GOR Gesellschaft für Operations Research e.V.
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GOR-Arbeitsgruppe: Praxis der Mathematischen Optimierung
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Herewith, we invite you to the 95th meeting of the GOR working group "Real World Mathematical Optimization" in the Physikzentrum Bad Honnef (Hauptstr. 5, 53604 Bad Honnef, http://www.pbh.de). This meeting is hold as a symposium with the topic

Mathematical Optimization under Uncertainty

The workshop starts on November 19th, 2015 at 10:00 am and ends on November 20th at about 4:30 pm.

The working language will be preferably English, since some speakers or participants are expected from abroad.

Please note that the participation in a GOR-AG-Workshop for non-members is subject to a registration fee, unless you are a speaker or a host. Except for students, the Physics Center collects an infrastructure fee of 40 Euro/person.

Please register yourself online using https://www.redseat.de/pmo95/ as soon as possible, but not later than November 1st, 2015. The latest information on the meeting is available on the homepage of the GOR (https://gor.uni-paderborn.de/index.php?id=54).

Yours sincerely,

Josef Kallrath & Steffen Rebennack
(GOR AG) (Colorado School of Mines)

Mathematical Optimization under Uncertainty

This symposium is about real world optimization problems involving uncertainties. Uncertainties can be modeled in various different ways to be embedded into the context of exact optimization. The four most prominent methodologies are: (1) stochastic optimization, (2) robust optimization, (3) chance-constraints, and (4) fuzzy logic. Each of these different modeling techniques requires different, tailored solution methodologies. Uncertainties are present in many real world optimization problems across all industries.

This two-day event attempts to give an overview of the current state-of-the-art of mathematical optimization techniques to treat uncertainties. Please contact Steffen Rebennack (steffen.rebennack@gmail.com) or myself if you are interested to contribute a talk or a presentation.

In talks, each approx. 40 to 50 minutes, experts from practice, research institutions or software companies, will present selected problems and the corresponding solutions.

The following presentations have been confirmed (in alphabetic order):

Eckart Boege (Vattenfall Energy Trading GmbH, Hamburg, Germany)
A Lagrange Relaxation Implementation in GAMS for Stochastic Optimization Based Bidding in Day-Ahead Electricity Auction Markets (joint talk with Dr. Michael Bussieck)

Dr. Michael Bussieck (GAMS GmbH, Braunschweig, Germany)
A Lagrange Relaxation Implementation in GAMS for Stochastic Optimization Based Bidding in Day-Ahead Electricity Auction Markets (joint talk with Eckart Boege)

Hatim Djelassi (RWTH Aachen University, Aachen, Germany)
Restriction-based Algorithms for Semi-infinite Programming

Armin Gauss (Fichtner IT Consulting AG, Stuttgart, Germany)
Energy System Planning – Examples, general approach and aspects related to other industrial OR applications

Prof. Dr. Arie M.C.A. Koster (RWTH Aachen University, Aachen, Germany)
Robust Optimization for Combined Heat-and-Power Generation

Prof. Dr. Nils Löhndorf (WU Vienna University of Economics and Business, Vienna, Austria)
QUASAR: a General Purpose Solver for Stochastic Optimization

Dr. Martin Mevissen (IBM Research, Dublin, Ireland)
Decision-support Tools and Approaches for Optimization under Uncertainty

Prof. Dr. Esther Mohr (University of Mannheim, Mannheim, Germany)
On Risk Management in Newsboy Problems with Limited Information

Jennifer Puschke (RWTH Aachen University, Aachen, Germany)
Robust Dynamic Optimization with Parametric Uncertainties – A Heuristic Approximation

Prof. Dr. Steffen Rebennack (Colorado School of Mines, Golden, CO, USA)
Stochastic Optimization with Tolerance Level

Hannes Schwarz (Karlsruher Institut für Technologie (KIT), Karlsruhe, Germany)
Parallel Optimization of Decentralized Energy Systems Modelled as Large-scale, Two-stage Stochastic MIP

Jonas Schweiger (IBM Italy, Italy)
Operation and Optimization of Gas Transmission Networks

Dr. Ingmar Steinzen (ORCONOMY GmbH, Paderborn, Germany)
Supply Chain Network Design in the Automotive Industry under Uncertainty

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95. Meeting of the GOR Working Group
„Real World Mathematical Optimization"

Mathematical Optimization under Uncertainty

Physikzentrum, Bad Honnef, November 19 & 20, 2015

Thursday, Nov 19 - 2015: 10:00 – 22:00

10:00-10:05 **Opening and Welcome Session** (J. Kallrath & S. Rebennack)

10:05-10:50 **Prof. Dr. Arie M.C.A. Koster** (RWTH Aachen University, Aachen)
Robust Optimization for Combined Heat-and-Power Generation

10:55-11:40 **Prof. Dr. Nils Löhndorf** (WU Vienna University of Economics and Business, Vienna, Austria)
QUASAR: a General Purpose Solver for Stochastic Optimization

11:40-12:25 **Dr. Martin Mevissen** (IBM Research, Dublin, Ireland)
Decision-support Tools and Approaches for Optimization under Uncertainty

12:30-14:00 ------------------------------ Lunch Break -----------------------------------

14:00-14:45 **Dr. Jonas Schweiger** (IBM Italy, Italy)
Operation and Optimization of Gas Transmission Networks

14:45-15:30 **Dr. Ingmar Steinzen** (ORCONOMY GmbH, Paderborn,Germany)
Supply Chain Network Design in the Automotive Industry under Uncertainty

15:30-15:50 ------------------------------ Coffee Break -----------------------------------

15:50-16:50 ---------------- Extended Break for Discussions ---------------------

16:50-17:35 **Hannes Schwarz** (Karlsruher Institut für Technologie (KIT), Karlsruhe)
Parallel Optimization of Decentralized Energy Systems Modelled as Large-scale, Two-stage Stochastic MIP

17:35-17:50 **Internal Meeting** of the Working Group

18:00 - **Conference Dinner** – Buffet; get-together in the wine-cellar
Celebrating the 95th meeting of our GOR Working Group

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Friday, Nov 20 - 2015: 09:30 – 16:30

09:30-10:20 **Prof. Dr. Esther Mohr** (University of Mannheim, Mannheim, Germany)
On Risk Management in Newsboy Problems with Limited Information

10:20-10:50 ------------------------------ Coffee Break ---------------------------------

10:50-11:40 **Hatim Djelassi** (RWTH Aachen University, Aachen, Germany)
Restriction-based Algorithms for Semi-infinite Programming

11:40-12:30 **Jennifer Puschke** (RWTH Aachen University, Aachen, Germany)
Robust Dynamic Optimization with Parametric Uncertainties – A Heuristic Approximation

12:30-13:45 ------------------------------ Lunch Break ----------------------------------

13:45-14:35 **Eckart Boege** (Vattenfall Energy Trading GmbH, Hamburg, Germany) & **Dr. Michael Bussieck** (GAMS GmbH, Braunschweig, Germany)
A Lagrange Relaxation Implementation in GAMS for Stochastic Optimization Based Bidding in Day-Ahead Electricity Auction Markets

14:35-14:50 ------------------------------ Coffee Break ---------------------------------

14:50-15:40 **Armin Gauss** (Fichtner IT Consulting AG, Stuttgart, Germany)
Energy System Planning -- Examples, general approach and aspects related to other industrial OR applications

15:40-16:30 **Prof. Dr. Steffen Rebennack** (Colorado School of Mines, Golden, USA)
Stochastic Optimization with Tolerance Level

16:30 **Final Discussion – End of the Workshop – Coffee Break**

The Speakers

Eckart Boege studied mathematics at Friedrich-Schiller-University Jena and wrote his diploma thesis about a special case of the lot-sizing problem.

He started his professional career at a management consultancy in Dsseldorf. In 2009 he joined Vattenfall where he initially worked in the field of power/gas logistics and reserve management . After an assignment as Forecasting Analyst in Amsterdam, he moved to the Analysis department of Vattenfall Business Areas Markets.

In his current positions as Head of Operations Research he leads a team of Analysts in Hamburg, Stockholm and Amsterdam that develops dispatch optimisation and bidding support tools.

Michael R. Bussieck received a diploma degree and a PhD in Mathematics from Technical University of Braunschweig, Germany. He worked from 1998 to 2004 at GAMS Development Corp. in Washington DC, USA as a senior optimization analyst. During that time he worked on optimization projects with clients from industry (Energy, Automotive, and Chemical), the military, and government. In a joint project with ARKI Consulting (the home of the NLP solver CONOPT) he developed the MINLP solver SBB and was in charge of the GAMS/CONOPT link. Since 2004 he is a managing director of GAMS Software GmbH leading the development group for the GAMS software in Braunschweig, Germany. In addition to the development responsibilities, he frequently engages in customer optimization projects delivering cutting-edge optimization technology to clients all over Europe and the US. Michael has published in many first class optimization journals, frequently gives lectures at international conferences, and leads the academic outreach program at GAMS Software GmbH. He also serves as an member in the board of advisors of the German OR Society.

Hatim Djelassi is a research assistant at the chair of Process Systems Engineering (SVT) at RWTH Aachen University since 2014. He holds a master's degree in mechanical engineering with specializations in simulation technology and fluids technology from RWTH Aachen University. His research interests are the rigorous solution of hierarchical optimization problems and their application to optimization under uncertainty.

Armin Gauss obtained his "Diplomingenieur" in Technical Cybernetics from the University of Stuttgart in 1993 and is currently working as Project Manager and Principal Consultant at Fichtner IT Consulting. He coordinated the development of modular toolboxes for energy system planning and managed numerous projects to train and implement tools for energy system planning in utilities, in the public sector and in industrial enterprises. He has particular experience in energy system planning of large energy systems and concepts for optimizing distributed virtual energy systems.

Interests include robust solutions of practical optimization problems, large scale MIP optimization, decision support based on uncomplete information and uncertainties, multi model approach.

Arie Koster is professor of discrete optimization at RWTH Aachen University. His research interests include integer linear programming, algorithmic graph theory, network optimization, and most recently robust optimization. He has been coordinator of the BMBF project "Robust Communication Networks" and currently leads two BMBF / BMWi projects on robust optimization in telecommunciations and energy networks.

Nils Löhndorf is an assistant professor at the WU Vienna University of Economics and Business. He holds a masters degree from the University of Mannheim and a PhD from the University of Vienna.

His research interests are in applying computational stochastic optimization to solve difficult decision problems under uncertainty. Results of his research have recently appeared in Operations Research, IIE Transactions, and the International Journal of Production Economics.

Nils is the founder of the university spin-off, Quantego, which is dedicated to developing state-of-the-art stochastic optimization software to help decision-makers make better decisions in the face of uncertainty.

Martin Mevissen is the Research Manager of the Optimization and Control group at IBM Research - Ireland. He received his M.S. degree from ETH Zurich in 2007, and his Ph.D. from Tokyo Institute of Technology in 2010. His main research fields are decision-making under uncertainty, nonlinear optimization, semidefinite programming, data-driven optimization, and their applications to real-world problems - in particular those arising from power systems, water and transportation networks.

Esther Mohr is assistant professor at the University of Mannheim. She holds a diploma from Karlsruhe Institute of Technology (KIT) and a PhD from Saarland University / Max-Planck-Institute for Informatics. Esther explores to what extent companies are able to practice optimal decision-making without a complete range of relevant data. The Ministry for Science, Research and Arts Baden-Württemberg is funding her research project 'Decision-making with Limited Information'. In general, her research is concerned with the development of models and methods that provide decision support under uncertainty. Results have recently appeared in Discrete Applied Mathematics, Surveys in Operations Research and Management Science as well as Annals of Operations Research.

Jennifer Puschke is a research assistant at the chair of Process Systems Engineering (SVT) of the RWTH Aachen University since 2012. She holds a diploma degree from the RWTH Aachen University in mechanical engineering with specialization in process systems engineering. Her research interests is solving dynamic optimization problems of industrial processes with uncertainties in the parameter values with respect of real-time ability for robust control.

Steffen Rebennack is Associate Professor at the Colorado School of Mines, USA. He obtained his PhD at the University of Florida in 2010. His research interests are in dimension-reduction techniques for large-scale optimization problems, particularly with applications in power systems, stochastic optimization and global optimization. He is the vice-president of the "Real World Optimization" working group of the "German Operations Research" (GOR) society.

Hannes Schwarz is a research associate at the Chair of Energy Economics, Institute for Industrial Production (IIP), Karlsruhe Institute of Technology (KIT). In his dissertation, he focuses on modeling, optimization and analysis of decentralized energy systems under uncertainty.

Jonas Schweiger currently works as Experienced Researcher in the EU Initial Training Network MINO for IBM CPLEX Optimization in Bologna, Italy. Before joining IBM, he was research assistant at Zuse Institute Berlin where he was part of the project ForNe (Forschungskooperation Netzoptimierung), a joint project of the German gas network operator Open Grid Europe GmbH and and several academic partners. His research is motivated by the application of mathematical optimization to real world problems especially featuring uncertainty and nonlinearities. He is one the authors of the book "Evaluating Gas Network Capacities" in the MOS-SIAM Series on Optimization.

Ingmar Steinzen is Managing Director at ORCONOMY GmbH – an innovative solution provider for high-quality custom application using optimization. Prior to joining ORCONOMY, Dr. Steinzen worked as Analytic Specialist for McKinsey & Company. He received his PhD in Operations Research from Paderborn University, Germany. His main fields of expertise include supply chain optimization, scheduling, production planning and vehicle routing.

A Lagrange Relaxation Implementation in GAMS for Stochastic Optimization Based Bidding in Day-Ahead Electricity Auction Markets

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We consider the problem of building optimal bidding curves in a day-ahead energy market. A day-ahead electricity market is a short term hedge market that operates a day in advance of the actual physical delivery of power. In these environments, the generation decisions for the next day are in most cases the result of a double (two-sided) auction where producing (selling) and consuming (buying) agents submit a set of price-quantity curves (bids). It is typical in day-ahead markets to require producers to submit such bids for each of the 24 h of the day-ahead schedule. These bid curves give for each hour the price per unit of power associated with a volume of power that the producer is willing to sell at. Offer curves are typically non-decreasing step functions that are independent of each other.

A bidding model for a producer will depend on the particular market structure e.g. auction rules and protocols. In addition, producers face uncertainty in demand for power and in many cases uncertainty in the behavior of competing power producers. In addition, the unit commitment decisions are the responsibility of the producer and thus any bids for power must consider the cost of operating generation units as well as inter-temporal operating constraints such as minimum run times. Thus whereas bid curves are independent for each hour, costs and constraints for power production are not. This is the core problem that stochastic optimization based bidding addresses.

Scenario-based two-stage stochastic optimization is a powerful framework to address uncertainty in mathematical programming models such as the optimal bidding curves in day-ahead energy markets. The most common way to solve such problem is to solve the deterministic equivalent (DE). For real-world models and data instances a DE quickly become unmanageable/unsolvable due to explosion in size. Decomposition methods like Benders Decomposition and Lagrangian Relaxation are an obvious choice in such cases. Despite the importance of the problem class the commercial strength LP/MIP solvers do not provide such decomposition methods out of the box. Algebraic Modeling Languages (AML) with procedural components like AIMMS and GAMS are proven technology to implement such decomposition methods utilizing the LP/MIP (and even NLP and MINLP) solvers as sub-solvers in the decomposition algorithm.

In this paper we present the basics of the model for optimal bidding curves in day-ahead energy markets and describe the path from an (unsolvable) closed form DE of the model to a practical implementation of a Lagrangian Relaxation (LR) method with primal heuristics in GAMS taking advantage of the parallel hardware architecture (multi-core). We will also present numerical evidence that the algorithm provides a (primal) solution to the previously unsolvable DE with an optimality gap around 2% in few (usually less than 15) LR iterations or less than 1 hour wall time.

Restriction-based algorithms for semi-infinite programming

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Semi-infinite programs (SIPs) are mathematical programs with a finite number of variables and an infinite number of constraints. This is commonly expressed by a parameterized constraint, which has to hold simultaneously for all possible values of a parameter from a set of infinite cardinality. One solution approach for SIPs is a finite discretization of this parameter set, which results in a relaxation of the original program [2]. The relaxed program is a nonlinear program (NLP) and can be solved by existing solvers to provide a lower bound to the solution of the SIP. Given an adaptive discretization scheme, a series of these lower bounding NLPs can be solved such that the lower bound converges to the solution of the SIP in the limit. This basic algorithm, however, cannot guarantee feasible iterates in finite time. Recently, several methods were proposed that solve SIPs to a feasible ϵ-optimal point in finite time [1, 3, 4, 5].

In this presentation, we analyze two discretization-based bounding algorithms [4, 5] that introduce (implicitly or explicitly) a restriction of the semi-infinite constraint to achieve feasible iterates. We show that for certain problems, both algorithms tend to generate an overpopulated discretization and therefore require many iterations to converge. Motivated by the comparison, we derive a hybrid method relying on modified procedures from both algorithms to generate an adaptive restriction of the semi-infinite constraint and thereby avoid overpopulation. The new method performs better on problems where overpopulation would be a problem while remaining competitive on established SIP benchmark problems [6].

References

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[4] A. Mitsos. Global optimization of semi-infinite programs via restriction of the right-hand side. Optimization, 60(10-11):1291-1308, 2011.

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Energy System Planning
- Examples, general approach and aspects related to other industrial OR applications -

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Linear and MIP Optimization models have been used for energy system planning for more than 40 years. Initially used for large scale models of regions, countries, large utilities and energy intensive industry, similar methods are applied today for energy management and energy optimization of smaller systems, e.g. industrial energy management and energy optimization of facilities. Increasing power generation from fluctuating renewables and fast changing regulation and market conditions cause high uncertainties. Decisions based on incomplete information require advanced methods for short, medium and long term planning for infrastructure providers and market participants. Industrial companies have to meet increasing energy management requirements.

Two project examples will present a general approach for energy system planning and specific aspects related with practical optimization problems in other application fields.

How to deal with large and complex energy systems, uncertainties, incomplete data and nonlinear dependencies? Challenging projects like the set up of a power system master plan for Afghanistan will force a kind of puzzle competition. Key elements include preliminary analysis, model simplification, core model optimization and an extensive validation process. Several iterations may use different points of view and different models of the original decision problem. Incomplete data and high uncertainties are part of the original decision problem and imply multi-stage decision processes for candidate projects. Additional model constraints for the timeline of these candidate projects ensure robust strategies.

Current and future changes of the power market on the one hand and fast integrating IT and automation technologies on the other hand enable new energy and measurement based services for specific infrastructure providers of airports, ports and industrial sites. The SmartEnergyHub research project addresses these opportunities and will use an optimization module to explore new specific energy and measurement based services. Apart from application fields and market segments, a cost/benefit analysis is used to define size, details and complexity of underlying optimization models.

Robust Optimization for Combined Heat-and-Power Generation

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Considering the change in the energy supply systems in Europe, the potential of running small sized and variable energy generators attracts a great amount of interest, especially from private investors. In this talk the operation of a combined heat and power plant is considered, taking into account a fixed heat to power ratio, heat storage and the day ahead electricity market. The heat demand is uncertain and has to be met self-sufficiently, whereas power demand can be covered, and spare power can be sold, at the market. We present a robust optimization model that, given an uncertainty set, computes an operation plan consisting of the energy production as well as the market activities. Here the freedom given by the heat storage is twofold, as it can be used to shift power production into more profitable times, as well as to compensate for uncertainties in the heat demand. The plan is robust feasible if the storage values remain within their limits for all possible realizations in the uncertainty set. Preliminary computational experiments show the tractability of the model. Joint work with Stefano Coniglio (RWTH Aachen), Alexander Hein (ProCom GmbH), Nils Spiekermann (RWTH Aachen), and Olaf Syben (ProCom GmbH).

QUASAR: a general purpose solver for stochastic optimization

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This talk introduces QUASAR, a general-purpose solver for stochastic optimization, which combines approximate dynamic programming with scenario reduction techniques to tackle real-world decision problems under uncertainty. The solver handles stochastic-dynamic programming problems in a fashion similar to solvers for linear programming but allows model coefficients to be modeled as stochastic processes. Embedded into a mathematical workbench, QUASAR provides users with an interface for algebraic modeling, stochastic input model estimation, as well as simulation output analysis. The basic functionality of the solver and the interface is demonstrated for a simple operational planning problem. The talk finishes with a case study on using QUASAR for medium-term planning of an Austrian pumped-hydro storage system.

Decision-support tools and approaches for optimization under uncertainty

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For an industry planner, taking the right decision can be difficult even when there are only a few variables and possible outcomes. Taking these decisions is even harder when the data is affected by uncertainty arising from, for example, approximations and aggregations, error in instrumentation, and predictions of volatile supply and demand patterns.

In addition, optimization under uncertainty involves many challenges such as large numbers of scenarios, complex mathematical models for stochastic and robust optimization, and lack of user adoption. We present a decision support system aimed at addressing these challenges, called Uncertainty Toolkit. This toolkit solicits information on the uncertain data, automatically generates models which incorporate the uncertainty, and it includes visual analytics for trade-off analysis, a scenario generator and decomposition techniques.

Finally, we present one particular data-driven approach for distributionally robust optimization for classes of nonlinear optimization problems affected by uncertainty. In this approach we construct distributional uncertainty sets based on density estimates from given samples of the uncertain problem parameters, and show that the resulting distributionally robust counterpart is equivalent to a generalised problem of moments.

On Risk Management in Newsboy Problems with Limited Information

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This work considers the dilemma of the newsboy – how many newspapers should he order to resell when he does not know demand? We aim to find optimal order quantities without having the entire customer demand available at the outset. Although it exists, the underlying demand distribution is neither known nor given as part of the input. We consider the dilemma from the perspective of online algorithms that process input piece-by-piece in a serial fashion. Under the relative minimax regret criterion, we provide a generic solution to the optimal order quantity that can be adapted to the information that the decision maker has at hand. Moreover, we include a flexible risk management mechanism in our newsboy model. When gathered demand distribution information is uncertain, it is wise to adapt order quantities according to decision makers' willingness to assume risk. We show that it is optimal to choose an order quantity from a range between the online order quantity and the critical fractile – a well-known solution to minimizing the newsboy's total costs when customer demand follows a certain distribution. This interval forms the cost-risk efficient frontier. Ordering based on the critical fractile involves the maximum reasonable amount of risk; thus, assuming more risk increases expected total costs. From a practical perspective, our results allow decision makers to identify the optimal trade-off between risk and costs.

Robust Dynamic Optimization with Parametric Uncertainties - A Heuristic Approximation

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The optimal solution of dynamic optimization problems often shows active path constraints. Given parametric uncertainties, this might lead to constraint violations. If this uncertain model is for example embedded in a model predictive controller, where the constraints are often safety constraints, constraint violations are not acceptable. Therefore, a robust feasible approach is investigated.

One possible approximation for such a robust feasible dynamic optimization is the so-called two-model approach [?], wherein two models are optimized simultaneously. One model contains the nominal parameter values and the other one contains parameter values that correspond to a worst-case with respect to the path constraints. The challenges in defining the worst-case parameters and obtaining their values are presented. To overcome these difficulties, a heuristic approach based on sensitivity analysis is used.

The comparison of the two-model approach and the optimization with the nominal model solely is illustrated by an industrial case-study of a semi-batch process and shows that the two-model approach is more robust feasible and exhibits a higher conservatism. This is caused by the addition of the worst-case model, which increases the number of constraints such that the violation of the path constraints is less likely.

The presented approximation does not guarantee robust feasibility, but it is a pragmatic, easily generated approach, wherein the optimal solution is kept away from the path constraints compared to the solution of the optimization with the nominal model only.

References

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Stochastic Optimization with Tolerance Level

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Since the seminal work by Dantzig in 1955, the stochastic linear programming problem has been well-studied by assuming the knowledge of the involved probability distribution. But in practical applications, the distribution is rarely known with sufficient accuracy, even if good estimators are at hand.

In this context, a practically useful approach is to impose only partial knowledge about the probability distribution, by assuming that it is element of a set of distributions, instead of a single one as commonly used in stochastic optimization. In the literature, this is also referred to as stochastic optimization with (statistical/distributional) ambiguity. Solution methods proposed for such problems can be classified into two categories: The Bayesian approach and Distributionally Robust Stochastic Optimization.

In this talk, we present some preliminary results on a third method which can be viewed as a compromise between the Bayesian and the Distributionally Robust Stochastic Optimization approaches. First, we develop a new method to optimally combine all available estimation methods through a combinatorial optimization problem. This yields an optimal restriction of the family of distributions up to a chosen confidence level. By defining an estimator in the interior of the resulting confidence region, we are able to yield an optimization problem which solves the stochastic optimization problem under uncertainty up to a (known) constant for all elements of the family of distributions. The error constant depends on the chosen confidence level, the distances between the estimator and the members of the family of distributions, and the maximum objective function value. The error constant is small for a sufficiently large i.i.d. sample size. We coin this new approach "Stochastic Optimization with Tolerance Level" and show that it is a generalization of the classical stochastic optimization approach when the family of distributions consists out of only one element. The resulting error is zero in this case.

Parallel optimization of decentralized energy systems modeled as large-scale, two-stage stochastic MILP

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Stochastic modeling techniques enable an adequate consideration of manifold uncertainties of decentralized energy systems. In order to keep the mixed-integer linear program (MILP) still feasible, we present a module-based, parallel computing approach using an approximate gradient-based optimization on the first stage and scenario reduction techniques on the second stage of the stochastic program. It is demonstrated for residential quarters having PV systems in combination with heat pumps and storages. The required input data are simulated by a Markov process. These are transformed to sets of energy demand and supply profiles for the stochastic optimization problem.

Operation and Optimization of Gas Transmission Networks

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Gas transmission networks are complex structures that consist of passive pipes and active, controllable elements such as valves and compressors. Operating a large-scale gas network is a challenging task: Find settings for all active elements such that a nominated amount of gas can be transmitted through the network, without violating physical or operational constraints. In this talk, we present a nonlinear mixed-integer model taking into account continuous (like pressure and flow) and discrete decisions (like the configuration of active devices). As investments in the infrastructure are very cost-intensive and long-living, network extensions should not only focus on one bottleneck scenario, but should increase the flexibility to fulfill different demand scenarios. We formulate a model for the network extension problem for multiple demand scenarios and propose solution strategies.

This work was performed within the project ForNe (Forschungskooperation Netzoptimierung) when the author was at Zuse Institute Berlin (ZIB).

Supply chain network design in the automotive industry under uncertainty

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In this talk, we discuss the strategic supply chain design problem under uncertainty from a practitioner's perspective. The problem is to allocate future product demand to factories and lines such that network costs are minimal. It includes end-to-end supply chain cost: purchase, production, warehousing, inventory and transportation. Car manufacturers can gain competitive advantage by running supply chain network scenarios, evaluating and re-configuring their networks in response to changes like new product introduction, changes in demand patterns or costs, addition of new supply sources, and changes in tax laws. We will discuss our experiences from various projects with major car manufacturers in Germany.