Young Research Workshop: Abstracts

Minicourses

Andrea Boccia and Vryan Gil Palma: “On Various Aspects of MPC”
Abstract: Model predictive control (MPC) is a control design technique relying on the iterative solution of optimal control problems. Among its primary applications are stabilization and tracking problems. This course is an introduction to the theory of MPC. We will cover the main area of research starting from the basic definitions and showing, when possible, the directions of current research. Specific topics will be: stability and suboptimality of the MPC scheme using a relaxed dynamic programming approach and Lyapunov functions, multistep MPC feedback laws, feasibility and robustness issues when state constraints are present and numerical implementation.

Cristopher Hermosilla: “Stratification and Regularity Concepts”
Abstract: The main objective of this mini course is to give a brief overview about stratification and regularity notions of nonsmooth analysis for sets. The plan is to give formal definitions as well as many examples.
The lecture will start by motivating the interest of considering stratifiable sets and their relation with the optimization theory. Then, a quick review about normal and tangent cones is given. Afterwards, different notions of regularity for stratification are going to be presented, among them the classical Whitney conditions and other more recents. The final part consists in discussing about the classes of sets which are stratifiable and in presenting some open questions in the field.

Dante Kalise: “Essentials of Reduced Order Modeling for Control Design.”
Abstract: The dimension of the underlying dynamics always constitutes a major bottleneck in control systems design. A powerful tool to circumvent this limitation is the use of reduced order modelling techniques, which aim at synthesizing the most relevant features of a given dynamical system in a manifold of lower dimension. The aim of this minicourse is to present some introductory ideas concerning the approximation of large-scale dynamical systems, in connection to the implementation of different control strategies. We will review some basic algorithms for model reduction such as Balanced Truncation and Proper Orthogonal Decomposition, and we will illustrate its use in the context of feedback controls and optimal control of partial differential equations.

Athena Picarelli and Francisco Silva: “An introduction to stochastic optimal control”
Abstract: In the first part, the notions of probability space, filtration, Brownian motion and stochastic differential equation are recalled. The optimal control problem is introduced and results on the existence of optimal controls are presented. A simple proof of a basic Pontryagin principle will be provided using the familiar Lagrange multiplier rule. The second part is devoted to the solution of the optimal control problem via the Dynamic Programming approach. A proof of the Dynamic Programming Principle is provided. This leads to the characterization of the value function as a viscosity solution of a second order Hamilton-Jacobi-Bellman equation. A comparison result in the space \R^n is stated, and other cases (as Neumann or oblique-derivatives boundary conditions) are discussed. The last part of the course is devoted to numerical aspects.

Contribute Talks

Maria Soledad Aronna: "Limit Trajectories of Control Systems"

Abstract: The main purpose of the present talk is to motivate a unified notion of solution for affine impulsive control systems, which we will denote limit solution or strong limit solution when an additional approximation property is verified. Then we will compare such notion of solution with others presented in the literature, paying particular attention to the case in which the system is commutative.

Juan Pablo Maldonado: "Discrete time mean field games"

Abstract: We present a model for discrete time mean field games and discuss some of the advantages/disadvantages of our model with respect to continuous time mean field games.

Marco Mazzola: "Impulsive feedback controls"

Abstract: In this talk I will illustrate with several examples that some mechanical models bring to the study of impulsive control systems, where the control functions are in feedback form. When the evolution equation depends linearly on the time derivatives of the control, the notion of graph completion can be extended to feedback controls. We will see how this notion allows to investigate solutions of impulsive feedback control systems under appropriate assumptions.

Teresa Scarinci: "A new approach to Mayer problems for differential inclusions."

Abstract: A more general representation to model control systems is the one that describes a control system as differential inclusions, instead of the well-known parametrized form introduces by Pontryagin. It is well-known the possibility of parameterize multifunctions, but the existence of smooth one is still a very challenging open problem. We will face typical issues that arise in nonparameterized control systems, discussing the Mayer problem. Our structural assumptions are not influenced by any particular parameterization of the problem, but they are given directly on the multifunction (in the Hamiltonian form). We will discuss of first-order necessary optimality conditions and sufficient conditions for the the regularity of the value function.

Mario Zanon: "Numerical methods for NMPC and MHE"

Abstract: Many control applications need to deal with nonlinear, unstable and constrained processes. Nonlinear Model Predictive Control (NMPC) can explicitly handle nonlinear dynamics while enforcing mixed state and input constraints by solving on line an optimal control problem (OCP). In the past, the computational burden of solving an OCP has limited the application of NMPC to slow processes. Recent algorithmic advances allow to reduce the computational times to a few milliseconds, making it possible to apply NMPC also to fast mechatronic systems. Moving Horizon Estimation (MHE) is an observer that performs on line state estimation by formulating it as an optimization problem. The MHE and NMPC problems share a similar structure and can be solved by using the same algorithms.

Invited Talks

Mohammad Hassan Farshbaf-Shaker: "Relating phase field and sharp interface approaches to structural topology approximation"
Abstract: A phase field approach for structural topology optimization which allows for topology changes and multiple materials is analyzed. First-order optimality conditions are rigorously derived and it is shown via formally matched asymptotic expansions that these conditions converge to classical first-order conditions obtained in the context of shape calculus. Finally, we present several numerical results for mean compliance problems and a cost involving the least squares error to a target displacement.

Dietmar Hömberg: "Sufficient optimality conditions for a semi-linear parabolic system related to multiphase steel production"
Abstract: Multiphase steels combine good formability properties with high strength and have therefore become important construction materials, especially in automotive industry. The standard process route is hot rolling with subsequent controlled cooling to adjust the desired phase mixture. In the first part of the talk a phenomenological model for the austenite-ferrite phase transition is developed in terms of a nucleation and growth process. The model is coupled with an energy balance to describe the phase transitions on a run-out tasble after hot rolling. Here, the most important control parameters are the amount of water flowing per time and the feed velocity of the strip. The spatial flux profile of the water nozzles has been identified from experiments.
Since the process window for the adjustment of the phase composition is very tight, the computation of optimal process parameters is an important task also in practice. This is discussed in the second part of the talk using a classical optimal control approach, where a coefficient in the Robin boundary condition acts as the control. I will discuss necessary and sufficient optimality conditions, describe a SQP-approach for its numerical solution and conclude with some numerical results.
(joint wok with K. Krumbiegel and N. Togobytska, WIAS)

Jürgen Sprekels: "Introduction into the optimal control of PDEs"
Abstract: In this talk, a brief tutorial on optimal control problems for elliptic boundary value problems is given. Fundamental aspects such as differentiability of the control-to-state operator, first-order necessary and second-order sufficient optimality conditions, and (if time permits) of the occurrence of measures in the adjoint system if pointwise state constraints are given, will be touched.