OPTEC
K.U.Leuven Optimization in Engineering Center

Numerical optimization:
concepts, algorithms and applications in process modeling and control.

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Scope: Numerical optimization is a key element in today's industry. For a variety of industrial processes numerical optimization algorithms enable (i) to systematically build accurate process models which predict process measurements as good as possible and (ii) based on the developed models to effciently find the best design and/or operation given practical restrictions. These processes can range from the manoeuvering of a robot arm over the driving of a car to the production of (bio)chemicals in (bio)reactors. This course will introduce the concepts of numerical optimization and developments in view of process modeling and control. State-of-the-art algorithms and software will be presented. In addition all the concepts, ideas and software are illustrated based on case studies from (bio)chemical, mechanical and thermal engineering.

Aim: In this short course students learn about the general concepts and ideas underlying mathematical optimization. They get in touch which current state-of-the-art numerical software for fast gradient based optimization approaches (using e.g., Matlab, Python, ACADO, …). In view of process modeling and control, they learn about the concepts of offline and online dynamic optimization. Practical sessions provide the students with a hands-on illustration of the presented approaches.



Content:

Part I: Theory

- General intro on (nonlinear) optimization (4h):
  - Formulation and concepts
  - Classification of optimization problems
  - Necessary conditions for optimality
  - Numerical algorithms: concepts, (dis)advantages & illustration
- Optimization for process modeling (2h):
  - Parameter estimation using least squares
  - Statistical background
  - Numerical algorithms: concepts, (dis)advantages & illustration
- Optimization for process control (4h):
  - Offline optimal control / dynamic optimization:
    - Formulation and concepts
    - Approaches: single shooting, multiple shooting and collocation
    - Illustration: (bio)chemical reactor operation
  - Online optimal control / dynamic optimization ((Nonlinear) Model Predictive Control):
    - Formulation and concepts
    - Illustration: water reservoirs and distilation column
    - Real-time and hardware aspects

Part II: Practical sessions

- *Optimization for process modeling: parameter estimation (2h)*
- *Optimization for process control: linear model predictive control (2h)*
- *Optimization for process control: off- and online nonlinear model predictive control (2h)*