Incorporating competition in demand-based optimization models

Stefano Bortolomiol, EPFL

Oligopolies are markets dominated by a small number of players competing for the same pool of customers. These players are utility maximizers, and their strategic decisions are influenced by both the preferences of the customers and the decisions of their competitors. In our work, the preferences of the customers are modelled at a disaggregate level according to the random utility theory, while competition among market players is modelled as a non-cooperative game. The result is a bilevel program that models a non-cooperative multileader-follower game in which each leader solves a mathematical program with equilibrium constraints. The peculiarity of our problem lies in the integrality constraints enforced on the lower-level variables that model customer choice according to the utility maximization framework. The goal of our research is to investigate the concept of Nash equilibrium for this type of games.

Monte Carlo sampling for the probabilistic orienteering problem

Xiaochen Chou, IDSIA-USI-SUPSI

The Probabilistic Orienteering Problem is a variant of the orienteering problem where customers are available with a certain probability. Given a solution, the calculation of the objective function value is complex since there is no linear expression for the expected total cost. In this work we approximate the objective function value with a Monte Carlo Sampling technique and present a computational study about precision and speed of such a method. We show that the evaluation based on Monte Carlo Sampling is fast and suitable to be used inside heuristic solvers.

Optimized staff scheduling at Swissport

Peter Fusek, ZHAW

We present a major research and business project aimed at developing efficient and flexible software for automated airport staff rostering. Industrial partner is Swissport International, one of the largest ground handling companies worldwide. The diversity of the ground handling functions at Zurich Airport, the large number of operational duties, and the around-the-clock business hours result in hundreds of different types of shifts to be planned every month, and an employee base consisting of several thousand persons with numerous different skills. Employee scheduling typically involves a number of sub-problems. The rostering process considered here focuses on the days-off planning and shift assignment phase. The methodology used for solving the associated complex large-scale optimization problems comprises a broad range of optimization techniques including pre-processing, decomposition and relaxation approaches, large-scale integer programming models and various heuristic procedures. We present computational experience with real world instances and discuss operational impacts of the developed planning tool.

Tracking large stock-market indices

Mario Gnägi, University of Bern

Index-tracking funds aim to track the returns of a given financial benchmark index as closely as possible. These funds are attractive to investors, especially when the index is large and thus well diversified. We consider the problem of determining a portfolio for an index-tracking fund that is benchmarked against a large stock-market index subject to real-life constraints imposed by investors, stock exchanges, or investment guidelines. For this problem, we present a novel matheuristic based on a novel mixed-integer quadratic programming formulation. We tested the matheuristic on a set of problem instances based on large stock-market indices with up to more than 9,000 constituents. Our computational results indicate that within a limited computational time, the matheuristic yields very good portfolios in terms of the objective function value and out-of-sample risk-return characteristics.

Improved approximation for tree augmentation: Saving by rewiring

Christos Kalaitzis, ETH Zürich

The Tree Augmentation Problem (TAP) is a fundamental network design problem in which we are given a tree and a set of additional edges, also

called links. The task is to find a set of links, of minimum size, whose addition to the tree leads to a 2-edge-connected graph. A long line of results on TAP culminated in the previously best known approximation guarantee of 1.5 achieved by a combinatorial approach due to Kortsarz and Nutov [ACM Transactions on Algorithms 2016], and also by an SDP-based approach by Cheriyan and Gao [Algorithmica 2017]. Moreover, an elegant LP-based (1.5+ε)-approximation has also been found very recently by Fiorini, Gross, Könemann, and Sanità [SODA 2018]. In this paper, we show that an approximation factor below 1.5 can be achieved, by presenting a 1.458-approximation that is based on several new techniques.

Submodular minimization under congruency constraints

Martin Nägele, ETH Zürich

Submodular function minimization (SFM) is a fundamental and efficiently solvable problem with a multitude of applications in various fields. The most relevant constraint class under which SFM remains efficiently solvable is parity constraints, which capture problems like the odd-cut problem, and are a key tool in a recent technique to efficiently solve integer programs with a constraint matrix whose subdeterminants are bounded by two in absolute value. We show that efficient SFM is possible even for a significantly larger class than parity constraints. In particular, we can show that efficient SFM is possible over all sets of cardinality r mod m, as long as m is a constant prime power. This covers generalizations of the odd-cut problem with open complexity status, and with relevance in the context of integer programming with higher subdeterminants. Our results also settle two open questions by Geelen and Kapadia [Combinatorica, 2017] on computing girth and cogirth of certain matroids. (Joint work with Benny Sudakov and Rico Zenklusen.)

Freight railway network design problem

Nikola Obrenović, EPFL

In freight railway networks, commodities are usually transported via hubs, which are called marshaling or shunting yards, depending on their capacity. Consequently, the number and locations of these yards effect the transport costs to a great extent. The goal of our work is to reduce the freight transport and yard operation costs by determining the optimal number and locations of the yards. Therefore, we have defined an optimization problem, which integrates the hub location and multicommodity network design problems. The problem is intended for the real freight railway network of SBB Cargo. Due to the network and transport demand sizes, we are developing a heuristic algorithm to solve the problem. The algorithm combines ideas of the adaptive large neighborhood search, for the yards location task, and the prioritized passenger assignment algorithm, adapted for the task of commodities routing. In this talk, we will present the defined problem, algorithm, and preliminary results.

Lagrangian relaxation for the demand-based benefit maximization problem

Meritxell Pacheco Paneque, EPFL

The integration of discrete choice models in Mixed Integer Linear Programming (MILP) models provides a better understanding of customers' preferences to operators while planning for their systems. However, the formulations associated with choice models are highly nonlinear and non convex. In order to overcome this limitation, we propose a linear formulation of a general discrete choice model that can be embedded in any MILP model by relying on simulation. We characterize a demand-based benefit maximization problem to illustrate the use of this approach. Despite the clear advantages of this integration, the size of the resulting formulation is high, which makes it computationally expensive. We consider Lagrangian relaxation to decompose the demand-based benefit maximization problem by taking advantage of the underlying structure of the model and by discerning the decisions of the two sides involved in the problem: the operator and the customers.

Stochastic dynamic programming using optimal quantizers

Anna Timonina-Farkas, EPFL TOM

Multi-stage stochastic optimization is a well-known quantitative tool for decision-making under uncertainty, which applications include financial and investment planning, inventory control, energy production and trading, electricity generation planning, supply chain management and similar fields. Theoretical solution of multi-stage stochastic programs can be found explicitly only in very exceptional cases due to the complexity of the functional form of the problems. Therefore, the necessity of numerical solution arises. In this work, we introduce a new approximation scheme, which uses optimal quantization of conditional probabilities instead of typical Monte-Carlo simulations and which allows to enhance both accuracy and efficiency of the solution. We enhance accuracy of the estimation by the use of optimal distribution discretization on scenario trees, preserving efficiency of numerical algorithms by the combination with the backtracking dynamic programming.

Quantum risk analysis

Stefan Wörner, IBM Research - Zurich

We present a novel quantum algorithm to analyze risk more efficiently than Monte Carlo simulation traditionally used on classical computers. Quantum amplitude estimation is used to evaluate risk measures such as Value at Risk and Conditional Value at Risk on a gate-based quantum computer. In addition, we show how to implement this algorithm and how to trade off convergence rate and circuit depth. Already for a slowly increasing circuit depth our algorithm provides a near quadratic speed-up compared to Monte Carlo methods. The algorithm is demonstrated using two toy models. First, we use real hardware to measure the financial risk in a T-bill faced by a possible interest rate increase. Second, we simulate our algorithm to illustrate how a quantum computer can determine financial risk for a more complex two-asset portfolio. Both models confirm the improved convergence rate over Monte Carlo methods.

A robust optimization perspective on bilinear programming

Jianzhe Zhen, EPFL

We first consider a subclass of quadratic programming problems, that is, disjoint bilinear problems. We show that disjoint bilinear problems can be case as two-stage robust linear optimization problems with fixed-recourse and right-hand-side uncertainty, and techniques for two-stage robust optimization can be used to solve the resulting problems. To this end, a scheme based on a blending of Fourier-Motzkin elimination and linear decision rules is used. Moreover, we show that the approximation via linear decision rules for the two-stage robust optimization reformulations is in general tighter than McCormick relaxation for the original disjoint bilinear programming problems. We further extend our approach to solve general bilinear problems. Numerical experiments on Bimatrix games and concave quadratic minimization problems show that the proposed method is superior to the off-the-shelf solvers SCIP and CPLEX.