6 ECTS

14D002

Deterministic Models and Optimization

Overview and Objectives

The main objective in this course is to give students a thorough grounding in optimization models, theory, and algorithms. The course level is introductory and the scope is broad, so only the most important and representative models and algorithms will be covered. The presented material will be closely linked to modern statistical methods like network analysis, quantile regression, and high-dimensional statistics. Students will be expected to program as well as use software for optimization.

Prerequisite reading

Students should brush up on their undergraduate calculus and linear algebra before the class. The relevant material is covered in the brush-up course.

Course Outline

Part I. Combinatorial optimization algorithms (20 hours)

- Graphs and networks
- Greedy algorithms
- Divide and conquer
- Dynamic programming
- Bipartite matching
- Max-flow min-cost problems

Part II. Continuous optimization (20 hours)

1. Linear programming
   a. formulation
   b. the simplex method
   c. duality and complementary slackness
   d. statistical examples: quantile regression, generalized linear models

2. Convex optimization
   a. convex sets and functions
   b. convex duality and KKT conditions

c. non-differentiable functions and the subgradient
d. statistical examples: modelling sparsity and other high-dimensional techniques

3. Algorithms for continuous optimization
   a. gradient descent, Newton's method for unconstrained smooth functions
   b. projected gradient descent for constrained smooth functions
   c. coordinate descent and other methods

Required Activities

Exercises, lab, project.

Evaluation

Homework exercises, Programming project, and Final exam.

Materials

Recommended Books:

J. Matousek and B. Gärtner. *Understanding linear programming*. Springer 2007.

J. Kleinberg and E. Tardos. *Algorithm design*. Addison-Wesley 2005.

S. Boyd and L. Vandenberghe. *Convex optimization*. Cambridge University Press 2004.
(also available online: http://web.stanford.edu/~boyd/cvxbook/)

T. Hastie, R. Tibshirani and M. Wainwright. *Statistical learning with sparsity*. Chapman&Hall 2015.
(also available online: https://web.stanford.edu/~hastie/StatLearnSparsity/)