Systems Optimization

Winter Semester 2016
Technische Universität Ilmenau
Faculty of Computer Science and Automation
Institute of Automation and Systems Engineering
Dept. of Simulation and Optimal Processes

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Lectures: Thursday 11:00 - 12:30, Room: Sr K 2002A
Tutorial: Friday 13:15 - 14:45, Room: Sr Oe 1118 (every week)

Course Description
The course is designed to deliver the basic mathematical principles and methods for the solution of systems optimization problems. It discusses the basic (non-heuristic) optimization strategies to obtain optimal designs and best performance from physical systems (like mechanical, electrical, mechatronic, signal & image processing, fluid dynamic, thermodynamic, etc.) arising from engineering applications. The course consists of two parts: steady-state systems optimization (Part-I) and dynamic systems optimization (Part-II). The Matlab Optimization Toolbox will be extensively used to solve optimization problems with an introduction to the GAMS optimization modeling system and the Modelica/JModelica object-oriented modeling & optimization platform.

Course Objectives: To enable the student acquire the basic skills required to model and classify optimization problems, identify the relevant optimization algorithms in order to solve real-life engineering optimization problems, and be able to analyze the viability of the obtained solutions for practical use.

COURSE CONTENT

PRELIMINARIES

1. Introduction, Motivation, and Preliminaries [2 Lecture Hours]
   - Importance of Systems Optimization
   - Mathematical Preliminaries
- Convex sets and Convex Functions

PART - I : Steady-State Optimization Problems and Applications

Methods of Unconstrained Optimization Problems [4 Lecture Hours]

2.1. First- and Second-Order Optimality Conditions
2.2. The Method of Steepest Descent
2.3. The Newton Method
2.4. The Levenberg-Marquardt Method
2.5. Quasi-Newton Methods
2.6. Line-search Methods
2.7. Solution Methods for Systems of Nonlinear Equations

Methods of Constrained Optimization Problems [3 Lecture Hours]

3.1. The Karush-Kuhn-Tucker Optimality Conditions
3.2. Convex Optimization Problems
3.3. Penalty Methods
3.4. Barrier and Interior-Point Methods
3.5. The Sequential Quadratic Programming (SQP) Method

Part-II: Dynamic Optimization Problems and Applications

6. Introduction to Dynamic Optimization
7. Numerical methods of Ordinary Differential Equations (ODEs), Differential Algebraic Equations (DAEs) and Applications [3 Lecture Hours]

7.1. Numerical methods of initial value and boundary value ordinary differential equations
    - Euler method, Runge-Kutta, BDF, implicit Runge-Kutta, single- and multiple-shooting methods, orthogonal polynomial collocation
7.3. The concept of Index in DAEs, Consistent Initialization
7.4. Numerical Methods for DAEs

8. Methods of Dynamic Optimization Problems [3 Lecture Hours]

    - Indirect Methods
8.2. Modern Methods of Dynamic Optimization - Direct Methods - Global and Local Collocation Methods

Software:

- The Matlab Optimization Toolbox
- The GAMS Optimization Solver
- The Matlab ODE Toolbox
- The OpenModelica Modeling and Simulation Environment: Https://www.openmodelica.org
• CasADi (symbolic framework for algorithmic (automatic) differentiation and numeric optimization): https://github.com/casadi/casadi/wiki

References:


• Additional references will be cited relevant to individual lecture topics.