiltonian system and to provide the associated reduced order LQG controller.

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MS46

Robustness of Nonlinear Optimal Regulator for Reduced Distributed Parameter System

This paper proposes an evaluation index of robustness to disturbances for distributed parameter systems with nonlinear optimal feedback designed by the stable manifold method that is a numerical calculation method of Hamilton Jacobi equations, and the POD-Galerkin method that is a finite dimensional reduction method. We state a robust control problem described by POD bases and disturbances. Then, we show that the problem can be formulated as a generalized eigenvalue problem.

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MS47

Computing Reachable Sets by Distance Functions and Solvers for Optimal Control Problems

Reachable sets of nonlinear state-constrained control problems are calculated by solving parametric optimal control problems with a suitable OCP solver. Here, the feasible set equals the reachable set and the optimal value coincides with the distance function of a grid point to the reachable set. A lower-dimensional projected reachable set of a single-track model for collision avoidance is computed. Possible speedups of the algorithm by the piecewise linear interpolated distance function and parallelization are demonstrated.

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MS47

A Dual Model/Artificial Neural Network Framework for Privacy Analysis in Traffic Monitoring Systems

Most large-scale traffic information systems rely on a combination of fixed sensors (e.g. loop detectors) and user generated data, the latter in the form of probe traces sent by GPS devices on vehicles. While this type of data is relatively inexpensive to gather, it can pose multiple privacy risks, even if the location tracks are anonymous. We propose a new framework for analyzing a variety of privacy problems arising in transportation systems.

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MS47

Hamilton-Jacobi Approach for Second Order Traffic Flow Models

While being simple and tractable, the first order LWR model does not reproduce certain meaningful traffic phenomenon. Second order traffic flow models have been developed to fill this gap. In this talk, I will focus on the Generic Second Order Model (GSOM) family which embeds lots of these models. Recasting the GSOM in Lagrangian coordinates allows us to use the Hamilton-Jacobi framework and to deduce a Lax-Hopf type formula which is helpful for numerical resolution.

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MS47

Robust Control Problems - from the Perspective of

Evolution Equations for Sets

In "robust" control problem, two types of controls occur and, the user can choose only one of them whereas the other one is not known exactly (i.e., uncertainty). Whenever all possibilities for the second control are considered simultaneously, states should be described as sets. We discuss an extension of differential equations to set-valued states. It is illustrated by examples and their numerical solutions. It even lays the analytical foundations for control problems with state constraints.

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MS48

Linear Stochastic Control with State and Control Dependent Noise

The control of a linear stochastic system with stochastic coefficients, linear state and control dependent noise, and a quadratic cost is formulated and solved. A stochastic Riccati equation is used to obtain the explicit optimal control in a direct way using a decomposition of submartingales from the running cost and the Lagrangian Grassmannian for the control problem. This problem have been considered by some others using different approaches.

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MS48

Hidden Markov Change Point Estimation

A hidden Markov model is considered where the dynamics of the hidden process change at a random 'change point' T. In principle this gives rise to a non-linear filter but closed form recursive estimates are obtained for the conditional distribution of the hidden process and of T.

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MS48

On Cooling of Stochastic Oscillators

Active control of micro/macro mechanical systems to reduce thermal noise is implemented in atomic force microscopy, polymer dynamics and gravitational wave detectors. For a system of nonlinear stochastic oscillators, we consider the problem of feedback controlling the system efficiently to a desired steady state corresponding to lower thermal noise both asymptotically and in finite time . The solution (in closed-form in the Gaussian case) involves extending and adapting the classical theory of Schroedinger bridges.

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MS48

On some Connections between Information Theory, Nonlinear Estimation and Statistical Mechanics

In this talk I discuss the connections that exist between Nonlinear Filtering for Diffusion Processes, the Variational Characterization of Gibbs Measures and Information-theoretic characterization of optimality of nonlinear estimators . It relies on T.E. Duncans important work on the computation of Mutual Information for Diffusion Processes. I discuss also the role of Information Theory in the context of the Separation Theorem of Stochastic Control, Dual Control and Self Tuning Regulators

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MS49

Homogenization Results for Hamilton-Jacobi Equations on Networks

Abstract not available.

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MS49

Singular Perturbation of Optimal Control Problems on Periodic Multi-Domains

In this talk we consider the singular perturbation of an optimal control problem in which the controlled system involves a fast and a slow variables. The fast variable lives in periodic multi-domains. The problem can be reformulated as a Hamilton-Jacobi-Bellman (HJB) equation, while the geometric singularity of the multi-domains leads to the discontinuity of the Hamiltonian. Under a controllability assumption on the fast variable, the limit problem has been analyzed and the associated HJB equation has been obtained. This equation describes the limit behavior of the value function of the perturbed problem when the scale of periodicity tends to 0.

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MS49

The Hamilton Jacobi Equation for Optimal Control

Problems with State Constraints

We discuss conditions under which the value function for a state-constrained optimal control problem can be characterized as the unique generalized solution of the Hamilton Jacobi equation. Special attention is given the interplay between the validity of this characterization and system theoretic properties (controllability and monotonicity) of the underlying dynamic constraint and the regularity of the data, and new classes of problems are identified, for which the characterization is possible.

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MS49

Optimal Control Problems on Generalized Networks

This talk concerns some optimal control problems on d-dimensional networks. We will present a new characterization of the value function as solution to a system of Hamilton- Jacobi- Bellman equations with appropriate junction conditions. This result doesn't require the usual controllability condition on the junction and it still holds when the value function is discontinuous.

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MS50

Stabilisation of Dynamical Systems Subject to Switching and Two Time Scale Phenomena

This talk is dedicated to the problem of stability analysis and control design of singularly perturbed switched systems. The problem of norms computations such as H2 and H infinity norms is presented and the generalization to the case of switching and switched singularly perturbed systems is discussed. The talk focuses on open problems for this class of hybrid systems. We illustrate the different notions and properties discussed in this presentation using numerical examples.

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MS50

Commutators, Robustness, and Stability of Switched Linear Systems

The subject of this work is stability analysis of switched linear systems, described by a family of continuous-time linear dynamical systems and a rule that orchestrates the switching between them. There are well-known results stating that stability is preserved under arbitrary switching provided that certain commutation relations hold between the matrices being switched, in particular, if the matrices commute or generate a nilpotent or solvable Lie algebra. The present works aims at obtaining stability conditions along these lines which are robust with respect to sufficiently small perturbations of the system data (such perturbations destroy exact commutatitivy). This leads directly to questions like when are almost commuting matrices nearly commuting, i.e., does smallness of commutators imply proximity to commuting matrices? When the answer is yes, existence of Lyapunov functions coupled with a perturbation analysis can be used to show stability and to estimate allowable deviations of the commutators from zero. Similar results can be derived for nilpotent or solvable Lie algebras. Among a number of available results on almost commuting vs. nearly commuting matrices, we work with the Łojasiewicz inequality which lower-bounds the value of a polynomial in terms of the distance to its set of zeros. Applied in our framework, the Łojasiewicz inequality and other related results allow us to obtain robust versions of Lie-algebraic stability criteria for switched linear systems.

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MS50

Stability of Linear Difference Equations with Switching Parameters and Applications to Transport and Wave Propagation on Networks

This talk addresses the stability of linear difference equations of the form

$$x(t) = \sum_{i=1}^{N} A_i(t)x(t - L_i), \qquad x(t) \in C^d,$$

for positive delays L_i. When the matrices A_i are time-independent, the corresponding autonomous system can be analyzed by Laplace transform methods leading to the well-known Silkowski's criterion, but this technique fails to apply to the non-autonomous case. Using an explicit formula for solutions, we get a stability criterion for the non-autonomous system. When applied to the case of switching matrices $A_i(\cdot)$ subject to arbitrary switching signals, one obtains a criterion in terms of a generalized joint spectral radius, which extends Silkowski's criterion. Corresponding stability criteria for transport and wave propagation on networks with variable coefficients are derived by expressing these systems as difference equations. In particular, we show that the wave equation on a network with arbitrarily switching damping at external vertices is exponentially stable if and only if the network is a tree and the damping is bounded away from zero at all external vertices but one.

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MS50

Analysis of the Limit Sets of Switched Systems

We consider switched systems, both linear and non linear, whose trajectories are bounded by a weak Lyapunov function V. We investigate the convergence of the trajectories towards two different locus according to the class of switching laws considered. For each vector field f_i we consider the set K_i where the derivative of V along f_i vanishes, and the subset N_i of K_i invariant under f_i. The limit sets for inputs with (roughly speaking) dwell-time are contained in the union of the N_i, and the limit sets for general inputs are contained in the union of the K_i. Consequently the asymptotic properties of such systems are entirely encrypted in the geometry of the N_i's, or the K_i's, according to the kind of inputs we consider. In the case of two asymptotically stable linear vector fields the asymptotic properties are also related to the observabiliy properties of a related system, generally much smaller. To finish we show that a system which is asymptotically stable for dwell-time inputs but not GUAS possesses trajectories that converge to the origin as slowly as wanted, but that with a fixed dwell-time an exponential convergence rate is obtained. These last two results can be partially extended to non linear systems.

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MS51

Time-Zero Controllability and Density of Orbits for Quantum Systems

For a bilinear finite dimensional closed quantum system on the sphere S^{2n-1} we study under which conditions we can control the system in an arbitrary small time. This study is based on representation theory of su(n) and on the equivalence between approximate and exact controllability for finite dimensional quantum systems, that has been recently proved. One interesting fact is that, without additional hypotheses, this result does not extend to the Schroedinger equation as a PDEs.

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MS51

Theoretical and Numerical Aspects in Control of Open Quantum Systems

We address the problem of controllability of quantum systems interacting with an engineered environment,with dynamics described by a non-Markowian master equation. The manipulations of the dynamics is realized with both a laser field and a tailored non-equilibrium, and generally time-dependent, state of the surrounding environment. Lie algebra theory is used to characterize the structures of the reachable state sets and to prove controllability. In order to ensure certain physical properties of the quantum systems optimal control problem are formulated and solved using an optimization algorithm. The results are supported by examples.

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MS51

Sparse Time-Frequency Control of Quantum Systems

We propose an optimal control framework to generate control fields with a very simple time-frequency structure. We achieve this by using cost functionals in the time-frequency plane that enhance sparsity in frequencies and smoothness in time. Mathematically this is realized by working in a space of function-valued measures. I will give an outline of the proposed control framework, will discuss first order optimality conditions and present numerical results for an example from molecular control.

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MS51

Quantum Filtering and Parameter Estimation

Open quantum systems subject to measurement backaction and decoherence are described by stochastic master equations. We present here a quantum filtering process, based on the measurement outcomes, to discriminate between different parameter values and we prove its stability. Numerical implementations on simulated and experimental data illustrate the interest of this estimation method.

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MS52

Semidefinite Programming for Stochastic Control

We formulate constrained stochastic control problem as an infinite dimensional linear program. We use semidefinite programming (SDP) to approximate the primal and dual linear program. As such, we approximate the value function of the optimal control problem from the primal linear program and we approximate the optimal policy from the dual linear program. We discuss computational tractability of the SDP algorithm. Furthermore, we illustrate the approach on a few benchmark case studies.

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MS52

Inference and Stochastic Optimal Control

The path integral control theory describes a class of control problems whose solution can be computed as an inference computation. The efficiency of the inference computation is related to the proximity of the sampling control to the optimal control. This forms the basis of a novel adaptive sampling procedure. The adaptive sampling procedure can be used to compute optimal controls as well as to accelerate other Monte Carlo computations.

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MS52

Randomized Methods for Stochastic Constrained Control

We address finite-horizon control for a stochastic linear system subject to constraints on control input and state. A control design methodology is proposed where the tradeoff between control cost minimization and state constraints satisfaction is decided by introducing appropriate chance-constrained problems depending on some parameter to be tuned.From an algorithm viewpoint, a computationally tractable randomized approach is proposed to provide an approximate solution with probabilistic guarantees about its feasibility for the original chance-constrained problem.

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MS52

Learning in Mean-Field-Type Teams and Games

We consider mean-field-type stochastic games with continuous action spaces. We show that one can achieve target actions as risk-sensitive team optima and equilibria without knowing the underlying payoff functions. Furthermore, under fairly general settings on Brownian-driven state dynamics, one can efficiently approximate risk-sensitive mean-field optima in (expected) Hamiltonian potential games and in games with monotone sub-gradient (expected) payoffs. We then focus on speedup model-free learning techniques. Our result builds upon various uncertainty quantification and variance reduction techniques.

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MS53

Symbolic Regression for the Modeling of Control Functions

Abstract not available.

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MS53

Low-Complexity Stochastic Modeling of Turbulent Flows

Second-order statistics of turbulent flows can be obtained either experimentally or via direct numerical simulations. Due to experimental or numerical limitations it is often the case that only partial flow statistics are reliably known. Thus, it is of interest to complete the statistical signature of the flow field in a way that is consistent with the known dynamics. We formulate a convex optimization problem that addresses this challenge.

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MS53

Crom-Based Closed-Loop Control of a Canonical Separated Flow

Abstract not available.

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MS53

Closed-Loop Turbulence Control Using Machine Learning

Abstract not available.

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MS54

Practical Advances in Data-Driven Koopman Spectral Analysis and the Dynamic Mode Decomposition

The dynamic mode decomposition (DMD) is a technique for approximating the Koopman operator and extracting dynamical descriptions of a system from observed snapshot data. Here, we present several variations of DMD that facilitate Koopman spectral analysis in practical contexts involving large, streaming, and/or noisy datasets. We also show that extending DMD to include additional observables can yield more authentic Koopman-based descriptions. Each DMD method will be demonstrated on numerical and experimental fluids data.

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MS54

Application of the Koopman Operator to Differential Positivity

Differential positive systems are systems that infinitesimally contract a given cone field. Under mild assumptions, their solutions asymptotically converge to a one-dimensional attractor, which must be a limit cycle in the absence of fixed points in the limit set. We use the spectral properties of the Koopman operator to show a converse theorem for differential positivity: every system is differentially positive in the basin of attraction of a hyperbolic limit cycle.

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MS54

Koopman Operator Theory for Dynamical Systems and Control Practice

We discuss current theory and practice of applications of Koopman operator methods in dynamical systems and control and its relationship with computational methods. The approach has recently been extended to associate geometrical objects such as isochrons and isostables - using level sets of Koopman eigenfunctions. We will also discuss the relationship between numerical methods such as Dynamic Mode Decomposition and Koopman Mode Decomposition, and extensions of theory to stability of nonlinear systems and control.

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MS54

Koopman Spectral Analysis for Estimation, Forecasting and Detection

The dynamics of observables or system outputs defined on state space of a (nonlinear) dynamical system evolve linearly in time in Koopman spectral representation. We exploit this property to construct a linear time invariant system for output evolution, and thereby develop a framework for exploiting linear system estimation, detection and control theory for nonlinear systems. We demonstrate our framework for modeling and forecasting of time series data, estimating missing sensor data, and anomaly detection.

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MS55

Pontryagin Maximum Principle for Control Systems on Infinite-Dimensional Manifolds

We present a proof of Pontryagin's Maximum Principle for control problems on infinite-dimensional Banach manifolds. Our proof makes use of techniques of nonsmooth analysis, demonstrating their utility even for smooth problems. In addition, we introduce the technique of Lagrangian charts for geometric problems of dynamic optimization and discuss an interesting constraint qualification. Failure of this constraint qualification implies the abnormal case of the Maximum Principle, while its presence allows removal of endpoint constraints through penalization.

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MS55

A Maximum Principle for Implicit and DAE Systems

The presentation focuses on a nonsmooth maximum principle for problems involving implicit control systems. The starting point is a known result in *Optimal Control with Mixed Constraints* by [Clarke et all, in SIAM J. Control Optimization, 2010]. We first extend this result to cover some situations where less regularity is assumed. We then illustrate the special features of this result, in the smooth and nonsmooth case, with some simple examples. In particular, we apply it to some special cases, namely control systems involving semi-explicit differential algebraic equations.

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MS55

Necessary and Sufficient Conditions for Invariance of Time Delayed Systems

In this talk we will present necessary and sufficient conditions of invariance for time delayed systems parametrized by differential inclusions. Weak invariance properties will be presented as well as our progress towards characterizing strong invariance in this setting. In addition, we will explain the effects of our results towards developing a Hamilton-Jacobi theory for the minimal time problem under time delayed constraints.

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MS55

An Adaptive Mesh Refinement Algorithm for Optimal Control Problems

When solving nonlinear optimal control problems via direct methods, the time interval is discretized and, most frequently, equidistant-spacing meshes are used. However, to achieve the desired accuracy in nonlinear problems, these meshes might have a large number of nodes which, in some cases, prevent the optimizers to find an adequate solution. We propose an adaptive time-mesh refinement algorithm, considering different levels of refinement and several mesh refinement criteria. In particular, the local error of the adjoint multipliers is chosen as a refinement criterion. This error can be computed efficiently by comparing the solution to a linear differential equation system – the adjoint equation of the maximum principle – with the numerically obtained dual variables. Finally, we extend this refinement algorithm to solve a sequence of optimal control problems in a Model Predictive Control (MPC) scheme. We apply the developed scheme to a problem involving manoeuvres of nonholonomic vehicles with state constraints. We show that the refinement technique leads to numerical results with higher accuracy and yet with lower overall computational time, when compared with alternative methods.

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MS56

Null Controllability of Grushin and Kolmogorov Equations

From the controllability viewpoint, degenerate parabolic partial differential equations have interesting features. Depending on the strength of the degeneracy, null controllability may hold or not; it may also require a geometric condition and a positive minimal time. In this talk, proofs will be explained on prototype equations of Grushin and Kolmogorov type.

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MS56

A Control Condition for a Weak Harnack Inequality

We introduce a condition allowing to get a weak Harnack inequality for nonnegative solutions to linear second order degenerate elliptic equations of X-elliptic type. Roughly speaking, our condition requires that the Euclidean balls of small radius are representable by means of X-controllable almost exponential maps. Our results apply to Δ_λ-Laplacians (e.g., Grushin-type operators) as well as to Elliptic Operators on Lie groups (e.g., Sub-Laplacians on Carnot groups).

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MS56

The Minimal Control Time for Degenerate Parabolic Equations of Grushin Type

We control degenerate parabolic equations of Grushin type: $\partial^2_{xx} + V(x)\partial^2_{yy}$ on the rectangle $(x, y) \in (-1, 1) \times (0, 1)$, where $V \geq 0$ vanishes only on the line $x = 0$. Our input is a source term supported on parallel strips on each side of this line. Previous works with $V(x) = |x|^{2\gamma}$ proved that null controllability fails for $\gamma > 2$, holds arbitrarily fast for $\gamma \in (0, 1)$, and requires a positive minimal time for $\gamma = 1$. We prove that this time is the distance of the control strips from the degeneracy line $x = 0$ computed using the Agmon metric $V(x)dx^2$ instead of dx^2.

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MS56

Intrinsic Random Walks and Diffusion in Sub-Riemannian Geometry

In Riemannian geometry, a possible definition of the Laplace-Beltrami operator is as the generator of the diffusion obtained as the limit of geodesic random walks. This coincides with the usual divergence of the gradient. We discuss how to extend these definitions in sub-Riemannian geometry, where it is not clear what is an intrinsic random walk and what is an intrinsic volume. Joint work with U. Boscain and R. Neel.

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MS57

L_2-Induced Gains of Switched Linear Control Systems

In this talk, we present results on L_2-gain issues related to linear control switched systems. For that purpose, we introduce several concepts of extremal norms in the spirit of the well-known Barabanov norm. Joint work with P. Mason and M. Sigalotti.

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MS57

A Hamilton-Jacobi Approach to Barabanov Norms of Positive Linear Systems

We study switched positive linear systems, and show that for these systems, Barabanov norms are equivalent to weak-KAM solutions of a class of Hamilton-Jacobi PDE. Then, we discuss the application of PDE or semigroup methods to establish the existence of Barabanov norms, exploiting controllability conditions or contraction properties in Hilbert's projective metric. We investigate the asymptotic behavior of optimal trajectories of the associated control problem.

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MS57

Resonance of Extremal Norms, Marginal Instability, and Sublinear Growth

We analyse the marginal Instability of switching linear systems, both in continuous and discrete time. That is, we are interested in situations where the system is not stable, but all trajectories grow less than exponentially. We disprove two recent conjectures of Chitour, Mason, and Sigalotti (2012) stating that for generic systems, the resonance is sufficient for marginal instability and for polynomial growth of the trajectories. We provide an efficient characterization of marginal instability under some mild assumptions on the system. Finally, we analyze possible types of fastest asymptotic growth of trajectories. An example of a marginally unstable pair of matrices with sublinear growth is given. This is joint work with V. Protasov.

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MS57

Extremal Norms and Linearization Principles for Monotone Systems

Extremal norms characterize the exponential growth rate for several classes of systems that model time-varying uncertainty, such as discrete or differential inclusions, or ot use a different terminology switched disrete-time, continuous-time or differential-algebraic systems. For linear inclusions that leave a cone invariant it can be shown under a mild irreducibility condition that extremal norms exist that respect the order induced by the cone, i.e. the extremal norms are monotone. On the one hand this provides a new criterion for the existence of extremal norms, which as corollaries provides new insight in robustness, stability and sensitivity results that have known proofs relying on the properties of extremal norms. A further application of interest is particular to the case of cone-invariance. Linear inclusions that leave a cone invariant occur naturally as the linearization at fixed point of differentiable monotone inclusions. It turns out that the use of extremal norms in the local stability analysis at fixed points yields sharp stability estimates for monotone inclusions, which extend classical results available for time-invariant monotone dynamical systems.

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MS58

An Optimal Device Placement Approach for Semi Linear Pde Systems over Irregular Spatial Domains

A methodology is presented for placing actuating and sensing devices with respect to power criteria for semi-linear PDE process systems over irregular spatial domains. The PDE is discretized using nonlinear Galerkin's method with statistically-derived basis functions, Laplace transforms and singular perturbation arguments. A non-convex NLP is then formulated and solved using an interior point global search algorithm. The methodology is illustrated on the placement of sensing devices for an environmental process.

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MS58

Networked Control of Spatially Distributed Systems Using Quantized and Delayed Sensing and Actuation

This work considers the stabilization of spatially-distributed systems with low-order dynamics, using networked sensors and actuators subject to quantization and communication delays. A finite-dimensional model-based controller that explicitly compensates for communication disruptions and delays is designed, and its closed-loop stability properties under sensor/actuator quantization are characterized using Lyapunov techniques. This characterization is used to develop sensor/actuator reconfiguration strategies that mitigate the impact of delays and quantization on performance. The results are illustrated through numerical simulations.

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MS58

Sensor Location in Feedback Stabilization of the Boussinesq Equations

In this talk, we discuss the problem of sensor placement in feedback stabilization of a thermal fluid described by the Boussinesq equations. This problem is motivated by the design and operation of low energy consumption buildings. We apply the MinMax compensator design to obtain a reduced-order observer for state estimation based on the geometric structure of feedback functional gains. A two dimensional problem is employed to illustrate the theoretical and numerical results and to demonstrate the feasibility of this method.

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MS58

Shape Optimization for Second-Order Systems

Modern materials mean that it is possible to provide passive damping for vibrations. Consider choosing viscous damping in abstract second-order systems; that is choose $d(x)$ in

$$\ddot{w}(x,t) + A_o w(x,t) + d(x) I \dot{w}(x,t) = 0$$

where A_o is a non-negative self-adjoint operator. The motivating example is a vibrating beam or string where patches are placed to increase viscous damping. Optimal damping in a vibrating string has been studied by many researchers; for instance Cox and Zuazua (1994), Fahroo and Ito (1997), Hébrard and Henrot (2005), Privat *et al* (2013). The approach of Morris (2011) is extended to obtain new results, which also apply to first order systems. It is shown that minimization of a quadratic cost functional is appropriate for maximization of the decay rate. The existence of an optimal actuator location depends on the continuity of the generator with respect to d. The results are illustrated with simulations.

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MS59

Towards Moment Matching of a Perturbed Wave PDE

Finite-dimensional approximations of partial differential equations are used not only for simulation, but also for controller design. The model reduction technique we use is the so-called time-domain moment matching method. The idea is that the steady-state response of the approximant when excited by some specific input signal matches the steady-state response of the given model, when excited by the same input. The result of applying this method is a family of parameterized approximations which contains a wide variety of models suitable for different goals. We are going to exploit this asset for boundary control systems and explore it for a particular fractional system, namely a perturbed wave equation.

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MS59

Well-Posedness of Hyperbolic Partial Differential Equations on the Semiaxis

Hyperbolic partial differential equations on the semiaxis are studied. This class of systems includes models of beams and waves as well as the transport equation and networks of non-homogeneous transmission lines on the semiaxes. The main result of this talk is a simple test for C_0-semigroup generation in terms of the boundary conditions at the point zero. The results are illustrated with several examples.

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MS59

Strong Stabilization of the SCOLE Model using a Tuned Mass Damper

We study the vibration reduction of the non-uniform SCOLE (NASA Spacecraft Control Laboratory Experiment) model representing a vertical beam clamped at the bottom, with a rigid body having a large mass on top, using a Tuned Mass Damper (TMD). The TMD is a heavy trolley mounted on top of the rigid body, connected to the rigid body via a spring and a damper. Such an arrangement is used to stabilize tall buildings. Using our recent well-posedness and strong stabilization results for coupled impedance passive linear time-invariant systems (possibly infinite-dimensional), we show the following: The SCOLE system with the trolley is well-posed and regular on the energy state space with the force or torque acting on the rigid body as input and with the speed or angular velocity of the rigid body as output, and this system is strongly stable on the energy state space.

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MS59

Waves: Observation, Control and Numerics

We present a recent result on numerical approximation of boundary-controlled wave equations. When the wave equation is discretized, most numerical schemes produce high frequency wave packets with null group velocity that do not reach the boundary, and accordingly cannot be controlled. We construct a suitable non-uniform grid, such that controllability is ensured uniformly on the mesh size parameter. This allows ensuring the convergence of the numerical approximations of the boundary controls without added filtering mechanisms.

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MS59

Exponential Stabilization of Boundary Controlled Linear Port Hamiltonian Systems with Non-linear Dynamic Control

Exponential stability of boundary controlled port-Hamiltonian systems defined on a one-dimensional spatial domain with non-linear dynamic boundary controller is addressed. For a finite-dimensional controller it is shown that the closed-loop system possesses unique solutions, and that exponential stability can be obtained. This result follows by regarding the closed-loop system as a linear boundary control system subject to a Lipschitz continuous non-linear perturbation at its boundary. By estimating the decay of energy exponential stability is proved.

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MS60

Homogenization of a Precipitation-dissolution Model in a Porous Medium

We employ homogenization techniques to provide a rigorous derivation of the Darcy scale model for precipitation and dissolution in porous media. The starting point is the pore scale model which is a coupled system of evolution equations involving a parabolic equation. This models ion transport in the fluid phase of a periodic porous medium and is coupled to an ordinary differential equations modeling dissolution and precipitation at the grains boundary (van Duijn and Pop (2004)). The main challenge is in dealing with the dissolution and precipitation rates, which involve a monotone but multi-valued mapping. In order to pass to the limit in these rate functions at the boundary of the grains, we prove strong two scale convergence for the concentrations at the microscopic boundary and use refined arguments in order to identify the form of the macroscopic dissolution rate, which is again a multi-valued function. The resulting upscaled model is consistent with the Darcy scale model formally proposed in van Duijn, Knabner, Hengst (1995).

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MS60

Quasi-stationary Approximation and Shadow Limit for Reaction-diffusion-ode Models of Biological Pattern Formation using Renormalisation Group Method

The talk is devoted to reduction of multiscale reaction-diffusion-ode models. Such systems of equations arise, for example, from modeling of interactions between diffusing signaling factors and processes localized in cells and on cell membranes. We propose a rigorous approach based on the renormalisation group (RG) approximation of singularly perturbed equations. We consider various scalings which lead to quasi-stationary approximation or shadow limits. Applicability of the reduced models to study dynamics of pattern formation is discussed on several examples from mathematical biology.

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MS60

Upscaling of Interaction of Flow, Chemical Reactions and Deformation in Heterogenous Media

Experimental research on deformable porous media, like living tissues, is providing more and more detailed information on the nano- and micro-scale and this talk we will present mathematical modeling of reactive flow and transport and its interaction transport through tissue under varying mechanical and chemical conditions. Here we consider equations on the fine scale modeling the real processes occurring in the deformable pore space, in the solid structure and in the interfaces (membranes). We are including

1. Fluid flow and diffusion, transport and reactions of the substances it transports.
2. Exchange of fluid and substances at the interfaces. Small deformation of the solid structure.
3. Changes of the structures and their mechanical properties with the flow and with the substances concentrations.

Our goal is to obtain the upscaled system modeling reactive flow through biological tissues on the macroscopic scale, starting from a system on the pore level. Using multiscale techniques, we preform the scale limit and derive a macroscopic (effective) model system, preserving relevant information on the processes on the microscopic level. One obtains in the limit a system similar to the quasi-static Biot-law but coupled with chemical reactions. Using the characteristic time scalings resulting from the analysis of the real data, we will undertake further analysis and show how the mechanics could be decoupled from the reactive flows. The modeling novelty in our paper is dependence of the Young modules, of the elastic structure, on the concentration. Consequently, the reactive flows causes the deformation. Adding diffusion, transport and reactions of chemical substances and their interaction to mechanics leads to new mathematical difficulties requiring new ideas and methods. In addition to the formal upscaling, we will give some hints about the rigorous homogenization result.

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MS60

Capturing Secondary Nucleation Effects in Becker-Doering Interactions: The Homogenization Route

We present a continuum PDE-ODE model for collagen self-assembly describing the interplay between the change in the polymer distribution and the evolution of monomers. We endow the model with periodic coefficients, where the small parameter is interpreted in this context as the ratio of lengths of monomers and fibrils. After applying a fixed-point homogenization argument and proving corrector estimates, we use the microscopic information incorporated in the first-order correctors to explain the so-called turbidity measurement. Finally, we compare qualitatively our multiscale modelling, mathematical analysis, and simulation results with experimental data. This work is a joint collaboration with B. van Lith and C. Storm (Eindhoven). See [B.S. van Lith, A. Muntean, A. Muntean: A continuum model for hierarchical fibril assembly. Europhysics Letters (EPL), 106 (2014), 08004.¡http://iopscience.iop.org/0295-5075/106/6/68004] and [O. Krehel, T. Aiki, A. Muntean: A thermo-diffusion system with Smoluchowski interactions: well-posedness and homogenisation. Networks and Heterogeneous Media 9(2014), 4, 739-762] for further reading.

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MS61

Multiobjective Optimal Control Techniques in Energy Management

We present a numerical set-oriented technique for the solution of multiobjective optimal control problems. First, the problem is transformed into a classical nonlinear multiobjective optimization problem by an appropriate discretization of the control. Then, the entire Pareto set is computed using both global subdivision and continuation methods. The functionality of the different algorithms is compared and illustrated by the optimization of *energy consumption* and *temporal performance* of an electric drive.

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MS61

Integrated Building Energy Management: Current State and Key Technology Challenges

This presentation will outline the current key research and demonstration activities of UTRC in the area of building energy management including two main demonstration efforts on buildings and HVAC modelling and control currently undertaken in the US and Ireland. The presentation will highlight the key challenges and research opportunities for the applied mathematics community that will drive the mini-symposium discussion.

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MS61

Scheduling of Multi Energy Systems: Do We Really Need a Global Optimum?

The definition of the optimal scheduling of a multi-energy system is in general a very complex and computational intensive process. On the other hand, models and inputs to the optimization are affected by significant uncertainty. Starting from these considerations, the paper analyses the role of optimality versus the role of flexibility and robustness of the solution. Theoretical considerations are combined with real life experience in the optimization of different real city quarters.

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MS61

Fault Tolerant Control of Hvac Systems for Energy Efficient Buildings

System-level or operational faults in building Heating Ven-

tilation and Air Conditioning (HVAC) systems, can have significant impact on the desired and expected building energy performance and user comfort. Fault-tolerant control systems is characterized by its capability, after fault occurrence, to recover performance close to the nominal desired performance. In this paper a method for fault decoupling in dynamic systems is presented. In an integrated design, the proposed approach is composed of two stages : The first step is the detection and isolation of the fault based on the generation of directional residuals while the second step is represented by the reconfiguration mechanism which consists in the estimation of new control parameters after evaluation of the performance degradation.

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MS62

Pontryagin Principles for Systems Governed by Functional Differential Equations

We present a new proof of Pontryagin principle for finite and infinite horizon nonlinear problems which are governed by a functional differential equation.

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MS62

Infinite-Horizon Multiobjective Optimal Control Problems for Bounded Processes

Infinite-horizon multiobjective optimal control problems for bounded processes are studied in the discrete time case. These problems are governed by difference equations or inequations. The results generalize to the multiobjective case results obtained for singleobjective optimal control problems in that framework. Necessary conditions and sufficient conditions of Pareto optimality are provided namely Pontryagin maximum principles in the strong form and in the weak form.

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MS62

On the Convexity of the Value Function for A Class of Nonconvex Variational Problems: Existence and Optimality Conditions

We study a class of perturbed constrained nonconvex variational problems depending on either time/state or time/state's derivative variables. Its (optimal) value function is proved to be convex and then several related properties are obtained. Existence, strong duality results and necessary/sufficient optimality conditions are established. Moreover, via a necessary optimality condition in terms of Mordukhovich's normal cone, it is shown that local minima are global. Such results are given in terms of the Hamiltonian function. Finally various examples are exhibited showing the wide applicability of our main results. This a joint work with F. Flores-Bazan and G. Mastroeni.

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MS62

Periodicity in Infinite Horizon Problems of Optimal Harvesting

We investigate if the optimal harvesting of single species on the infinite horizon can be proper periodic (a question intensively discussed among practitioners). Two alternative optimality concepts are used for a given objective integrand: average revenue and discounted total revenue. We show that proper (asymptotically) periodic optimal solutions may appear if the heterogeneity of the species with respect to age is taken into account. The analysis involves a "properness test" for the averaged problem and established relations between the two problems.

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MS62

Structure of Extremals of Variational Problems in the Regions Close to the Endpoints

We study the structure of approximate solutions of autonomous variational problems on large finite intervals. In our research which was summarized in Zaslavski, Turnpike properties in the calculus of variations and optimal control, Springer, New York, 2006 we showed that approximate solutions are determined mainly by the integrand, and are essentially independent of the choice of time interval and data, except in regions close to the endpoints of the time interval. In the present talk we study the structure of approximate solutions in regions close to the endpoints of the time intervals.

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MS63

An Approximate Controllability Result with Continuous Spectrum: the Morse Potential with Dipolar Interaction

This note presents a positive approximate controllability result for a bilinear quantum system modelling a chemical bond. The main difficulties are due to the presence of a continuous spectrum part for the uncontrolled Hamiltonian (modelled by a Morse potential) and the unboundedness of the interaction potential (dipolar interaction). Our proof uses averaging theory and spectral analysis.

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MS63

Inverse Problems in Quantum Control in Presence of Uncertainties and Perturbations

The inversion problem of recovering the Hamiltonian and dipole moment is considered in a quantum control framework. The inversion process uses as inputs some measurable quantities (observables) for each admissible control; however the implementation of the control is noisy (the perturbations are additive constants in a countable set of values) and therefore the data available is only in the form of the law of the measured observable. Nevertheless it is proved that the inversion process still has unique solutions (up to some phase factors). Numerical illustrations support the theoretical results.

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MS63

Controllability of the Schrödinger Equation with Three Inputs Via Adiabatic Techniques

In this talk we will present a constructive method to control the bilinear Schrödinger equation by means of three controlled external fields. This method can be used for instance to control the electromagnetic Schrödinger equation with three controlled (electromagnetic) potentials. The method is based on adiabatic techniques and works if the spectrum of the Hamiltonian admits eigenvalue intersections, with respect to variations of the controls, and if the latter are conical.

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MS63

Ensemble Controllability: Recent Results and Applications to Quantum Inversion

The controllability of bilinear systems in presence of perturbations is discussed. We give first some recent results concerning the ensemble controllability of collection of bilinear systems on connected, compact, simple Lie groups. The theoretical results are then applied to the controllability of collection of perturbed systems with perturbations being constant on at least on some common interval. The circumstance of more general perturbations (time-dependent stochastic random processes) is also discussed.

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MS64

Risk-Averse Control of Continuous-Time Markov Chains

We consider continuous time Markov process and design time-consistent risk measurement. The construction is based on discrete-time time-consistent Markov measures and their dual representation. A general constructions as well as several particular cases will be discussed.

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MS64

On Stationary Markov Perfect Equilibrium in a Risk-Sensitive Dynamic Stochastic Decision Model

A stochastic dynamic choice model with the quasi-hyperbolic discounting is analysed. WIthin such a framework agents preferences may hinge on time. This requirement, in turn, leads to a non-cooperative infinite horizon stochastic game played by a countably many selves representing him during the play. A novel feature in our approach is an application of the entropic risk measure to calculating agent's utility. As a result, we provide theorems on the existence of Markov perfect equilibria.

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MS64

Risk-Averse Control of Discrete-Time Markov Systems

We shall discuss fundamental questions of modeling risk in dynamical systems and discuss the property of time consistency and the resulting interchangeability in optimal control models. Special attention will be paid to discrete-time Markov systems. We shall refine the concept of time consistency of risk measures for such systems, introducing conditional stochastic time consistency. We shall also introduce the concept of Markov risk measures and derive their structure. This will allow to derive a risk-averse counterpart of the dynamic programming equation. Finally, we shall review solution methods and present some examples.

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MS64

A Risk-Averse Analog of the Hamilton-Jacobi-Bellman Equation

We introduce the concept of continuous-times risk measure for diffusion process. The risk-averse control problem is established via FBSDE (forward-backward stochastic differential equation) system. We derive the dynamic programming principle and prove the value function is a viscosity solution of the risk-averse Hamilton-Jacobi-Bellman equation. We also discuss the approximation scheme when the classical solution exists.

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MS65

Data-Driven Modeling and Control of Complex Systems: Sparse Sensing and Machine Learning

Abstract not available.

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MS65

Self-Tuning Electromagnetic Systems

Abstract not available.

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MS65

On Discovering Coherent Spatial-Temporal Modes from State and Control Input Histories with Special Emphasis on Infectious Disease Systems

Abstract not available.

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MS65

Enhancing Data-Driven Koopman Spectral Analysis using Machine Learning Approaches

In recent years, Koopman spectral analysis has become a popular tool for the decomposition and study of nonlinear systems. We will discuss methods that blend ideas from machine learning with Koopman-based analyses including a kernel reformulation of Extended Dynamic Mode Decomposition (Extended DMD), which is a generalization of Dynamic Mode Decomposition. We will apply these techniques to both numerically generated data, where their accuracy can be quantified, and to experimentally obtained data from fluid dynamics.

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MS66

Sliding Mode Control for Anti-Lock Braking Systems

The novel anti-lock brake algorithm is suggested. The algorithm is based on constrained extremum searching feedback via the second order sliding mode. The algorithm allows to combine anti-lock brake system or traction system with yaw antiskid control. Convergence and stability of the closed loop is proved via multimodal Lyapunov function. The yaw control algorithm developed gives additional margins of vehicle stability during adverse driving maneuvers over a variety of road conditions.

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MS66

Yakubovich's Oscillations in Systems with Discontinuous Nonlinearities

Sufficient conditions of attracting limit cycle existence for a linear system with sign nonlinearity are discussed. It is assumed that the linear part of the system is stabilizable by an output feedback, the nonlinearity has linear negative term plus positive one proportional to the output sign. Conditions of oscillation existence in the sense of Yakubovich for this class of systems are also presented.

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MS66

A Bifurcation Approach to Locate Stable Limit Cycles in Nonlinear Switched Systems and Its Application to Anti-Lock Braking Systems

If a switched system switches between nonlinear systems, then deriving effective criteria for the existence and stability of limit cycles is a difficult problem. Due to complicate friction characteristics the anti-lock braking systems (ABS) are essentially nonlinear. In this talk I propose a new approach where the limit cycle of a switched system (akin the ABS) is obtained as a bifurcation from a switched equilibrium when a suitably designed parameter crosses the bifurcation value.

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MS66

Hybrid Anti-Lock Braking System Algorithms and Switched Extended Braking Stiffness Observers:

Two Tools for Modern Braking Systems

We consider a class of anti-lock brake algorithms based on wheel-deceleration thresholds, for which we analyze the stability of limit cycles using the Poincar map. We also consider the observation of an unmeasured variable called XBS. We propose an observer design based on Burckhardt's tire model. The observer's convergence is analyzed using tools for switched linear systems. Both experiments and simulations confirm the convergence properties predicted by our theoretical analysis.

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MS67

Control and Stabilization of Degenerate Wave Equations

The control of degenerate PDE's arise in many applications such as cloaking (building of devices that lead to invisibility properties from observation), climatology, population genetics, and vision. For such equations, the diffusion operator degenerates on some subset of the spatial domain. We shall present some recent results on observability, control and stabilization of degenerate wave equations. This is a joint work with Piermarco Cannarsa (University di Roma Tor Vergata, Italy) and Gunter Leugering (Friedrich-Alexander-Universitat Erlangen-Nurnberg, Erlangen, Germany).

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MS67

Optimal Control on Reducing Carbon Emission

Abstract not available.

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MS67

Title Not Available - Souplet

Abstract not available.

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MS67

On An Optimal Control Problem Arising from Induction Heating

Abstract not available.

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PP1

Outer Synchronization of Networks with Mobile Robots

In this work, outer synchronization of coupled networks with non-identical topology is reported. In particular, outer synchronization in nearest-neighbor and small-world networks with coupled mobile robots is achieved by using complex systems theory. By means of extensive numerical simulations we show the advantages in outer synchronization of small-world networks against nearest-neighbor networks. Different cases of interest are studied for a large number of mobile robots as nodes, including network synchronization without master mobile robot, and synchronization of networks with different master-slave configurations.

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PP1

A Novel Equation Error for Direct Adaptive Control for a Class of First Order Systems with External Disturbances

A novel equation error for direct adaptive control for a class of first order systems, is studied in this paper. It is shown that the Output Error, Equation Error and the proposed equation error have different convergence speeds, transient response characteristics and the system robustness. Simulation results are used to show that the proposed equation error is very much powered in disturbance rejection and has less transient time oscillations.

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PP1

Fractional Order Pid Controller Design for Mechatronic Systems

In this paper is described the general framework of fractional order PID controller parameter tuning. The method is exemplified for two typical, basic models from mechatronic: the mass-spring-damper system and a benchmark system consisting of a DC motor, a gearbox, an elastic shaft and a load. The simulation results highlight the advantages of the method.

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PP1

Synchronization of Mobile Robots in Deterministic Small-World Networks

This work presents the network synchronization of coupled mobile robots in deterministic small-world networks. Small-world networks are ubiquitous in real-life systems. Most previous models of small-world networks are stochastic. It is known to us all, stochasticity is a common feature of complex network models that generate small-world and scale-free topologies. In particular, we consider deterministic small-world networks created by edge iterations, i.e. the networks are growing due to deterministic algorithm. The network synchronization is achieved by using complex systems theory, in which, for all reported case studies, we obtain synchronization of deterministic small-word networks by using the same coupling strength. That is, the increase of mobile robots in the deterministic networks does not affect the synchronization condition.

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PP1

Clustering Methods for Control-Relevant Decomposition of Complex Process Networks

Complex process networks are ubiquitous in chemical/energy plants, and typically cannot be controlled effectively via purely decentralized control approaches. We consider the identification of constituent sub-networks such that the components of each network are strongly connected whereas different sub-networks are weakly connected. We propose a hierarchical clustering method to generate manipulated input/controlled output clusters of varying modularity, using relative degree information to define appropriate notions of distance (closeness) between such clusters and compactness within clusters.

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PP1

Observer Design for Distributed Parameter Systems

In this paper we suggest a novel design of a nonlinear observer for distributed parameter system described by combination of partial differential equations and ordinary differential equations. The proposed observer is based on sliding mode that provides robustness to possible mismatches between the system model and the actual system. A formula for the observer gain is derived that guarantees stability and convergence of the distributed observer state to the actual system state. Several examples are considered that illustrate the approach.

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PP1

A Novel Tuning Method for Fractional Order Pid Controller

The idea of the magnitude optimum method is to find a controller that makes the frequency response from reference to plant output as close as possible to unity for low frequencies. However, the method is not frequently used in practice being sensitive to modeling errors. A novel approach is proposed in this work, using fractional order controllers, recognized for their robustness to plant gain variations. The case study is the pilot plant of ^{13}C separation.

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PP1

On Dynamics of Current-Induced Static Wall Profiles in Ferromagnetic Nanowires Governed by the Rashba Field

This article deals with the analytical study of propagation of static wall profiles in ferromagnetic nanowires under the effect of spin orbit Rashba field. We consider the governing dynamics as an extended version of Landau-Lifshitz-Gilbert equation of micromagnetism which comprise the nonlinear dissipation factors like dry-friction and viscous. We establish threshold and Walker-type breakdown estimates for the external sources in the steady regime and also illustrate the obtained results numerically.

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PP1

Construction of Hybrid Decision Processes

In the real world, we often encounter the complex phenomena which could not be analyzed only by probability theory. In order to overcome this difficulty, Li and Liu have proposed chance theory. In this paper we consider a method of constructing of a Markov-type hybrid process from stochastic kernel and credibilistic kernel and give the existence and the property of optimal policies.

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PP1

Title Not Provided - Kasimova

Randomly generated control of insects motion experimentally studied in formicarium and by mathematical model of ants foraging paths from nest to food locus [1]. Paths are impeded by barriers , viz. segments of given size, randomly centered-oriented with respect to nest-food straight line. When insects collide with the obstacle the trajectory bifurcates and the branch making an acute angle with the smell gradient is selected. Trajectories consists of 1 or 3 components. Space-realizations average travel time is evaluated.

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PP1

Model-Free Optimal Tracking Control Via Nuclear Norm Minimization

Model-based control is a two step procedure: 1) a model of the plant is identified from data, 2) a controller is synthesized using the model. Model-free control aims to find the control signal directly from the data. We show that model-free control is equivalent to Hankel structured low-rank matrix approximation and completion. The missing data in the matrix formulation is the to-be-found control signal and the approximation is the tracking error. Nuclear norm relaxation is used for numerical solution of the problem.

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PP1

Extension of the Sethi Model to the Advertising of Digital Products

In this paper, a model is formulated that modifies the Sethi model of advertising optimization to incorporate unique features present in the mobile game space. Although the optimization of advertising in traditional industries has been thoroughly studied, the optimization models used lack sufficient predictive power for several emerging market sectors. For the free-to-play video game industry in particular, there are issues that arise in the form of uncertain revenue from users and the effect of the ranking systems used for these games. This paper compares the modified and original Sethi models and it is shown how little or no advertising in the video game industry can still result in a large market share given sufficient virality parameters for the game.

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PP1

Feedback Stabilization of a Fluid-Structure Model: Theory and Numerics.

We study the stabilization of the Navier-Stokes equations in 2D around an unstable stationary solution. The configuration corresponds to a flow around a bluff body. Two beams are located at the boundary of the body and their deformations are used to stabilize the flow. The control is a force in the beam equations. We study theoretically and numerically the feedback stabilization of this system coupling the Navier-Stokes equations with the beam equations.

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PP1

Robustified H_2-Control of a System with Large State Dimension

We consider the design of an output feedback controller for a large scale system like the linearized Navier-Stokes equation. We design an observer-based controller for a reduced system that achieves a compromise between concurring performance and robustness specifications. This controller is then pulled back to the large scale system such that closed-loop stability is preserved, and such that the trade-off between the H_2- and H_∞-criteria achieved in reduced space is preserved. The procedure is tested on a simulated fluid flow study.

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PP1

Design of a Soft Sensor Based on Neural Networks for the Estimation of High Differential Pressure on High Temperature Shift Catalyst in Ammonia Production Plants

The ammonia production plants use to experience an increment of the differential pressure across the High Temperature Shift (HTS) catalyst. This issue results in reduced ammonia production due to a continuous plant rate reduction to accommodate the increasing pressure and also a solid waste formation. An alternative method for monitoring the pressure is a soft sensor based on in neural networks. In the present work, a neural network has been design and training relating the pressure (output) with a set of the process variables and kinetic of the reaction. The results indicated an accuracy of 4%. A soft control system based on the neural network has been found to substantially good for the reduction of pressure fluctuations. This kind of system can be used to prevent the same problem in any other similar ammonia plants.

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PP1

Bioeconomic Analysis Supports the Endangered Species Act

The Endangered Species Act (ESA) was enacted to restore declining natural populations. The ESA mandates species protection irrespective of costs; this translates to restriction of activities harming endangered populations. We discuss criticisms of the ESA in the context of public land management and examine under what circumstance banning non-conservation activity on multi-use lands can be socially optimal. We develop a bioeconomic model to frame the management problem and identify scenarios where ESA-imposed regulation is optimal.

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PP1

Optimal Identification of Distributed System

We seek to find effective identification algorithms for a system that involves a set of spatially distributed sensors and a fusion center. The sensors make local observations which are noisy versions of a signal of interest. Each sensor transmits compressed information about its measurements to the fusion center which should recover the original signal within a prescribed accuracy. The key problem is to identify models of the sensors and the fusion center. We show how the required models follow from the solution of the associated least squares problems.

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PP1

Controller Design for High Precision Servo Systems with Model Uncertainties, Saturations and Disturbances

This paper proposes a novel adaptive backstepping sliding mode control methodology for an X-Y high precision servo manipulation system. The control methodology is proposed for tracking desired motion trajectories in the presence of unknown system parameters, input saturations, and external disturbances. In this study, an auxiliary structure is employed to analyze the effect of input saturations, by which the proposed control scheme is successfully designed to achieve a high tracking performance in the presence of the aforementioned conditions. The stability of the closed-loop system is analyzed and the proposed control architecture is tested in real-time experiments. Finally, simulation results and experimental results are provided to illustrate the effectiveness of the proposed criteria.

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