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A Gentle and Incomplete Introduction to Bilevel Optimization

Bilevel optimization is a field of mathematical programming in which some variables are constrained to be the solution of another optimization problem. As a consequence, bilevel optimization is able to model hierarchical decision making processes. This is appealing for modeling real-world problems, but it also makes the resulting optimization models hard to solve in theory and practice. The scientific interest in computational bilevel optimization increased a lot over the last decade and is still growing - in particular due to many applications in networked systems.

In this tutorial, we discuss the most important aspects that render bilevel problems more challenging than single-level optimization problems and present the basic structural theory for linear bilevel models as well as the basic techniques for solving these problems. After these basics, we discuss three recent contributions in the area of bilevel optimization: (i) the computational (in)tractability of nonlinear bilevel problems, (ii) the connections between bilevel and robust optimization, and (iii) using bilevel techniques to compute counterfactual explanations.