1TD 184 Optimization

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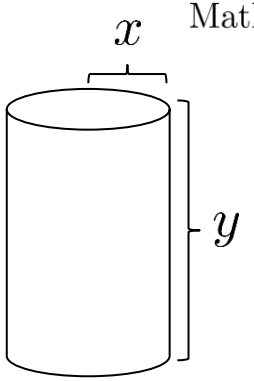
Preliminaries

- (Mathematical) optimization is about
  - Finding the “best possible” solution to a problem that is formulated mathematically
  - Use of numerical methods to compute the solution (typically iteratively)
- Example of optimization problem
  - Consider a beverage can as a cylinder
  - Suppose we wish to minimize the area (= amount of material) subject to a volume constraint; what is the optimal shape?



Mathematical formulation with optimization variables x and y

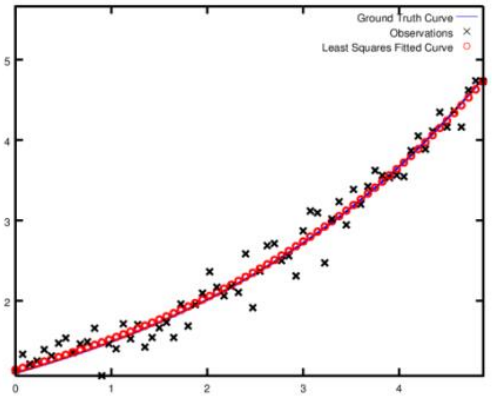
$$\begin{aligned} \min \quad & 2\pi x^2 + 2\pi xy \\ \text{s. t.} \quad & \pi x^2 y = v \qquad (v = \text{required volume}) \\ & x \geq 0, y \geq 0 \end{aligned}$$

The course in short: Modeling and methods for solving optimization problems

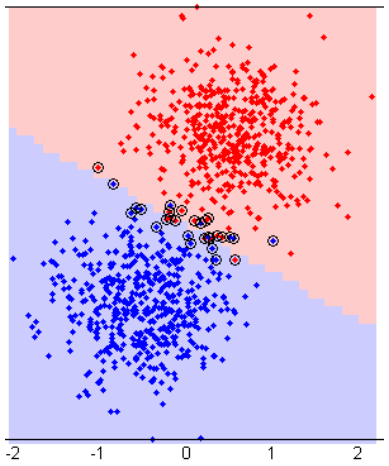
Applications of Optimization

- Data fitting
- Data clustering (in machine learning)
- Portfolio optimization
- Biology
- Logistics (e.g., crew scheduling)
- Communication networks
- … and many, many more

Data fitting



Data sample clustering



Course Goals

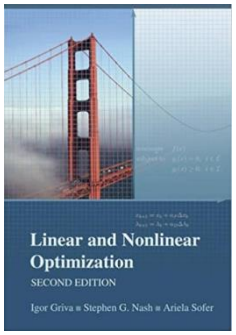
- By the syllabus, after the course you should be able to
  - formulate problems in science and engineering as optimization problems;
  - describe and explain the principles behind algorithms covered in the course;
  - explain and apply basic concepts in optimization, such as convexity, basic solutions, extreme points, duality, convergence rate, Lagrangian, KKT conditions;
  - choose appropriate numerical method for different classes of optimization problems using the methods' advantages and limitations as a starting-point;
  - choose and use software for solving optimization problems
- At a more general level, you should be able to do the following in your future career
  - **Estimate (roughly) the work necessary** to accomplish an optimization task
  - **Foresee difficulties** in different problem formulations
  - Know **what can be accomplished** with optimization
- Theoretical level
  - Lower than if given at the mathematics department
  - Higher than if given as an applied course

Course Content

Four blocks

- Introduction and basics
- Unconstrained optimization
- Constrained optimization
- Linear programming (a special type of constrained optimization)

Literature



- Lecture material
- (The Internet)
- Textbook: I. Griva, S. G. Nash, and A. Sofer. *Linear and Nonlinear Optimization*, 2nd edition, 2009

Structure and Examination

- 12 lectures
- 5 problem-solving sessions
- 3 seminars

- Assignments (2 credits); solutions to be presented in the seminars or hand-in reports
- Exam (3 credits): Focus on understanding rather than “number crunching”