OPTIMIZATION METHODS FOR MACHINE LEARNING AND QUANTITATIVE FINANCE

Aim

Optimization plays a key role in quantitative finance, both conceptual and computational. It is also the enabling technology for classical estimation procedures in statistics, as well as for fitting in machine learning. Recent developments in conic optimization and adaptive optimization under uncertainty have widened the scope of its applications. The aim of the course is to lay down solid foundations for theory and computation, illustrating the role of optimization model building for several financial applications.

Content

- Model building for portfolio optimization: mean-variance models; optimal tracking; mean-CVaR models; asset-liability management; super and quadratic hedging.
- Taxonomy of optimization models: LP, QP, MILP, SOCP, SDP, NLP.
- Complements of convex analysis: dual cones; conjugate functions.
- Duality in optimization: Lagrangian duality; conic duality; Fenchel duality.
- Numerical solution methods: simplex and interior point methods for LP; branch and bound methods for MILPs; gradient methods for NLPs.
- Paradigms for sequential decision making under uncertainty: stochastic programming with recourse; stochastic dynamic programming and reinforcement learning; robust optimization.
- Optimization and duality for machine learning: regularized regression; support vector machines; neural networks.
- MATLAB toolboxes for optimization.

Bibliography

- D. Bertsimas, D. Den Hertog. *Robust and Adaptive Optimization.* Dynamic Ideas, 2022.
- S. Boyd, L. Vandenberghe. *Convex Optimization*. Cambridge University Press, 2004. The book pdf can be downloaded from http://www.stanford.edu/_boyd/cvxbook/
- P. Brandimarte. *An Introduction to Financial Markets: A Quantitative Approach*. Wiley, 2018.
- P. Brandimarte. *From Shortest Paths to Reinforcement Learning: A MATLAB-Based Introduction to Dynamic Programming*. Springer, 2021.
- G. Cornuejols, J. Peña, R. Tütüncü. *Optimization Methods in Finance (2nd ed)*. Cambridge University Press, 2018.
- W.C. Kim, J.H. Kim F.J. Fabozzi. *Robust Equity Portfolio Management: Formulations, Implementations, and Properties using MATLAB*. Wiley, 2015.