DM872

Mathematical Optimization at Work

Introduction

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Outline

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Who is here?

31 registered in BlackBoard

Prerequisites

- Programming
- Linear Algebra
- Linear and Integer Programming (DM545/DM871)

from DM545 (5 ECTS)
who??

- Math-economy
- Others?

from DM871 (5 ECTS)
who??

- Computer Science (Master)
- Applied Mathematics
- Others?

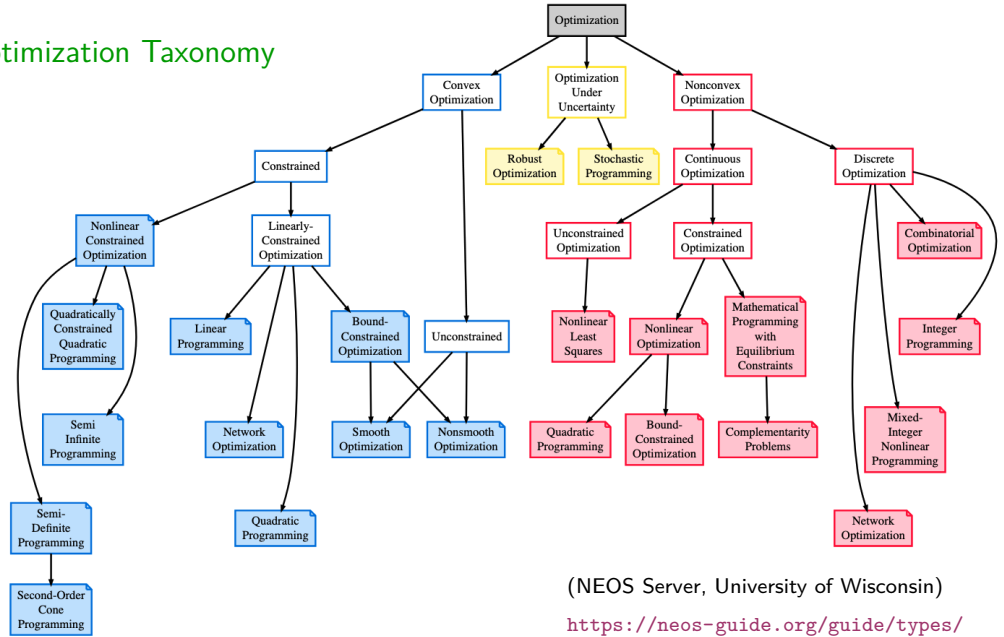
Aims of the course

Learn about solving large scale, real-life problems with mixed integer linear programming:

- **advanced techniques** for integer linear programming
- applications
- implementations

$\rightsquigarrow$ You will see the theory and apply the tools learned to solve real life problems using computer software

Optimization Taxonomy



(NEOS Server, University of Wisconsin)

https://neos-guide.org/guide/types/

https://docs.mosek.com/modeling-cookbook/

Contents of the Course (aka Pensum)

Advanced mixed integer linear programming techniques

0 LP and ILP Recap
1 More on Modeling
2 Cutting Planes
3 Dantzig-Wolfe decomposition
4 (Delayed) Column generation
5 Branch and price
6 Lagrangian relaxation
7 Matheuristics

Applications

7 TSP
8 Vehicle Routing
9 Vehicle Scheduling
10 Crew Scheduling
11 Machine Learning
12 Educational Timetabling

Practical Information

Teachers: Marco Chiarandini (imada.sdu.dk/u/march/)
Konstntin Pavlikov Instructor: None

Alternative views of the schedule:

- mitsdu.sdu.dk, SDU Mobile
- Official course description (læserplanen)
- https://dm872.github.io

Schedule:

- Scheduled 16 x 4 = 64
- Officially introductory classes: $\sim$ 26 hours ($\sim$ 13 classes)
- Officially training classes: $\sim$ 20 hours ($\sim$ 10 classes)
- We try to finish at the beginning of May, 3,4 weeks earlier than scheduled.

In practice, no distinction between classes, they are all common and with possible hands on activities.

Communication Means

- ItsLearning (LMS) $\Leftrightarrow$ Main/Public Web Page (WP)
  (link `https://dm872.github.io`)
- Announcements + Slides in BlackBoard
- Ask peers
- Write to Marco (`marco@imada.sdu.dk`)
- You are welcome to visit me in my office in working hours (9-17)

Course Material

Public Web Page (WP) is the main reference for list of contents

It contains:

- list of topics and references
- exercises
- links
- resources for programming tasks

Updated daily.

Classes

- Goal: Moderate course/track material and guide learning
  - Main material is the literature and (included) exercises
  - no lecture notes beyond the slides

- Questions and discussions welcome and encouraged at any time
  - If you have questions, ideas, or disagreement: interrupt and ask!
  - Discussing and questioning what you read/hear is part of the lecture
  - Interactive means: there is a need for a responsive counterpart :)

Exercises

- We start them in class, in groups of two
- You continue and finish them as self study
- Try to occasionally gather in different groups
- Prepared tasks are starting point for engaged and self-responsible learning
- We discuss any question or idea in plenum in the class after or you ask for personal feedback in the classes

Assessment

- Two obligatory medium size projects, evaluation by external censor
- First is individual and second is in group of at most two persons
- Learning goals:
  - first, understand and apply knowledge gained in a similar context, narrow scope
  - second, analyze, select and apply an appropriate method studied to a new context, open scope. Discuss and reflect.
- (language: Danish and/or English)
- Final grade: overall evaluation but as starting point the average grade rounded up

Implementations

- Python 3.10+ (check pyenv)
- MILP specific:
  - gurobipy, Gurobi 12+ (commercial 100 000 DKK, alternatives: Cplex, Xpress)
  - SCIP Optimization Suite + PyScipOpt (Commercial alternative Gurobi or Cplex $\approx$ 100 000 Dkk)
  - Python-MIP + CBC or Gurobi 12+
  - Pyomo + Ipopt, CBC, HiGHS, Gurobi 12+, Cplex
- jupyter, jupyterLab (= interactive python) or Google CoLab
- VS Code, Spyder3.

Average Working Load

Expected 135 working hourse for 5 ECTS

- Preparations (before/after lecture): [23 classes $\times 4h$]
  Read up on non-optional material
  Use optional material or own research to close gaps in understanding

- Exercises: [$10 \times 1h$]
  Go through the weekly sheets (github)
  Solve tasks left from classes
  Discuss with peers

- Project work: [$24h + 24h$]
  Research literature, Implement, Analyse

150 hours in total. 8.2 hours per week.