Robust Optimization and Statistical Learning

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This course provides a comprehensive exploration of mathematical techniques and models aimed at addressing uncertainty in decision-making processes. It is structured to equip students with a solid foundation in various aspects of robust optimization, covering topics such as linear programming, nonsmooth optimization, game theory, stochastic programming, and how they come up in statistical learning. The course requires comfortable knowledge of basic concepts in calculus, probability and statistics theory, and linear algebra. Familiarity with a programming language would be beneficial.

Course overview:

- **Introduction to Robust Optimization** Definition and principles of robust optimization, distinction between uncertainty and ambiguity, overview of applications in diverse fields.
- **Generalization and Statistical Robustness** Measure concentration, generalization bounds.
- **Nonsmooth Optimization and Stability of Machine Learning models** Fundamentals of nonsmooth optimization, numerical methods, solutions stability and their consequences in machine learning.
- **Stochastic Programming and Uncertainty management** Modeling, the linear programming case, risk measures, multistage decision problems.
- **Distributionally robust modeling** Comparison with robust and stochastic optimization, ambiguity sets and worst-case distributions, numerical methods for solving DRO problems.
- **Game Theory and Adversarial Settings** Robustness concepts in game theory, equilibrium analysis under uncertainty, applications in strategic decision-making

References:

- Aharon Ben-Tal, Laurent El Ghaoui, and Arkadi Nemirovski. *Robust optimization.* Princeton university press, 2009.
- Martin Wainwright. *High-dimensional statistics: A non-asymptotic viewpoint.* Cambridge university press, 2019.
- Alexander Shapiro, Darinka Dentcheva, and Andrzej Ruszczynski. *Lectures on stochastic programming: modeling and theory.* SIAM, 2021.
- Jose Blanchet, Daniel Kuhn, Jiajin Li, and Bahar Taskesen. *Unifying distributionally robust optimization via optimal transport theory.* preprint arXiv:2308.05414, 2023.
- Martin Osborne and Ariel Rubinstein. *A course in game theory.* MIT press, 1994.