Four-Day Summer School on

Direct Methods for Optimal Control of Nonsmooth Systems

September 12-15, 2023
University of Freiburg

For industrial and academic researchers, in particular PhD and master students in mathematics, engineering, physics, and computer science.

Registration link https://cloud.syscop.de/apps/forms/L7M4TX4PAMpg2jf4

Event page: https://www.syscop.de/teaching/ss2023/summer-school-direct-methods-optimal-control-nonsmooth-systems

universität freiburg

This four-day intensive course aims to provide both theoretical background and hands-on practical knowledge in formulating and numerical methods to solve optimal control problems with nonsmooth differential equation models with switches and state jumps. Nonsmooth dynamical systems arise in robotics, chemical engineering, biology, mechatronics, aerospace, or as soon as some if-else statements, switches, and state jump are encoded in the systems' dynamics.

Teachers and organizers: Prof. Dr. Moritz Diehl, Prof. Dr. Christian Kirches (TU Braunschweig), Armin Nurkanović, Jonathan Frey, Anton Pozharskiy

Content: This course provides an introduction and overview of recent advances in numerical methods for solving optimal control problems with switched, nonsmooth and hybrid dynamical systems. We will provide a recap of direct methods for optimal control problems with smooth differential equations, which serve as a basis for tailored methods for the nonsmooth case. We discuss some non-obvious pitfalls and limitations that arise with the application of standard methods to nonsmooth optimal control problems. An overview and classification of the different types of nonsmooth and hybrid systems will be provided. The course will also cover the time-freezing reformulation, which enables exactly reformulating systems with state jumps into switched systems, simplifying their numerical and theoretical treatment. We provide a detailed exposition of tailored methods for the time discretization of nonsmooth systems, with a focus on the Finite Elements with Switch Detection (FESD) method. In contrast to standard methods, it enables the correct computation of numerical sensitivities and high simulation accuracy. After the time-discretization of optimal control problems with nonsmooth systems, one usually has to solve Mathematical Programs with Complementarity Constraints (MPCCs). The course will cover the theory and solution methods for MPCCs. The lectures are accompanied by computational exercises. After this course you will be able to formulate and numerically solve optimal control problems subject to nonsmooth and hybrid dynamical systems.

Prerequisites and Workload: The course is self-contained and can be followed by all quantitative scientists with basic mathematical background (calculus, optimization, and linear algebra). It is recommended for both industrial and academic practitioners of control

universität freiburg

and optimization as well as for master and PhD students of engineering, computer science, mathematics, and physics.

Software: All lecture topics are accompanied by intensive computer exercises, for which we use the free and open-source optimization environments CasADi (https://web.casadi.org/) and NOSNOC (https://github.com/nurkanovic/nosnoc, https://github.com/FreyJo/nosnoc_py).

Registration Details

Participation fee: 200 EUR.
Registration Link: https://cloud.syscop.de/apps/forms/L7M4TX4PAMpg2jf4
Deadline: 12.08.2023

Please notice that the participation will be limited to approximately 50 people (first come first serve). You will receive the payment details for your registration via Email. The fee will cover, among others, the expenses for the catering, the welcome reception, and the dinner.

Location and Schedule: The course takes place from Tuesday, September 12, 2023, to Friday, September 15, 2023, from 9:00-17:30, in the main historical university building in the city center of Freiburg (Kollegiengebäude I, HS 1015, Platz der Universität 3, 79098 Freiburg).
Contact: Armin Nurkanović (armin.nurkanovic@imtek.uni-freiburg.de)

This course has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No. 953348 and from the Bundesministerium für Wirtschaft und Klimaschutz (BMWK.IIC6) via the project EnEff:Wärme: WOpS - Wärmefluss-Optimierung zur Sektorenkopplung in Fernwärmenetzen mitttels MPC unter Berücksichtigung eines strommarktorientierten Betriebes, Teilvorhaben: Modellierung, Simulation und Betriebsführung, with the project number 03EN3054A.

universität freiburg