Biannual Report

Department of Mathematics
Optimization
2015 and 2016

TECHNISCHE UNIVERSITÄT DARMSTADT

This document contains a subset of the information contained in the biannual report of the Department of Mathematics at TU Darmstadt for 2015 and 2016. It has been obtained by taking all the information the research group optimization supplied to the complete report. All empty chapters have been removed. This excerpt is meant to be a condensed supplement, because it is hard to filter out research group specific information from the full report of the department. No optimization of the layout has been performed.

Research Group Optimization, May 2018

For the full biannual report of the department of mathematics at TU Darmstadt see `http://www.mathematik.tu-darmstadt.de`.

Contents

1 Research Group Optimization

The research group **Optimization** consists of the two directions **Discrete Optimization** and **Nonlinear Optimization**, which cooperate closely. Mathematical Optimization considers the development, analysis, and application of efficient numerical methods for minimizing (or maximizing) a function under constraints. While Discrete Optimization studies mainly linear or convex combinatorial problems involving integer variables, Nonlinear Optimization focuses on nonlinear problems with continuous variables. The research group covers both research topics in a comprehensive way and cooperates in particular in the challenging field of Mixed Integer Nonlinear Programming, which considers nonlinear optimization with mixed discrete-continuous variables.

Discrete Optimization has become an important component in modern applied mathematics. Many problems from business and industry can be modeled as discrete optimization problems. The development of solution methods for these problems is the main focus of the group Discrete Optimization. This includes the development of mathematical models of real-world problems, the theoretical analysis (using methods mainly from graph theory, polyhedral combinatorics, and integer programming), and the design and implementation of fast algorithms as well as their evaluation in practice.
The group has experience, for instance, in the following applied areas: public mass transportation (line planning, disruption management), energy optimization (gas transport), or optimization in mechanical engineering (truss topology optimization), see the projects for details.

Nonlinear Optimization is nowadays an important technology in applied mathematics, science, and engineering. Nonlinear optimization problems appear in many applications, e.g., shape optimization in engineering, robust portfolio optimization in finance, parameter identification, optimal control, etc. Nonlinear Optimization has emerged as a key technology in modern scientific and industrial applications. Challenging are in particular optimization problems with partial differential equations as constraints (PDE-constraints), for example optimization problems for flows, transport problems, diffusion processes, wave propagation, or mechanical structures. An efficient solution of such problems requires highly developed optimization methods, that use modern adaptive multilevel techniques of scientific computing.
The research group Nonlinear Optimization considers the development, theory, implementation, and application of efficient algorithms for nonlinear optimization. Particular research topics are PDE-constrained optimization, large scale optimization, adaptive multilevel techniques, discretization error for PDE-constrained optimization, preconditioning, global optimization, and relaxation of discrete problems.

The research group Optimization is engaged among others in the Darmstadt Graduate School of Excellence GSC 233 *Computational Engineering: Beyond Traditional Sciences*, the Darmstadt Graduate School of Excellence GSC 1070 *Energy Science and Engineering*, the Collaborative Research Centre (SFB) 666 *Integral Sheet Metal Design with Higher Order Bifurcations – Development, Production, Evaluation*, the Collaborative Research Centre (SFB) 805 *Control of Uncertainty in Load-Carrying Structures in Mechanical Engineering*, the Collaborative Research Centre (SFB) 1194 *Interaction of Transport and Wetting Processes*, the Transregional Collaborative Research Centre (Transregio/SFB) 154 *Mathematical Mod-*

elling, Simulation and Optimization on the Example of Gas Networks, the International Research Training Group (IRTG) 1529 *Mathematical Fluid Dynamics*, the German Research Foundation (DFG) Priority Programme (SPP) 1736 *Algorithms for Big Data*, the German Research Foundation (DFG) Priority Programme (SPP) 1798 *Compressed Sensing in Information Processing* and the German Research Foundation (DFG) Priority Programme (SPP) 1962 *Non-smooth and Complementarity-based Distributed Parameter Systems: Simulation and Hierarchical Optimization*. In addition, the group has various industry partners, including cooperations with Open Grid Europe and Schenck.

Members of the research group

Professors

Yann Disser, Marc Pfetsch, Alexandra Schwartz, Stefan Ulbrich, Winnifried Wollner

Postdocs

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Secretaries

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Project: Numerical approximation of optimal control problems for hyperbolic conservation laws

A lot of continuum models for physical problems, such as traffic modeling and fluid mechanics, are described by hyperbolic conservation laws. Some of these networks include switching processes like traffic flow models and water/gas network models. This motivates an analytic study and numerical approximation of optimal control problems of nonlinear hyperbolic conservation laws on networks under modal switching, where switchings are considered in the source terms as well as at boundary nodes and junctions. The main difficulty in the analysis of conservation laws arises from the fact that even in the case of a single scalar conservation law and smooth data the entropy solution usually develops shocks, which causes the solution operator to not be differentiable in the usual sense. However, encouraging progress has been achieved recently for the optimal control of conservation laws by using a generalized notion of differentiability (so called shift-differentiability). Switching between different modes may result in additional discontinuities in the solution, which is, however, quite natural in the context of entropy solutions. The goal of the project is a detailed analysis of the resulting optimal controls, an investigation of the differentiability properties of the objective function and a numerical discretization of optimal control problems for switched networks of conservation laws.

Contact: P. Schäfer Aguilar, S. Ulbrich.

References

[1] S. Pfaff. *Optimal control of hyperbolic conservation laws on bounded domains with switching controls*. PhD thesis, 2015.

[2] S. Pfaff and S. Ulbrich. Optimal boundary control of nonlinear hyperbolic conservation laws with switched boundary data. *SIAM J. Control Optim.*, 53(3):1250–1277, 2015.

[3] S. Pfaff and S. Ulbrich. Optimal control of scalar conservation laws by on/off-switching. *Optimization Methods and Software*, 2016. To appear.

[4] S. Ulbrich. *Optimal control of nonlinear hyperbolic conservation laws with source terms*. Habilitation, TU München, 2001.

Project: Multilevel Optimization based on Reduced Order Models with Application to Fluid-Structure Interaction

In this project we derive and implement a multilevel optimization algorithm based on reduced order models with application to fluid-structure interaction (FSI) problems. The interaction of fluid flows with elastic deformation of structures is a problem occurring in many problems in engineering applications.

We build our work on a finite element discretization of the fluid flow modeled with the 2D Navier-Stokes equations for incompressible fluids and a hyperelastic material.

The model reduction is done by using the Proper Orthogonal Decomposition (POD) technique and the inf-sup stability is ensured by the enrichment of the POD spaces with supremizers. We further derive error control criteria and a convergence analysis under suitable assumptions.

The project builds on the work of Sarah Essert within GSC CE, who derives and implements adjoint-based derivative computations for fluid-structure interaction problems.

Partner: Darmstadt Graduate School of Excellence Computational Engineering (GSC 233); speaker Prof. Dr. Michael Schäfer (Department of Mechanical Engineering, TU Darmstadt)

Support: DFG

Contact: J. Biehl, S. Ulbrich.

Project: A Continuous Reformulation of Cardinality Constrained Optimization Problems

Cardinality constraints are used to model the fact that the solution of an optimization problem is expected or desired to be sparse. They impose an upper bound on the cardinality of the support of feasible points. In this project we consider a nonlinear objective function which is to be minimized subject to the cardinality constraint as well as further nonlinear constraints. A classical application of cardinality constrained optimization problems is portfolio optimization in which the cardinality constraint limits the number of active positions in a portfolio. Other applications are compressed sensing or the subset selection problem in regression.

A recent approach is to reformulate the cardinality constraint with complementarity constraints using continuous auxiliary variables [1]. This opens up the possibility to use methods from nonlinear optimization. The reformulation possesses a strong similarity to a mathematical program with complementarity constraints (MPCC) and, like an MPCC, does not fulfill standard constraint qualifications. The goal of this project is to use the strong link between the aforementioned reformulation of cardinality constrained optimization problems and MPCCs to transfer existing knowledge. Such results include optimality conditions [2] or relaxation techniques [3].

Partner: Darmstadt Graduate School of Excellence Computational Engineering (GSC 233); speaker Prof. Dr. Michael Schäfer (Department of Mechanical Engineering, TU Darmstadt)

Support: DFG

Contact: M. Bucher, A. Schwartz.

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[1] O. P. Burdakov, C. Kanzow, and A. Schwartz. Mathematical programs with cardinality constraints: Reformulation by complementarity-type conditions and a regularization method. *SIAM Journal on Optimization*, 26(1):397–425, 2016.

[2] H. Scheel and S. Scholtes. Mathematical programs with complementarity constraints: Stationarity, optimality, and sensitivitys. *Mathematics of Operations Research*, 25(1):1–22, 2000.

[3] S. Scholtes. Convergence properties of a regularization scheme for mathematical programs with complementarity constraints. *SIAM Journal on Optimization*, 11(4):918–936, 2001.

Project: Simulation Based Optimization and Optimal Design of Experiments for Wetting Processes (Subproject B04 of Collaborative Research Centre (SFB) 1194)

This project is part of the Collaborative Research Centre (SFB) 1194: "Interaction of Transport and Wetting Processes" and considers the development of adjoint-based multilevel optimization methods for optimization and parameter identification problems arising in wetting processes. Moreover, optimization-based approaches for the optimal design of experiments will be developed, such that the resulting experiments allow the estimation of non-measurable parameters with minimal error variance. The results of this project should be particularly valuable for the future selection of generic experimental setups and will make available quantities which are difficult to measure experimentally. Moreover, the geometry of surfaces as well as material properties of fluids or surfaces will be optimized to design wetting processes with desirable properties.

Partner: Collaborative Research Centre (SFB) 1194: "Interaction of Transport and Wetting Processes"; speaker Prof. Dr.-Ing. Peter Stephan (Department of Mechanical Engineering, TU Darmstadt)

Support: DFG

Contact: E. Diehl, S. Ulbrich.

Project: LogiScale - BigData in Logistics: Multi-scale and Combinatorial Optimization Methods

LogiScale is a joint research project with 4flow AG. The project is targeted at developing a multi-scale representation of logistics networks that allows to express data related to costs, time and location in various scales. The idea is to aggregate detailed structural insights and planning solutions on small scales, to couple these with larger scales, and to make this data available on demand for optimization algorithms. A multi-scale representation allows to simultaneously manage data of different granularities without loss of information. In conjunction with this, the aim of the project is to develop methods to allow algorithms to dynamically use data on different scales for optimization. Specifically, the goal is to provide procedures that allow to operate on complex logistics networks, to efficiently optimize both strategic and operative planning phases independently of network size, and to realistically model logistical processes and reduce their planning and operating costs. To this end, a new paradigm will be developed for the internal data flow of logistical optimization algorithms.

Partner: 4flow AG, Max Klimm (HU Berlin), Torsten Mütze (TU Berlin), Martin Skutella (TU Berlin)

Support: European Regional Development Fund (ERDF)

Contact: Y. Disser.

Project: Competitive Exploration of Large Networks

The goal of this project is to deepen the understanding of algorithms that operate on very large networks and the dynamics that arise from the competition or cooperation between such algorithms. To achieve this goal, we want to combine models and techniques from the areas of graph exploration and algorithmic game theory. To date, the literature in these areas is mostly disjoint. By closing this gap, we hope to develop new insights into the important algorithmic and economic challenges faced in large networks, most prominently in those that are part of the internet.

Partner: Jan Hackfeld (TU Berlin), Max Klimm (HU Berlin), DFG Priority Programme (SPP) 1736: "Algorithms for Big Data"; speaker Prof. Dr.-Ing. Ulrich Meyer (Institute for Computer Science, Universität Frankfurt)

Support: DFG

Contact: Y. Disser.

References

[1] Y. Disser, J. Hackfeld, and M. Klimm. Undirected graph exploration with $\Theta(\log\log n)$ pebbles. In *Proceedings of the 27th Annual ACM-SIAM Symposium on Discrete Algorithms (SODA)*, pages 25–39, 2016.

Project: Optimization of Process Chains under Uncertainty (Subproject B1 of Collaborative Research Centre (SFB) 805)

The aim of this subproject is to control uncertainty in process chains using mathematical models and optimization procedures in order to maximize the value of process chains. Uncertainty in the production of components emerges from random variations in the raw material, from unpredictable process behavior or because the customer's use can only be vaguely predicted. The optimization procedures are based on quantified (mixed-integer) linear programs.

Our considerations originate from production processes, e.g., between supplier and customer, which are divided into several stages and form a process chain. A typical optimization problem consists in the choice of a process chain which is as cheap as possible. In the production of components, however, uncertainties in the process chains emerge from more or less random influences. Our aim is to control such uncertainties with the help of mathematical optimization procedures and to minimize their consequences.

The relevant characteristics of uncertainty are stochastic uncertainty and interval uncertainty. In mathematical modeling, the former leads to distribution of prospective uncertain events (scenarios). In the latter case, only uncertainty intervals are known. Therefore, we use extensions of linear programs – especially quantified linear programs – as a mathematical tool, modeling optimization problems under uncertainty. We can generate deterministic equivalent programs (DEP) from them, which are high-dimensional mixed-integer linear programs with a regular block-structured constraint matrix, such that the blocks represent possible scenarios that are coupled by decision variables. Under some circumstances, we can derive bounds for the objective function values from the quantified programs without generating the DEP. If needed, the scenarios can be filtered with specialized reduction methods, to make the mixed-integer program feasible from an algorithmic perspective.

Partner: Collaborative Research Centre (SFB) 805: "Control of Uncertainty in Load-Carrying Structures in Mechanical Engineering"; speaker Prof. Dr.-Ing. Peter Pelz (Department of Mechanical Engineering, TU Darmstadt)

Support: DFG

Contact: T. Ederer, U. Lorenz, M. E. Pfetsch

Project: Adaptive Multigrid Methods for Fluid-Structure Interaction Optimization

Strong fluid structure coupling is part of many technical systems. The aim of this project is to develop an efficient adaptive multilevel algorithm to solve an optimization problem governed by Fluid-Structure Interaction (FSI).
This algorithm should combine modern techniques of PDE-constrained optimization, adaptivity and Fluid-Structure Interaction simulation. Since for elliptic as well as for parabolic partial differential equations an adjoint based Trust-Region SQP method has shown good results, we want to adapt this method. Thus we aim for an adjoint based algorithm that is able to refine the given grids (both the spatial and the temporal) adaptively during the optimization process.
The Fluid-Structure Interaction problem we consider as the constraint for the optimization problem, is in the weak form of the FSI problem considered in an Arbitrary-Lagrangian-Eulerian (ALE) framework. The coupling of the two different parts of the partial differential equation is done via strong coupling.
Suitably the adjoint equation is considered in an ALE framework and in a strongly coupled way.

Partner: Michael Schäfer (TU Darmstadt), Darmstadt Graduate School of Excellence Computational Engineering (GSC 233); speaker Prof. Dr. Michael Schäfer (Department of Mechanical Engineering, TU Darmstadt)

Support: DFG

Contact: S. Essert, S. Ulbrich

Project: Analysis and numerical approximation of shape optimization problems governed by the Navier-Stokes and the Boussinesq equations

This project is part of the International Research Training Group (IRTG) 1529: "Mathematical Fluid Dynamics". The project deals with shape optimization problems associated with the Navier-Stokes and the Boussinesq equations on a infinite and discretized level.

More precisely, the instationary incompressible Boussinesq equations with Robin boundary conditions for the temperature are considered for shape optimization via the method of mapping by Murat and Simon. This extends our results concerning the shape optimization theory for the instationary incompressible Navier-Stokes equations, cf. [1]. Furthermore, shape differentiability properties of the instationary Navier-Stokes equations are investigated on a discrete level by using a P1/P1 Lagrange Galerkin discretization by Notsu and Tabata. This is done in cooperation with the numerics group of Prof. Notsu at Waseda University during a six month exchange program. Besides the theoretical investigations a Taylor-Hood based discretization of the Boussinesq equations is implemented in order to validate the theoretical results on a discrete level.

Partner: International Research Training Group (IRTG) 1529: "Mathematical Fluid Dynamics"; speakers Prof. Dr. Matthias Hieber (TU Darmstadt) and Prof. Dr. Yoshihiro Shibata (Waseda University, Tokyo)

Support: DFG

Contact: M. Fischer, S. Ulbrich.

References

[1] M. Fischer, F. Lindemann, M. Ulbrich, and S. Ulbrich. Fréchet differentiability of unsteady incompressible Navier-Stokes flow with respect to domain variations of low regularity by using a general analytical framework. 2016. Submitted.

Project: Exploiting Structure in Compressed Sensing Using Side Constraints (EXPRESS)

In the EXPRESS project we study the compressed sensing (CS) problem in the presence of side information and additional constraints. Side information as well as constraints are due to a specific structure encountered in the system model and may originate from the structure of the measurement system or the sensing matrix (shift-invariance, subarray structure, etc.), the structure of the signal waveforms (integrality, box constraints, constellation constraints such as non-circularity, constant modulus, finite constellation size, etc.), the sparsity structure of the signal (block or group sparsity, rank sparsity, etc.) or the channel, as well as the structure of the measurements (quantization effects, K-bit measures, magnitude-only measurements, etc.). We investigate in which sense structural information can be incorporated into the CS problem and how it affects existing algorithms and theoretical results. Based on this analysis, we develop new algorithms and theoretical results particularly suited for these models. It is expected, on the one hand, that exploiting structure in the measurement system, i.e., the sensing matrix, can lead to fast CS algorithms with novel model identifiability conditions and perfect reconstruction/recovery results. In this sense, exploiting structure in the observed signal waveforms and the sparsity structure of the signal representation can lead to reduced complexity CS algorithms with simplified recovery conditions and provably enhanced convergence properties. On the other hand, we expect that quantized measurements, which are of great importance when considering cost efficient hardware and distributed measurement systems, will generally result in a loss of information for which new algorithms and perfect recovery conditions need to be derived.

Partner: DFG Priority Programme (SPP) 1798: "Compressed Sensing in Information Processing"; speakers Prof. Dr. Rudolf Mathar (Institute of Theoretical Information Technology, RWTH Aachen) and Prof. Dr. Gitta Kutyniok (Department of Mathematics, TU Berlin)

Support: DFG

Contact: T. Fischer, M. E. Pfetsch, A. Tillmann.

References

[1] J. Lange, M. E. Pfetsch, B. M. Seib, and A. M. Tillmann. Sparse recovery with integrality constraints. arXiv abs/1608.08678, 2016.

[2] C. Steffens, M. Pesavento, and M. E. Pfetsch. A compact formulation for the $\ell_{2,1}$ mixed-norm minimization problem. arXiv abs/1606.07231, 2016.

Project: Global Methods for Stationary Gastransport (Subproject A01 of Transregio/SFB 154)

This project is part of the Transregio/SFB 154: "Mathematical Modelling, Simulation and Optimization on the Example of Gas Networks". In this subproject, adaptive methods for the global solution of nonlinear mixed-integer optimization problems with ODEs are developed. This will be performed on the example of stationary gastransport. One goal is the global decision about optimality and feasibility of such optimization problems. The global solution of large instances is computationally hard and requires the development of new and clever combination with existing mathematical methods. One motivation for the considered optimization problems is the long-term planning of the operation of gastransport networks, i.e., the question whether a given gas amount can be transported from given entries to exits. In this context we first deal with stationary gas flows. The basic model is formed by the Euler equations, which are treated with adaptive techniques. In addition, flow conservation conditions at junctions and nonlinear descriptions of compressor stations as well as integer decisions, e.g., at valves, arise. This yields a mixed-integer feasibility problem for a coupled system of differential and algebraic equations. For the solution of such problems, a simplification or approximation of the system via a coarse discretization and/or model reduction has to be performed, which is then iteratively refined. Here, a priori error bounds will be applied. Integral decisions and non-convexities are handled via variable and spatial branching, respectively. Of particular interest are the adequate combination of branching methods with adaptive techniques for the discretization.

Partner: Transregio/SFB 154: "Mathematical Modelling, Simulation and Optimization using the Example of Gas Networks"; speaker Prof. Dr. Alexander Martin (Department of Mathematics, FAU Erlangen-Nürnberg)

Support: DFG

Contact: O. Habeck, I. Joormann, M. E. Pfetsch, S. Ulbrich.

Project: Polyhedral Symmetry Handling Techniques

Symmetries in (mixed) binary programs may have a negative impact on the performance of brach-and-bound solvers, since symmetric solutions reappear multiple times during the solving process.

The aim of this project is to develop polyhedral models which allow to solve symmetric (mixed) binary programs. We focus on the facial structure of the derived polytopes to obtain strong cutting planes which can be used within branch-and-cut procedures to speed up the solution process of such binary programs. Furthermore, we investigate complete linear descriptions of polytopes that arise by considering further constraints. The goal is to combine symmetry information with the additional properties to derive strong cutting planes for applications.

Partner: Thomas Rehn (Universität Rostock)

Contact: C. Hojny, M. E. Pfetsch.

References

[1] C. Hojny and M. E. Pfetsch. Polytopes associated with symmetry handling. Optimization online, 2017.

[2] M. E. Pfetsch and T. Rehn. A computational comparison of symmetry handling methods for mixed integer programs. Optimization online, 2015.

Project: Mightiness of Optimization Algorithms

Mightiness of optimization algorithms is a new perspective on algorithmic complexity. Instead of classifying problems by how hard it is to solve them, algorithms are classified by the problems they are able to solve. This work was initiated by Disser and Skutella in [1], where they proved that several algorithms are NP-mighty, that is, they can solve every problem in the complexity class NP. This set of algorithms includes the original variant of the Simplex algorithm, the successive shortest path algorithm and many more. Since then, a lot of algorithms have been proven to be NP-mighty or even PSPACE-mighty, i.e., they can solve every problem in the complexity class PSPACE [2].

There are two main goals of this project. The first goal is to further investigate PSPACE-mightiness of several optimization algorithms. The second and long-term goal is to justify the running times of algorithms that solve problems in the complexity class P of polynomially solvable problems but do not achieve the best possible running time. We plan to investigate the mightiness of such algorithms, conditioned on conjectures as the "Strong Exponential Time Hypothesis" for 3SAT, the "3SUM conjecture" and others. Approaching conditional lower bounds from an algorithm-centered perspective may expose new connections between different conjectures that would contribute to the unification of the conditional sub-classes of P.

Partner: Darmstadt Graduate School of Excellence Computational Engineering (GSC 233); speaker Prof. Dr. Michael Schäfer (Department of Mechanical Engineering, TU Darmstadt)

Support: DFG

Contact: A. Hopp, Y. Disser.

References

[1] Y. Disser and M. Skutella. The simplex algorithm is NP-mighty. In *Proceedings of the 26th ACM-SIAM Symposium on Discrete Algorithms (SODA)*, pages 858–872, 2015.

[2] J. Fearnley and R. Savani. The complexity of the simplex method. In *Proceedings of the Forty-seventh Annual ACM Symposium on Theory of Computing*, STOC '15, pages 201–208. ACM, 2015.

Project: Optimization of Energy Systems for Settlements Involving Renewable Energy Systems

In this project we investigate the energy network design of multiple energy carrier systems, concentrating on electricity, natural gas and district heating and their coupling through energy conversion plants. In addition to conventional energy sources we consider geothermal-, solar- and wind-energy sources. The settlements are equipped with a borehole heat exchanger, wind turbines and photovoltaic systems. Our goal is to obtain a cost-minimal strategy satisfying the consumers' energy demand in a settlement by determining the dimensioning of transmission lines and storages as well as routing the particular energy carriers through the energy distribution system.
In order to achieve this aim, further steps will be the mathematical analysis of the given mixed-integer nonlinear problem (MINLP) with partial differential equations (PDEs) and the derivation of optimality conditions under given assumptions for our network problem. To master the remaining complexity of the network, we will apply the branch-and-bound method including global relaxation methods. For solving the PDE constraints and nonlinear equations of the transmission processes, we will use discretization methods and convexify the investigated equations. This must be balanced however with the discretization errors. To show the applicability, the developed approaches will be implemented and tested in detail.

Partner: Darmstadt Graduate School of Excellence Energy Science and Engineering (GSC 1070); speakers Prof. Dr. Wolfram Jaegermann and Prof. Dr. Johannes Janicka (TU Darmstadt)

Support: DFG

Contact: K. Janzen, S. Ulbrich.

Project: Simulation-based optimization methods for the hydroforming of branched structures (Subproject A6 of Collaborative Research Centre (SFB) 666)

This project is part of the Collaborative Research Centre (SFB) 666: "Integral sheet metal design with higher order bifurcations – development, production, evaluation" and is concerned with the optimal control of the sheet metal hydroforming. The sheet metal hydroforming process is a complex forming process, which involves contact, friction, and plasticity to manufacture complexly curved sheet metals with bifurcated cross-section. Mathematically, this leads to a quasi-variational inequality. We want to find optimal controls for typical control variables, e.g., the time dependent blank holder force and the fluid pressure, by the use of simulation-based optimization methods. Our goal is to obtain a desired final configuration, taking into consideration relevant parameters for the production. On the one hand, we use derivative free optimization methods to solve the optimal control problem, where the commercial FEM-software ABAQUS is invoked for the simulations and, on the other hand, instantaneous optimization methods are under investigation. In this context model reduction techniques, e.g., Proper Orthogonal Decomposition, will be employed to achieve a suboptimal solution for the optimal control problem. In addition to the optimization of the controllable parameters of the hydro-forming process, we optimize the height profile of stringer sheets to avoid production defects like stringer buckling.

Partner: Collaborative Research Centre (SFB) 666: "Integral sheet metal design with higher order bifurcations – development, production, evaluation"; speaker Prof. Dr.-Ing. Dipl.-Wirtsch.-Ing. Peter Groche (Department of Mechanical Engineering, TU Darmstadt)

Support: DFG

Contact: D. Bratzke, A. Walter, S. Ulbrich

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[1] D. Bratzke. *Optimal Control of Deep Drawing Processes based on Reduced Order Models*. Dr. Hut Verlag, 2015.

[2] P. Groche, S. Gramlich, and E. Bruder, editors. *Manufacturing Integrated Design - Sheet Metal Product and Process Innovation*. Springer, 2017.

[3] M. Ulbrich, S. Ulbrich, and D. Bratzke. A multigrid semismooth newton method for semilinear contact problems.

Project: Mathematical Programming in Robust Design (Subproject A3 of Collaborative Research Centre (SFB) 805)

The objective of the subproject is the optimal design of load-carrying systems under uncertainty based on complex finite-element component models. This is achieved by the development and application of novel mathematical methods for the robust optimization of geometry, topology and for actuator placement. For an efficient numerical treatment, first- and second-order approximations with respect to the uncertain parameters will be used. Based on finite-element models, optimal excitations and sensor positions will be determined such that model uncertainty during production and usage can be identified reliably.

Partner: Collaborative Research Centre (SFB) 805: "Control of Uncertainty in Load-Carrying Structures in Mechanical Engineering"; speaker Prof. Dr.-Ing. Peter Pelz (Department of Mechanical Engineering, TU Darmstadt)

Support: DFG

Contact: P. Kolvenbach, S. Ulbrich.

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[1] T. Gally, C. M. Gehb, P. Kolvenbach, A. Kuttich, M. E. Pfetsch, and S. Ulbrich. Robust truss topology design with beam elements via mixed integer nonlinear semidefinite programming. In P. F. Pelz and P. Groche, editors, *Uncertainty in Mechanical Engineering II*, volume 807 of *Applied Mechanics and Materials*, pages 229–238. Trans Tech Publications, 2015.

Project: Mathematical methods and models for the optimal combination of active and passive components in trusses (Subproject A4 of Collaborative Research Centre (SFB) 805)

This project is part of the Collaborative Research Centre (SFB) 805: "Control of Uncertainty in Load-Carrying Structures in Mechanical Engineering". The project deals with the optimal design of mechanical trusses under uncertainty. Trusses are important in many applications (undercarriages of airplanes, bicycles, electrical towers, etc.) and are often overdimensioned to withstand given forces under several uncertainties in loadings, material and production processes. Active parts can react to these uncertain effects and reduce the dimension of trusses. The Collaborative Research Centre (SFB) 805 introduces new technologies to handle uncertainty in load-carrying systems. The aim of this project is to find optimal combinations of active and passive parts in a mechanical truss under uncertain loadings. Mathematically, this leads to mixed-integer nonlinear semidefinite problems. For this kind of problem, there exists no solver that exploits the structure of the problem efficiently. Besides the development of an appropriate solver, another focus lies in a mathematical handling of the upcoming uncertainties. Ellipsoidal and polyhedral sets are used to integrate uncertainty in different loading scenarios. The focus of the second funding period lays in the generalization to dynamic loads and the integration of different hinges as well as different kinds of active elements. All of this includes interdisciplinary communication to mechanical engineers to achieve realistic models.

Partner: Collaborative Research Centre (SFB) 805: "Control of Uncertainty in Load-Carrying Structures in Mechanical Engineering"; speaker Prof. Dr.-Ing. Peter Pelz (Department of Mechanical Engineering, TU Darmstadt)

Support: DFG

Contact: T. Gally, A. Kuttich, M. E. Pfetsch, S. Ulbrich.

References

[1] T. Gally, C. M. Gehb, P. Kolvenbach, A. Kuttich, M. E. Pfetsch, and S. Ulbrich. Robust truss topology design with beam elements via mixed integer nonlinear semidefinite programming. In P. F. Pelz and P. Groche, editors, *Uncertainty in Mechanical Engineering II*, volume 807 of *Applied Mechanics and Materials*, pages 229–238. Trans Tech Publications, 2015.

[2] T. Gally, M. E. Pfetsch, and S. Ulbrich. A framework for solving mixed-integer semidefinite programs. Optimization online, 2016.

Project: Robust optimization (Subproject AP4 of SIMUROM)

This subproject is part of SIMUROM, a project that focuses on the modeling, simulation and optimization of electromechanical energy converters that can work as motors or generators. As a subproject the focus is on the optimal design of such energy converters under uncertainty. Due to manufacturing, there are uncertainties in material and production precision. During the design process it is important to consider these uncertainties in order to obtain reliable and efficient machines. A robust optimization problem is formulated that incorporates the uncertainties into the initial optimization problem utilizing the worst-case approach. In order to obtain numerically feasible problems, different approximation methods are investigated. For this, the robust counterpart is approximated by different degrees of Taylor expansions [1, 3, 2]. To solve the resulting nonlinear PDE constrained optimization problems, efficient algorithms are needed. To achieve this, different model order reduction techniques [4], adaptive multilevel methods [5] and possible extensions are investigated.

Partner: Sebastian Schöps (TU Darmstadt), Andreas Bartel (Bergische Universität Wuppertal), Michael Hinze (Universität Hamburg), Oliver Rain (Robert Bosch GmbH), Markus Brunk (Robert Bosch GmbH), Enno Lange (CST – Computer Simulation Technology AG)

Support: Federal Ministry of Education and Research (BMBF)

Contact: O. Lass, S. Ulbrich

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Project: Mathematical models and algorithms for an automated product development of branched sheet metal products (Subproject A2 of Collaborative Research Centre (SFB) 666)

This project is part of the Collaborative Research Centre (SFB) 666: "Integral sheet metal design with higher order bifurcations – development, production, evaluation" and addresses the shape optimization of sheet metal products. There are different types of considered sheet metal products: Multi-chambered profiles, mechanical connectors and hydroformed branched sheet metal structures.

For profiles, the goal is to find the optimal design of the profiles' cross sections as well as optimal decomposition into smaller parts that are easier to produce. For this purpose, a combination of topology and geometry optimization as well as graph partitioning techniques are applied. To solve the decomposition problem more efficiently, the information of the defined polyhedron will be used in the integer program solvers.

For the optimization of mechanical connectors, multibody models including contact constraints are used. The variety of shapes are increased by following the approach of isogeometric analysis. To solve the resulting PDE constrained problems optimization techniques for nonsmooth and nonconvex problems are applied.

As hydroformed parts can show arbitrary curvature, the geometry of those parts is parameterized by cubic B-spline surfaces. The product behavior is described by the three dimensional linear elasticity equations. To optimize the geometry of the branched and hydroformed sheet metal products, PDE constrained optimization techniques are used. The arising nonconvex geometry optimization problem is solved with an algorithm using exact constraints and a globalization strategy based on adaptive cubic regularization. For decreasing the computational effort multilevel-techniques are applied.

Partner: Collaborative Research Centre (SFB) 666: "Integral sheet metal design with higher order bifurcations – development, production, evaluation"; speaker Prof. Dr.-Ing. Dipl.-Wirtsch.-Ing. Peter Groche (Department of Mechanical Engineering, TU Darmstadt)

Support: DFG

Contact: T. Göllner, B. M. Horn, H. Lüthen, M. E. Pfetsch, S. Ulbrich.

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Project: Analysis and Optimal Control of Quasilinear Parabolic Evolution Equations in Divergence Form on Rough Domains

Nearly all irreversible processes in the natural sciences are modeled by parabolic evolution equations. In this project, we consider optimal control problems subject to quasilinear equations of such type in divergence form in an abstract setting.

Quasilinear equations exhibit some features which make their analysis quite difficult, the maybe most outstanding one being possibly varying domains for the elliptic differential operators, including existence of possible blow-up for the solutions. We choose an approach via maximal parabolic regularity, which is very flexible and suitable for the abstract framework, relying on results on maximal elliptic regularity. The general setting regarding the underlying spatial domain is a generally nonsmooth one, beyond the Lipschitz class. It is the aim to also be able to treat rather general nonlinearities in the equation, allowing to include also solution mappings for subordinated equations. In this way, also systems of equations can be handled at once; these were the original motivation for this project.

In the optimal control problem built around the quasilinear equation, we additionally impose both state- and control constraints on the system. The lack of a priori estimates for the solutions of the quasilinear evolution equations turns out to be especially difficult when establishing existence of globally optimal controls. Furthermore, one has to deal with the possibility of blow-up of solutions which seems incompatible with the general optimization procedure.

The developed theory is simultaneously tried and applied on a real-world example, the thermistor problem, for this class of optimal control problems.

Contact: H. Meinlschmidt, S. Ulbrich.

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Project: `polymake`

The mathematical software system `polymake` provides a wide range of functions for convex polytopes, simplicial complexes, and other objects.

While the system exists for more than a decade it was continuously developed and expanded. The most recent version fundamentally changes the way to interact with the system. It now offers an interface which looks similar to many computer algebra systems. However, on the technical level `polymake` differs from most mathematical software systems: rule based computations, a flexible object hierarchy and an extendible dual Perl/C++ interface are the most important characteristics. There are interfaces to programs written in C, C++, Java, and Perl.

`polymake` is an open source software project. The current version 3.0 can be downloaded freely from `www.polymake.org`.

Partner: Michael Joswig (TU Berlin), Ewgenij Gawrilow (TomTom N.V.) and the `polymake` team

Contact: A. Paffenholz

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Project: Optimization methods for mathematical programs with equilibrium constraints in function spaces based on adaptive error control and reduced order or low rank tensor approximations (Project P23 in SPP 1962)

This project investigates optimization methods for mathematical programs with equilibrium constraints (MPECs) in function space that adaptively control the accuracy of the underlying discretization and of inexact subproblem solves in such a way that convergence is ensured. This enables the use of adaptive discretizations, reduced order models, and low rank tensor methods, thus making the solution of MPECs with high dimensional equilibrium constraints tractable and efficient. Two prototype classes of MPECs in function space are considered in the project: One with a family of parametric variational inequalities as constraints and the other constrained by a parabolic variational inequality. Based on a rigorous analytical foundation in function space, the project will develop and analyze inexact bundle methods combined with an implicit programming approach. In addition, inexact all-at-once methods will be considered. In both cases, the evaluation of cost function, constraints, and derivatives is carried out on discretizations which are adaptively refined during optimization and can further be approximated by reduced order models or low rank tensor methods. We will develop implementable control mechanisms for the inexactness, which are tailored to the needs of the optimization methods and can be based on a posteriori error estimators. The algorithms will be implemented and tested for the considered prototype classes of MPECs.

Partner: Michael Ulbrich (TU München), Lukas Hertlein (TU München), DFG Priority Programme (SPP) 1962: "Non-smooth and Complementarity-based Distributed Parameter Systems: Simulation and Hierarchical Optimization"; speaker Prof. Dr. Michael Hintermüller (HU Berlin / WIAS Berlin)

Support: DFG

Contact: A.-T. Rauls, S. Ulbrich.

Project: Adaptive Multilevel Methods for the Optimal Control of Hyperbolic Equations in Gas Networks (Subproject A02 of Transregio/SFB 154)

This project is part of the Transregio/SFB 154: "Mathematical Modelling, Simulation and Optimization on the Example of Gas Networks". We analyze the optimal control of hyperbolic PDE systems with state constraints on the example of gas networks. Through the time-dependent control of compressors and valves, the pressure and velocity distribution of the transported gas in the network has to be optimized under constraints, e.g., such that the pressure lies within a specified tolerance range. The constraints of the resulting optimal control problem (P) consist of coupled systems of one-dimensional isothermal Euler equations describing the gas flow, node conditions and state constraints. We will derive optimality conditions for the state constrained problem (P) with switching controls. As a basis for numerical optimization methods, we will approximate the state constraints by Moreau-Yosida regularizations and we will study the convergence of the solution of the regularized problem to the solution of the state constrained problem. The main goal of this project is to provide an optimization theory, which will form the basis of adaptive multilevel methods.

Partner: Transregio/SFB 154: "Mathematical Modelling, Simulation and Optimization on the Example of Gas Networks"; speaker Prof. Dr. Alexander Martin (Department of Mathematics, FAU Erlangen-Nürnberg)

Support: DFG

Contact: J. M. Schmitt, S. Ulbrich.

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Project: Portfolio Optimization with robust risk measures

While in the most common (Markovitz) portfolio optimization problem the variance is used as a measure for the risk of a certain portfolio choice, there exist several other risk measures such as value-at-risk, conditional value-at-risk and their robust counterparts, which have advantageous properties. Under suitable assumptions on the corresponding random variable, these risk measures lead to objective functions consisting of the weighted sum of the expected value and the standard deviation of the return of the considered portfolio choice. Without these assumptions one ends up with a nonsmooth objective function. The aim of this project is to consider portfolio optimization problems with these risk measures and cardinality constraints and to develop suitable solution algorithms.

Partner: Martin Branda (Czech Academy of Sciences and Charles University, Prague); Michal Červinka (Czech Academy of Sciences and Charles University, Prague)

Contact: A. Schwartz, M. Bucher

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Project: Multi-Leader-Follower Games in Function Space (Project P21 in SPP 1962)

This project aims to design efficient and problem tailored numerical solution methods for certain classes of multi-leader-follower games (MLFG) in function space accompanied by the theoretical analysis of these problems. While in a classical Nash equilibrium problem we have several players that simultaneously make a decision, in an MLFG the group of players is split into the so-called leaders deciding first and followers reacting to this. This hierarchical game has various applications, e.g., in telecommunications, traffic networks and electricity markets. It can be seen as an extension of the single-leader-multi-follower (Stackelberg) game or mathematical program with equilibrium constraints. We start with the theoretical investigation (existence, uniqueness and suitable approximations of Nash equilibria) of finite-dimensional (i.e. static) MLFGs. Next, we develop new numerical methods for the static MLFGs. These outcomes are not only of interest by themselves, but serve us as starting point for the theory as well as the design of numerical solution methods for the dynamic (time-dependent) MLFG. Additionally applications are considered to build a test library for our algorithms.

Partner: Sonja Steffensen (RWTH Aachen), DFG Priority Programme (SPP) 1962: "Non-smooth and Complementarity-based Distributed Parameter Systems: Simulation and Hierarchical Optimization"; speaker Prof. Dr. Michael Hintermüller (HU Berlin / WIAS Berlin)

Support: DFG

Contact: A. Schwartz

Project: Optimal Control of Navier-Stokes with Combustion

Based on the work of the SFB 568 subproject D5 we continue to develop efficient methods for the optimization of combustion chambers containing turbulent fluid flow and combustion processes, which are modeled by partial differential equations.
The employed optimization methods rely on adjoints and derivative information, calculated by automatic differentiation [1]. The implementation uses the parallel multi-grid flow solver "Fastest", which incorporates recent simplified combustion models such as the flamelet-generated-manifold (FGM) method.

Partner: Darmstadt Graduate School of Excellence Energy Science and Engineering (GSC 1070); speakers Prof. Dr. Wolfram Jaegermann and Prof. Dr. Johannes Janicka (TU Darmstadt)

Support: DFG

Contact: C. Sehrt, S. Ulbrich.

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Project: Optimizing Fracture Propagation Using a Phase-Field Approach (Project P17 in SPP 1962)

We consider the numerical approximation and solution of control problems governed by a quasi-static brittle fracture propagation model. As a central modeling component, a phase-field formulation for the fracture formation and propagation is considered.
The fracture propagation problem itself can be formulated as a minimization problem with inequality constraints, imposed by multiple relevant side conditions, such as irreversibility of the fracture-growth or non-selfpenetration of the material across the fracture surface. These lead to variational inequalities as first order necessary conditions. Consequently,

optimization problems for the control of the fracture process give rise to a mathematical program with complementarity constraints (MPCC) in function spaces.
Within this project, we intend to analyze the resulting MPCC with respect to its necessary and sufficient optimality conditions by means of a regularization of the lower-level problem and passage to the limit with respect to the regularization parameter. Moreover, we will consider SQP-type algorithms for the solution of this MPCC in function space and investigate its properties. Additionally, we will consider the discretization by finite elements and show the convergence of the discrete approximations to the continuous limit.
The simultaneous consideration of the inexactness due to discretization and regularization error will allow us to construct and analyze an efficient inexact SQP-type solver for the MPCC under consideration.

Partner: Ira Neitzel (Universität Bonn), Thomas Wick (École Polytechnique), Christoph Ortner (University of Warwick), DFG Priority Programme (SPP) 1962: "Non-smooth and Complementarity-based Distributed Parameter Systems: Simulation and Hierarchical Optimization"; speaker Prof. Dr. Michael Hintermüller (HU Berlin / WIAS Berlin)

Support: DFG

Contact: M. Mohammadi, W. Wollner.

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Project: Discretization Error in Mixed Integer Optimization (Subproject A08 of Transregio/SFB 154)

The project is concerned with a posteriori error estimation in the context of mixed integer-continuous optimization. It aims at robustification of discrete decisions with respect to unavoidable discretization errors. In contrast to robustification against uncertainties that are only realized ex-post, the discretization errors can, in principle, be made arbitrarily small by increasing the computational effort. In continuous optimization, the error in the decision can thus be made arbitrarily small by spending additional computational time. If discrete decisions are involved this is no longer true, since discrete decisions inherently depend discontinuously upon the data of the problem. Consequently, the central question of this project is to derive conditions under which it can be ensured that a discrete decision would have been taken identically even if no discretization error had occurred, i.e., the decision is robust with respect to the chosen discretization accuracy.
In the context of gas networks, this problem can be demonstrated already with a single pipe with connected compressor. If, for disabled compressor, the pressure in the pipe is close to the minimal allowed pressure, a small discretization error may lead to a wrong decision whether to activate the compressor or not. The methods to be developed within this project therefore will allow to characterize these situations, and thereby provide information whether the decision may still depend upon the discretization accuracy, or if further changes in the discretization will not have any influence on the decisions made.

Partner: Pia Domschke (TU Darmstadt), Transregio/SFB 154: "Mathematical Modelling, Simulation and Optimization on the Example of Gas Networks"; speaker Prof. Dr. Alexander Martin (Department of Mathematics, FAU Erlangen-Nürnberg)

Support: DFG

Contact: S. Beckers, W. Wollner.

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Project: Finite Element Error in Discretization of State-Constrained Parabolic Optimization Problems

The aim of the project is the numerical analysis of optimal control problems governed by parabolic PDEs and subject to constraints on the state variable and its first derivative. The control is acting distributed in time only while the state constraints are considered pointwise in time and global in space; this setting generates an optimization problem of semi-infinite type.
A time-space discretization of the problem is considered, leading naturally to the study of the convergence of the discretized solution toward the continuous one as time and space mesh size tend to zero. This is based, at any level of discretization, on a priori error estimates for the solution of the parabolic differential equations which are obtained within this project.
One of the main challenges for state-constrained problems consists in the presence of a Lagrange multiplier appearing as a Borel measure in the system of first-order optimality conditions. In particular, such a measure enters the optimality system as data in the adjoint equation afflicting the regularity of the adjoint variable itself. This issue must be considered when deriving convergence rates as we cannot rely on adjoint information.
This situation is magnified for non-convex problems where the presence of local solutions and the need for second-order optimality conditions require a different strategy compared to the convex case, making the analysis more involved. Indeed, the convergence of the discretized solution towards the continuous one is based on a so-called quadratic growth condition, which arises from the second order optimality conditions. When using this quadratic growth-condition a phenomenon called two-norm discrepancy come into play: the objective functional is differentiable in a norm stronger than the one where the coercivity holds. For the problem at hand it is possible to remove this discrepancy, avoiding in this way the derivation of convergence rates for the control variable in the stronger norm. For both the convex and non-convex case our findings are verified numerically and we expect the convergence rates of the optimal control problems to coincide with the rates of the corresponding error in the differential equation.

Partner: Ira Neitzel (Universität Bonn)

Contact: F. Ludovici, W. Wollner.

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2 Collaborative Research Projects and Cooperations

The research group is involved in a number of interdisciplinary research projects including excellence projects, collaborative research centres and priority programs. This section gives a brief overview of these activities.

2.1 Collaborative Research Centre SFB 666

The Collaborative Research Centre SFB 666 "Integral Sheet Metal Design with Higher Order Bifurcations", established in 2005, considers the enormous prospective potential of the new linear flow splitting technique for sheet metal and develops methodical tools to integrate this technique into the product development processes. The research center is interdisciplinary, involving mechanical and civil engineers, mathematicians and material scientists.

The investigated technologies of the SFB, linear flow splitting and linear bend splitting, make it possible to produce branched sheet metal products in integral style. Hereby the disadvantages of conventional procedures to create branched sheet metal structures, e.g., gluing or welding, can be avoided. The SFB is structured into the four main units of development, production, evaluation and synthesis. In each of these units, new methodologies, techniques and proceedings arise. They cope with the occurring new requirements of this product category. This interdisciplinary research environment has lead to novel product development methodologies by combining engineering expertise with mathematical modeling and optimization methods.

The Department of Mathematics participates in the SFB 666 within three sub-projects (Kohler, Pfetsch, Ulbrich). The mathematical research is concentrated on development and on evaluation. In the product development process, the aim is to provide an optimal design of the desired product as well as an optimal process control of selected forming methods. This is done by means of discrete optimization and PDE-constrained nonlinear optimization. In the evaluation process, statistical methodologies are used to provide estimates for relations between properties of the considered sheet metal part and its structural durability. Thus, a smaller number of costly and time consuming experiments have to be carried out.

2.2 Collaborative Research Centre SFB 805

The Collaborative Research Centre SFB 805 "Control of Uncertainty in Load-Carrying Structures in Mechanical Engineering" was established in January 2009. The second funding period started in January 2013 and in 2016 the collaborative research centre was extended to a third funding period starting in January 2017. Its main objective is the development of methods and techniques to control uncertainties in the development, production and usage of load-carrying structures to significantly enhance their safety, reliability and economic efficiency. While uncertainty cannot be avoided or eliminated, its influence during the product lifecycle – from material properties to production and usage –

can be controlled and hence minimized. Especially in the area of light-weight construction, the trade-off between low weight and low production cost on one hand and adequate load-bearing capacity on the other hand makes the influence of uncertainties critical. Hence, the control of uncertainty is of significant importance and is therefore a focus of the research to be conducted by the SFB 805.

The control of uncertainty through the entire process chain of development, production and usage necessitates a close interdisciplinary cooperation of engineers and mathematicians. Within the collaborative research centre, the engineering sciences address uncertainty in terms of physical and technical phenomena. The mathematical research assesses the influence and effects of uncertainty and its interdependencies. It then derives optimal solution strategies for processes with minimal uncertainty and optimal design concepts for load-carrying systems from this.

The Department of Mathematics is involved in four projects of SFB 805 (Kohler, Pfetsch, Ulbrich). To deal with uncertainty, the tool of robust optimization is applied, where complex products are optimized while controlling inherent uncertainty already in the product development phase. Uncertainty may occur because of uncertain loadings, uncertain material properties or unknown user behavior. Furthermore, the SFB 805 examines the use of active elements to react on uncertainty in a load-carrying system. The question of optimal placement of active elements in the structure is a challenging nonlinear mixed-integer optimization problem. In the production process, the optimization of process chains under uncertainty is considered in order to reduce costs and uncertainty caused by uncertain market conditions. Additionally an attempt is made to control stochastic uncertainty at the planning stage of a product. Therefore knowledge of the effects of unavoidably occurring (random) fluctuations in the production or usage are required. Based on suitable models of the underlying process, methods of nonparametric regression were and will be developed to do this in an efficient way.

2.3 Collaborative Research Centre SFB 1194

The Collaborative Research Centre SFB 1194 “Interaction between Transport and Wetting Processes”, established in July 2016, involves researchers from the TU Darmstadt and the Max Planck Institute for Polymer Research Mainz. Their common goal is the fundamental analysis of the interaction between transport and wetting processes. The SFB focuses particularly on the interactions between wetting and transport processes when, parallel to momentum transport, also heat and mass transport occur, complex fluids are involved or complex surfaces are examined. Although the physical phenomena take place only in a range of nanometres or micrometres, they often determine the efficiency of the overall process and the resulting product quality. Therefore, fundamental processes and phenomena are examined over a wide range of length scales (nano-micro-macro) and the transfer of basic research to applications is an integral part of the research program.

The SFB comprises 18 projects in the current first funding period, grouped into three research areas: A – Generic Experiments, B – Modeling and Simulation and C – New and Improved Applications. The Department of Mathematics is involved in three projects of SFB 1194 (Bothe, Ulbrich), which are allocated to research area B.

Research area B includes developments of mathematical models and numerical simulation techniques that describe the interaction of wetting processes with momentum, heat and mass transport, using physics based approaches. These models and simulations are closely linked and validated with the generic experiments performed in research area A. Once validated, these models and simulations are not subjected to the same parameter constraints as the generic experiments, e.g. with respect to resolution or parameter space; hence they contribute essential information to the overall understanding of the phenomena. In order to perform sensitivity analysis, parameter studies and targeted optimizations, automatic differentiation techniques and numerical adjoint solutions will be used. This will lead to suggestions for improved designs and process control for specific applications, such as in printing or heat transfer devices. Throughout the future funding periods of the SFB the complexity of the fluids and surfaces being examined will increase.

2.4 Collaborative Research Centre Transregio TRR 154

The Collaborative Research Centre Transregio TRR 154 “Mathematical Modelling, Simulation and Optimization Using the Example of Gas Networks” was established in 2014. The energy transition ("Energiewende") in Germany and its success are currently in the focus of public interest. This transition is of central significance to society, politics, and science, since Germany, like many other industrial nations, finds itself in a situation of dramatically increased dependence on a reliable, secure, and affordable energy supply. At the same time, the request for clean, environment and climate-friendly energy generation is as large as never before. In order to achieve that and, in parallel, to master the nuclear power phase-out, natural gas as an energy source will play a pivotal role in the coming decades. Within this time span, a sufficient amount of natural gas will be available; it will be readily accessible, tradable, and storable. Nevertheless, the focus on an efficient natural gas supply implies a multiplicity of problems concerning gas transport and network technology as well as the consideration of market-regulatory conditions, and also the coupling with other energy sources. As an example, we mention that gas carriers must provide evidence that, within given technical capacities, all contracts which come into existence on the market are physically and technically satisfiable.

The aim of the TRR 154 is to offer answers to these challenges by using methods of mathematical modelling, simulation, and optimization and, in turn, to provide solutions of increased quality. Novel mathematical findings are required in different areas such as mathematical modelling, numerical analysis, and simulation as well as integer, continuous, and stochastic optimization in order to achieve this aim. As examples, we mention the modelling and analysis of complex networks of hyperbolic balance equations including switches and the development of a mixed-integer optimization theory together with its algorithmic realisation for such networks. Furthermore, efficient hierarchical numerical approximation techniques for the resulting algebraically coupled PDEs need to be developed and a sophisticated error control, taking the interaction with the mixed-integer optimization algorithms into account, is required.

The Department of Mathematics at TU Darmstadt is involved with Dr. Domschke and Professors Egger, Lang, Pfetsch, Ulbrich, and Wollner in the collaborative research centre Transregio TRR 154. Furthermore, groups at Universität Erlangen-Nürnberg (speaker), HU Berlin, TU Berlin, Universität Duisburg-Essen, Konrad-Zuse-Zentrum für Informationstechnik Berlin (ZIB), and Weierstraß-Institut für Angewandte Analysis und Stochastik (WIAS) – Leibniz-Institut im Forschungsverbund Berlin e.V. are part of TRR 154.

The homepage of TRR 154 is `trr154.fau.de`.

2.5 Graduate School of Computational Engineering

Computational Engineering (CE) denotes computer based modeling, analysis, simulation, and optimization. It is a cost-effective, efficient and complementary approach to studing engineering applications and to engineering new technical solutions when experimental investigations are too complex, risky, or costly. CE enables the creation of scalable models to support research, development, design, construction, evaluation, production, and operation of engineering applications which address key issues in future technology developments for the economy and society in areas such as energy, health, safety, and mobility. However, such engineering applications are becoming increasingly complex. Consequently, the theory and methodologies required to investigate corresponding systems become challenging.

With the Graduate School of Computational Engineering, TU Darmstadt was able to further strengthen its role in CE. The school enables highly talented PhD students to develop their scientific skills in a focused way, and to cooperate under optimal conditions in a highly stimulating interdisciplinary environment based on the interaction of Computer Science, Mathematics, and Engineering Sciences. Partnerships with well established research organizations as well as cooperation with industry increase the impact of the Graduate School. Building on the well established interdepartmental expertise at TU Darmstadt, the Graduate School focusses on the following key research areas: modeling and simulation of coupled multi-physics problems, simulation based optimization, and hierarchical multi-scale modeling and simulation. The research efforts in the above fields are accompanied by corresponding developments of methods of visualization, simulated reality, high-performance computing, verification and validation, as well as software engineering and lifecycle research. The PhD students work together within research foci comprising one or more of the above topics. The joint research on specially defined use cases will further strengthen the interdisciplinary skills and cooperation.

Seven professors of the Department of Mathematics are Principal Investigators within the Graduate School Computational Engineering (Aurzada, Bothe, Egger, Lang, Pfetsch, Ulbrich, Wollner) with expertise in Probability Theory and Stochastic Analysis, Mathematical Modeling and Analysis, Numerical Analysis and Scientific Computing, Numerics of Partial Differential Equations, Discrete Optimization, and Nonlinear Optimization and Optimal Control. Four more members of the department are Research Group Leaders (Disser, Erath, Schwartz, Ullmann) with scientific focus on Online Optimization, Numerical Analysis, Discrete-Nonlinear Optimization, and Uncertainty Quantification. Together they supervise more than 10 interdisciplinary PhD projects within the Graduate School in close cooperation with a co-supervisor from Engineering or Computer Science.

2.6 Graduate School of Energy Science and Engineering

The mission of the Darmstadt Graduate School of Energy Science and Engineering is to educate tomorrow's leading Energy Engineers in a multidisciplinary field of expertise needed to identify and master the most demanding scientific, engineering, economic and social challenges in an interdisciplinary approach. The main challenge is viewed to be a continuous transition from the carbon-based, non-renewable primary energy sources of today to renewable and environmentally friendly energy resources of tomorrow.

The optimal strategy to meet this challenge is, on the one hand, to improve conventional energy technologies and render them progressively more efficient to meet the ever more stringent demands on pollutant emissions and, on the other hand, to simultaneously develop innovative, advanced renewable energy technologies which must be brought to a competitive technological readiness level and provide safe, reliable and cost-effective solutions.
Two professors of the Department of Mathematics are Principal Investigators within the Graduate School Energy Science and Engineering (Lang, Ulbrich) with expertise in Numerical Analysis, Nonlinear Optimization and Optimal Control.

2.7 International Research Training Group IRTG 1529

The International Research Training Group "Mathematical Fluid Dynamics" (IRTG 1529) is funded by the German Research Foundation (DFG) and the Japan Society for the Promotion of Science (JSPS). It is associated with TU Darmstadt and with two universities located in Tokyo, Waseda University and University of Tokyo.
The research of the program focuses on analytical, numerical and stochastic aspects as well as on modeling, optimization and aerodynamics of fluid dynamics. It distinguishes itself through joint teaching and supervision. The core program consists of interdisciplinary lectures and seminars and includes research and study periods in Tokyo. Presently, there are 12 PhD students and 2 Postdocs on the Darmstadt side and a similar amount on the Japanese side.
The principal investigators in Darmstadt are Volker Betz, Dieter Bothe, Herbert Egger, Reinhard Farwig, Matthias Hieber, Ulrich Kohlenbach, Maria Lukáčová, Cameron Tropea, Stefan Ulbrich and Martin Ziegler. The participating colleagues in Tokyo are Tadahisa Funaki, Yoshikazu Giga, Yosuke Hasegawa, Akitoshi Kawamura, Hideo Kozono, Hirofumi Notsu, Yoshihiro Shibata, Masahiro Yamamoto, Masao Yamazaki and Keita Yokoyama.
IRTG 1529 is organizing seminars, short courses, workshops and conferences on a regular basis in Darmstadt and Tokyo. The list of speakers in 2015 and 2016 includes leading experts of the field, e.g., R. Danchin, G.P. Galdi, Th. Gallay, Y. Giga, J. Goldstein, M. Gubinelli, G. Karch, H. Knüpfer, H. Koch, Th. Nguyen, T. Ogawa, J. Prüss, O. Sawada, G. Seregin, G. Simonett, S. Shimizu, V. Solonnikov, R. Takada, M. Tucsnak and H. Weber.
Highlights of the program were altogether 8 conferences or bigger workshops in 2015 and 2016, e.g., the "International Workshops on Mathematical Fluid Dynamics" at Waseda University, Tokyo, in March 2015 and November 2016 and in Darmstadt in April 2015 and November 2016.
The workshop on "Young Researchers in Fluid Dynamics" in June 2015 attracted many PhD students and informed them about various activities of the IRTG.
In addition, a joint workshop between SPP 1506, Transport Processes at Fluidic Interfaces, and the IRTG took place in October 2015 in Darmstadt.

2.8 Priority Programme SPP 1962

Many of the most challenging problems in the applied sciences involve non-differentiable structures as well as partial differential operators, thus leading to non-smooth distributed parameter systems. Those systems are investigated by the DFG Priority Programme 1962 "Non-smooth and Complementarity-based Distributed Parameter Systems: Simulation and

Hierarchical Optimization”. The non-smoothness considered in this DFG-Priority Programme typically arises (i) directly in the problem formulation, (ii) through inequality constraints, nonlinear complementarity or switching systems, or (iii) as a result of competition and hierarchy.
In fact, very challenging applications for (i) come from frictional contact problems, or non-smooth constitutive laws associated with physical processes such as Bean’s critical state model for the magnetization of superconductors, which leads to a quasi-variational inequality (QVI) problem; for (ii) are related to non-penetration conditions in contact problems, variational inequality problems, or inequality constraints in optimization problems which, upon proper re-formulation lead to complementarity problems and further, by means of non-linear complementarity problem (NCP) functions, to non-smooth systems similar to (i); and for (iii) come from multi-objective control systems or leader-follower principles, as they can be found in optimal system design in robotics and biomechanics. Modelling “competition” often leads to generalized Nash equilibrium problems (GNEPs) or partial differential games. Moreover, modelling “hierarchy” results in mathematical programs with equilibrium constraints (MPECs), a class of optimization problems with degenerate, non-smooth constraints. All of these problems are highly nonlinear, lead to QVIs, and represent rather novel mathematical structures in applications based on partial differential operators. In these and related applications, the transition from smoothing or simulation-based approaches to genuinely non-smooth techniques or to multi-objective respectively hierarchical optimization is crucial.
The SPP1962 is coordinated by Michael Hintermüller (HU Berlin/WIAS Berlin). It started in 2016 and runs until 2019, comprising 23 projects in the current first funding period.
The Department of Mathematics participates in the SPP1962 with three projects (Schwartz, Ulbrich, Wollner).

2.9 Scientific and Industrial Cooperations

In the following we list all scientific and industrial projects by names of the researcher of our department in alphabetic order, by names of partners in universities and industry, and the title of the project.

Yann Disser

- Dr. Fidaa Abed (TU München): Maintenance scheduling.
- Andreas Bärtschi (ETH Zürich): Graph exploration and delivery.
- Dr. Aaron Bernstein (TU Berlin): Incremental maximization.
- Antje Bjelde (HU Berlin): Online TSP.
- Dr. Katerina Böhmová (ETH Zürich): Interval selection.
- Prof. Dr. Jérémie Chalopin (Aix-Marseille University): Graph exploration and delivery.
- Dr. Lin Chen (Hungarian Academy of Sciences): Maintenance scheduling.
- Dr. Shantanu Das (Aix-Marseille University): Graph exploration and delivery.

- Prof. Dr. Andreas Feldmann (Charles University): Highway dimension.
- Prof. Dr. Martin Gairing (University of Liverpool): Secretary leasing.
- Daniel Graf (ETH Zürich): Graph exploration and delivery.
- Dr. Martin Groß (University of Waterloo): Incremental maximization.
- Jan Hackfeld (TU Berlin): Collaborative exploration, online TSP.
- Christoph Hansknecht (TU Braunschweig): Online TSP.
- Prof. Dr. Max Klimm (HU Berlin): Competitive exploration, secretary leasing.
- Prof. Dr. Adrian Kosowski (Paris Diderot University): Collaborative exploration.
- Prof. Dr. Stefan Kratsch (Universität Bonn): Robust search.
- Dr. Jannik Matuschke (TU München): Graph orientations, network interdiction.
- Prof. Dr. Nicole Megow (Universität Bremen): Robust knapsack, maintenance scheduling.
- Julie Meißner (TU Berlin): Online TSP.
- Matúš Mihalák (Maastricht University): Graph exploration and delivery.
- Dr. Sandro Montanari (ETH Zürich): Rectilinear shortest paths and MST.
- Frank Mousset (ETH Zürich): Collaborative Exploration.
- Dr. Andreas Noever (ETH Zürich): Collaborative Exploration.
- Dr. Alexander Richter (TU Braunschweig): Maintenance scheduling.
- Dr. Kevin Schewior (University of Chile): Online TSP.
- Miriam Schlöter (TU Berlin): Online TSP.
- Daniel Schmand (RWTH Aachen): Secretary leasing.
- Prof. Dr. Alexander Skopalik (Universität Paderborn): Secretary leasing.
- Nemanja Škorić (ETH Zürich): Collaborative Exploration.
- Prof. Dr. Martin Skutella (TU Berlin): Mightiness of the simplex algorithm.
- Prof. Dr. Angelika Steger (ETH Zürich): Collaborative exploration.
- Prof. Dr. Sebastian Stiller (TU Braunschweig): Robust knapsack.
- Prof. Dr. Leen Stougie (University of Amsterdam): Online TSP.
- Andreas Tönnis (RWTH Aachen): Secretary leasing.
- Dr. Przemysław Uznański (ETH Zürich): Collaborative exploration.
- Prof. Dr. Peter Widmayer (ETH Zürich): Message delivery.

Christopher Hojny

- Dr. Imke Joormann (TU Braunschweig), JProf. Dr. Martin Schmidt (FAU Erlangen-Nürnberg): Connected Graph Partitioning.

Hendrik Lüthen

- Dr. Imke Joormann (TU Braunschweig), JProf. Dr. Martin Schmidt (FAU Erlangen-Nürnberg): Connected Graph Partitioning.
- Corinna Gottschalk, Prof. Dr. Britta Peis, Andreas Wierz (RWTH Aachen): Optimization Problems with Color-Induced Budget Constraints.

Hannes Meinlschmidt

- Dr. Joachim Rehberg (WIAS Berlin): Hölder-estimates for nonautonomous parabolic evolution equations on rough domains.
- Prof. Dr. Christian Meyer (TU Dortmund), Dr. Joachim Rehberg (WIAS Berlin): Optimal control of the thermistor problem in three spatial dimensions.
- Prof. Dr. Christian Meyer (TU Dortmund), Dr. Joachim Rehberg (WIAS Berlin): A space of controls for optimal control problems associated to nonlinear evolution equations.
- apl. Prof. Dr. Dirk Horstmann (Universität zu Köln), Dr. Joachim Rehberg (WIAS Berlin): Well-posedness of the full Keller-Segel model on nonsmooth domains.
- Lucas Bonifacius (TU München), Prof. Dr. Ira Neitzel (Universität Bonn), Dr. Joachim Rehberg (WIAS Berlin): Global solutions for quasilinear parabolic equations in a scale of Banach spaces.
- Dr. Karoline Disser, Dr. Joachim Rehberg (WIAS Berlin): Quasilinear parabolic systems on rough domains.

Andreas Paffenholz

- Prof. Dr. Christian Haase (FU Berlin): Permutation, Cut, and Marginal Polytopes; Polyhedral Adjunction Theory; Unimodular Triangulations.
- Prof. Dr. Benjamin Nill (Universität Magdeburg): Polyhedral Adjunction Theory.
- Prof. Dr. Francisco Santos (University of Cantabria): Unimodular Triangulations.
- Lindsay Piechnik (High Point University): Unimodular Triangulations.

Marc Pfetsch

- Prof. Dr. Martin Haardt (TU Ilmenau): Compressed Sensing in Signal processing.
- Group of Dr. René Henrion (WIAS Berlin): Gas Transport Optimization.
- Group of Prof. Dr. Thorsten Koch (Zuse-Institut Berlin): Software for Integer Programming and Gas Transport Optimization.

- Prof. Dr. Dirk Lorenz (TU Braunschweig): Compressed Sensing.
- Group of Prof. Dr. Alexander Martin (FAU Erlangen-Nürnberg): Gas Transport Optimization.
- Prof. Dr. Sebastian Pokutta (Georgia Tech., Atlanta): Methods for integer programs.
- Prof. Dr. Marius Pesavento (TU Darmstadt): Mixed-integer programs in signal processing.
- Group of Prof. Dr. Werner Römisch (HU Berlin): Gas Transport Optimization.
- Group of Prof. Dr. Rüdiger Schultz (Universität Duisburg-Essen): Gas Transport Optimization.
- Prof. Dr. Martin Skutella (TU Berlin): Algorithms for Gas Transport Optimization.
- Group of Prof. Dr. Marc Steinbach (Universität Hannover): Gas Transport Optimization.
- Open Grid Europe (OGE): Project FORNE.

Alexandra Schwartz

- Martin Branda (Czech Academy of Sciences and Charles University, Prague): Robust portfolio optimization.
- Oleg Burdakov (Linköping University): Solution algorithms for sparse and cardinality constrained optimization problems.
- Michal Červinka (Czech Academy of Sciences and Charles University, Prague): Robust portfolio optimization.
- Prof. Dr. Christian Kanzow (JMU Würzburg): Solution algorithms for sparse and cardinality constrained optimization problems.
- Dr. Sonja Steffensen (RWTH Aachen): Multi-leader-follower games in function spaces.

Stefan Ulbrich

- Prof. Dr. Serge Gratton (INP ENSEEIHT Toulouse): Subspace decomposition methods for optimization.
- Prof. Dr. Peter Groche (TU Darmstadt): Optimization of deep drawing processes.
- Prof. Dr. Matthias Heinkenschloss (Rice University): PDE-constrained optimization.
- Prof. Dr. Michael Hintermüller (WIAS Berlin): Optimal control of hyperbolic conservation laws.
- Prof. Dr. Michael Hinze (Universität Hamburg): Model order reduction in optimization.

- Prof. Dr. Alexander Martin (FAU Erlangen-Nürnberg): Gas transport optimization.
- Prof. Dr. Anton Schiela (Universität Bayreuth): Preconditioners for PDE-constrained optimization.
- Prof. Dr. Sebastian Schöps (TU Darmstadt): Optimization under uncertainty.
- Prof. Dr. Michael Ulbrich (TU München): PDE- and VI-constrained optimization.
- Prof. Dr. Stefan Volkwein (Universität Konstanz): Model order reduction in optimization.

Winnifried Wollner

- Prof. Dr. M. Braack (CAU Kiel): Space-Time Adaptive Flow Simulations .
- Prof. Dr. R. Herzog (TU Chemnitz): A Conjugate Direction Method for Linear Systems in Banach Spaces.
- Prof. Dr. M. Hintermüller (WIAS Berlin): Free-Material Optimization.
- Dr. A. Linke (WIAS Berlin): Pressure-Robust Stokes Elements.
- Dr. C. Merdon (WIAS Berlin): Pressure-Robust Stokes Elements.
- Prof. Dr. C. Meyer (TU Dortmund): Adaptive Optimal Control of Obstacle Problems.
- Prof. Dr. I. Neitzel (Universität Bonn): Optimizing Fracture Propagation Using a Phase-Field Approach.
- PD Dr. A. Rademacher (TU Dortmund): Adaptive Optimal Control of Obstacle Problems.
- Prof. Dr. R. Rannacher (Universität Heidelberg): A priori Error Analysis on Arbitrary Finite Element Meshes.
- JProf. Dr. M. Schmidt (FAU Erlangen-Nürnberg): Global Mixed-Integer Nonlinear Optimization.
- Prof. Dr. T. Surowiec (Universität Marburg): Free-Material Optimization.
- Prof. Dr. A. Veeser (University of Milan): Finite Element Approximation of PDE Constrained Optimization Problems.
- Dr. T. Wick (CMAP, Ecole Polytechnique): Optimizing Fracture Propagation Using a Phase-Field Approach.

3 Publications

3.1 Co-Editors of Publications

3.1.1 Editors of Journals

Marc Pfetsch

– *Operations Research Letters* (Associate Editor)

– *Mathematical Programming Computation* (Associate and Technical Editor)

– *INFORMS Journal on Computing* (Associate Editor)

Stefan Ulbrich

– *Journal of Optimization Theory and Applications* (Associate Editor)

– *Optimization Methods and Software* (Regional Editor Europe)

– *SIAM Journal on Optimization* (Associate Editor)

– *Asymptotic Analysis* (Associate Editor)

– *ESAIM: Control, Optimisation and Calculus of Variations* (Associate Editor)

– *SIAM Book Series: MOS-SIAM Series on Optimization* (Associate Editor)

Winnifried Wollner

– *International Journal of Applied and Computational Mathematics* (Editorial Board)

3.1.2 Editors of Collected Works

Marc Pfetsch

– *Evaluating Gas Network Capacities, SIAM, Philadelphia, USA, MOS-SIAM Series on Optimization, 2015* (jointly with Thorsten Koch, Benjamin Hiller, and Lars Schewe)

3.2 Monographs and Books

[1] S. Bott. *Adaptive SQP Method with Reduced Order Models for Optimal Control Problems with Constraints on the State Applied to the Navier-Stokes Equations*. Dr. Hut Verlag, 2016.

[2] D. Bratzke. *Optimal Control of Deep Drawing Processes based on Reduced Order Models*. Dr. Hut Verlag, 2015.

[3] I. Joormann. *Analyzing Infeasible Flow Networks*. Dr. Hut Verlag, 2015.

[4] S. Pfaff. *Optimal Control of Hyperbolic Conservation Laws on Bounded Domains with Switching Controls*. Dr. Hut Verlag, 2015.

[5] A. Philipp. *Mixed-Integer Nonlinear Programming with Application to Wireless Communication Systems*. Dr. Hut Verlag, 2015.

[6] C. Schäfer. *Optimization approaches for actuator and sensor placement and its application to model predictive control of dynamical systems*. Dr. Hut Verlag, 2015.

3.3 Publications in Journals and Proceedings

3.3.1 Journals

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[3] T. Bogart, C. Haase, M. Hering, B. Lorenz, B. Nill, A. Paffenholz, G. Rote, F. Santos, and H. Schenck. Finitely many smooth d-polytopes with n lattice points. *Israel J. Math.*, 207(1):301–329, 2015.

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[8] Y. Disser, A. Feldmann, M. Klimm, and M. Mihalák. Improving the H_k-bound on the price of stability in undirected shapley network design games. *Theoretical Computer Science*, 562:557–564, 2015.

[9] Y. Disser, M. Klimm, N. Megow, and S. Stiller. Packing a knapsack of unknown capacity. *SIAM Journal on Discrete Mathematics*. To appear.

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[12] R. Herzog and W. Wollner. A conjugate direction method for linear systems in banach spaces. *J. Inverse Ill-Posed Probl.*, 2016.

[13] C. Hojny and M. E. Pfetsch. A polyhedral investigation of star colorings. *Discrete Applied Mathematics*, 208:59–78, 2016.

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[15] C. Kanzow and A. Schwartz. The price of inexactness: Convergence properties of relaxation methods for mathematical programs with equilibrium constraints revisited. *Mathematics of Operations Research*, 40:253–275, 2015.

[16] O. Lass and S. Ulbrich. Model order reduction techniques with a posteriori error control for nonlinear robust optimization governed by partial differential equations. *SIAM Journal on Scientific Computing*. To appear.

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[18] A. Linke, C. Merdon, and W. Wollner. Optimal L^2 velocity error estimates for a modified pressure-robust crouzeix-raviart stokes element. *IMA J. Numer. Anal.*, 37(1):354–374, 2016.

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3.3.2 Proceedings and Chapters in Collections

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3.4 Preprints

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[2] M. Fischer, F. Lindemann, M. Ulbrich, and S. Ulbrich. Fréchet differentiability of unsteady incompressible Navier-Stokes flow with respect to domain variations of low regularity by using a general analytical framework. Technical report, Department of Mathematics, TU Darmstadt, 2016. Submitted.

[3] T. Fischer and M. E. Pfetsch. Branch-and-cut for linear programs with overlapping SOS1 constraints. Optimization online, 2015.

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[13] O. Lass, S. Trenz, and S. Volkwein. Optimality conditions and POD a-posteriori error estimates for a semilinear parabolic optimal control. Konstanzer Schriften in Mathematik 345, 2015.

[14] O. Lass and S. Ulbrich. Model order reduction techniques with a posteriori error control for nonlinear robust optimization governed by partial differential equations. *SIAM J. Sci. Comput.*, 2016. To appear.

[15] P. Le Bodic, J. W. Pavelka, M. E. Pfetsch, and S. Pokutta. Solving MIPs via scaling-based augmentation. Technical report, Optimization Online, 2015.

[16] F. Ludovici, I. Neitzel, and W. Wollner. A priori error estimates for state constrained semilinear parabolic optimal control problems. Preprint, TU Darmstadt, 2016.

[17] H. Meinlschmidt, C. Meyer, and J. Rehberg. Optimal control of the thermistor problem in three spatial dimensions, part 1: Existence of optimal solutions. Submitted, 2016.

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[19] I. Neitzel, T. Wick, and W. Wollner. An optimal control problem governed by a regularized phase-field fracture propagation model. Preprint, TU Darmstadt, 2015.

[20] I. Neitzel and W. Wollner. A priori L^2-discretization error estimates for the state in elliptic optimization problems with pointwise inequality state constraints. Preprint, TU Darmstadt, 2016.

[21] M. E. Pfetsch and T. Rehn. A computational comparison of symmetry handling methods for mixed integer programs. Technical report, Optimization Online, 2015.

[22] C. Steffens, M. Pesavento, and M. E. Pfetsch. A compact formulation for the $\ell_{2,1}$ mixed-norm minimization problem. Technical report, arXiv:1606.07231, 2016.

[23] M. Ulbrich, S. Ulbrich, and D. Bratzke. A Multigrid Semismooth Newton Method for Semilinear Contact Problems. *Journal of Computational Mathematics*, 2016. To appear.

[24] S. Ulbrich and J. C. Ziems. Adaptive Multilevel Trust-Region Methods for Time-Dependent PDE-Constrained Optimization. *Portugaliae Mathematica*, 2016. To appear.

3.5 Reviewing and Refereeing

Yann Disser: Distributed Computing, European Journal of Operations Research, INFORMS Journal of Computing, Journal of Optimization Theory and Applications, Journal of Scheduling, Mathematical Programming, Theoretical Computer Science, ACM-SIAM Symposium on Discrete Algorithms (SODA), European Symposium on Algorithms (ESA), Conference on Web and Internet Economics (WINE), International Colloquium on Automata, Languages, and Programming (ICALP), International Conference on Algorithms and Complexity, Symposium on Theoretical Aspects of Computer Science (STACS)

Christopher Hojny: Graphs and Combinatorics

Oliver Lass: IEEE American Control Conference, Journal of Applied Mathematics and Mechanics, ESAIM: Control, Optimisation and Calculus of Variations

Andreas Paffenholz: Journal of Algebraic Combinatorics, European Journal of Combinatorics, Discrete and Computational Geometry, Annals of Combinatorics, SIAM Journal on Discrete Mathematics, Journal of Combinatorial Theory, Series A

Marc Pfetsch: 18th Conference on Integer Programming (IPCO) 2016, 19th Conference on Integer Programming (IPCO) 2017, Applied Mathematical Modelling, Discrete Applied Mathematics, Discrete Optimization, Linear Algebra and Its Applications, Management Science, Mathematical Programming Computation, Public Transport, TOP, Transportation Science, Transactions on Signal Processing

Alexandra Schwartz: Applied Mathematics and Computation, Asia-Pacific Journal of Operational Research, Journal of Optimization Theory and Applications, Optimization, Optimization Letters, SIAM Journal on Optimization

Stefan Ulbrich: Computers & Mathematics with Applications, IMA Journal on Numerical Analysis, Numerische Mathematik, SIAM Journal on Control and Optimization, SIAM Journal on Optimization

Winnifried Wollner: Mathematical Reviews; Applications of Mathematics, Applied Mathematics and Computation, Applied Numerical Mathematics, Calcolo, Computational Optimization and Applications, ESAIM: Control, Optimization and Calculus of Variations, Journal of Applied Mathematics and Computing, Journal of Mathematical Analysis and Applications, Journal of Optimization Theory and Applications, Journal of Scientific Computing, Numerical Algorithms, SIAM Journal on Control and Optimization, SIAM Journal on Numerical Analysis, SIAM Journal on Optimization

3.6 Software

SCIP-SDP: *A mixed integer semidefinite programming plugin for SCIP*

SCIP-SDP is a plugin for SCIP to solve mixed integer semidefinite programs (MISDPs). It combines the branch-and-bound framework of SCIP with interior-point SDP-solvers to solve MISDPs using either a nonlinear branch-and-bound approach or an outer-approximation-based cutting-plane approach. It extends SCIP by several heuristics, propagators, file readers and the handling of SDP-constraints.
For more information, see `http://www.opt.tu-darmstadt.de/scipsdp/`

Contributor at TU Darmstadt: Tristan Gally, Marc E. Pfetsch

netmic: *A program that computes Irreducible Infeasible Subsystem Arc Covers in Flow Networks*

netmic is a python-package that implements several solution approaches for Irreducible Infeasible Subsystem Arc Covers for the special case of Network Flow problems. The main focus is on heuristics, but there are also exact solution approaches included. Additionally, netmic contains a generator for infeasible flow network instances.
For more information, see `www.tu-braunschweig.de/mo/staff/joormann`

Contributor at TU Darmstadt: Imke Joormann

polymake: *Software for Geometric Combinatorics*

polymake started out as a tool for the algorithmic treatment of convex polyhedra. By now it also deals with toric varieties, tropical polytopes, and other objects. The software is jointly developed by the polymake team, lead by Ewgenij Gawrilow (TomTom) and Michael Joswig.
For more information, see `www.polymake.org`

Contributor at TU Darmstadt: Andreas Paffenholz

SCIP: *Software for Solving Constraint Integer Programs*

SCIP is a framework for solving constraint integer programs and performing branch-cut-and-price. It allows total control of the solution process and the access of detailed information. SCIP is also currently one of the fastest non-commercial mixed integer programming (MIP) solvers. It is developed together with Zuse-Insitut Berlin and FAU Erlangen-Nürnberg.
For more information, see `scip.zib.de`

Contributor at TU Darmstadt: Tobias Fischer, Tristan Gally, Marc E. Pfetsch

DOpElib: *Differential Equations and Optimization Environment*

DOpElib is a software library for the solution of optimization problems subject to partial differential equations.
For more information, see `www.dopelib.net`

Contributor at TU Darmstadt: Winnifried Wollner

4 Theses

4.1 PhD Dissertations

2015

Bott, Stefanie, *Adaptive SQP Method with Reduced Order Models for Optimal Control Problems with Constraints on the State Applied to the Navier-Stokes Equations* (Stefan Ulbrich)

Bratzke, Daniela, *Optimal Control of Deep Drawing Processes based on Reduced Order Models* (Stefan Ulbrich)

Burggraf, Timo, *Development of an automatic, multidimensional, multicriterial optimization algorithm for the calibration of internal combustion engines* (Stefan Ulbrich)

Joormann, Imke, *Analyzing Infeasible Flow Networks* (Marc Pfetsch)

Pfaff, Sebastian, *Optimal Control of Hyperbolic Conservation Laws on Bounded Domains with Switching Controls* (Stefan Ulbrich)

Philipp, Anne, *Mixed-Integer Nonlinear Programming with Application to Wireless Communication Systems* (Stefan Ulbrich)

Schäfer, Carsten, *Optimization approaches for actuator and sensor placement and its application to model predictive control of dynamical systems* (Stefan Ulbrich)

4.2 Diplom Theses

2015

Höll, Roman, *Optimierung von Stabwerken unter globalen Knickbedingungen* (Stefan Ulbrich)

Korotkov, Tatjana, *Jump and Volatility Components in German Equity Trading* (Stefan Ulbrich)

Kringel, Lars, *Lösung von Rangbeschränkten Semidefiniten Programmen durch Completely Positive Programming* (Stefan Ulbrich)

Meier, Max, *Ein robuster Optimierungsansatz für Kreditportfolios mit Chance Constrains* (Stefan Ulbrich)

Pfeiffer, Thilo, *Dynamic Pricing for Airline Partners* (Stefan Ulbrich)

Senina, Olga, *Multilevel Optimierungsverfahren für PDE restringierte Probleme mit Nebenbedingungen an den Gradienten* (Stefan Ulbrich)

4.3 Master Theses

2015

Adami, Thomas, *Robuste Strategien zur Portfoliooptimierung* (Stefan Ulbrich)

Akman, Tugba, *Gradientenformeln für nichtlineare Wahrscheinlichkeitsrestriktionen mit Normalverteilungen und Anwendung auf Downlink Beamforming* (Stefan Ulbrich)

Bergner, Arnold, *Nash-Gleichgewicht: Geschichte und mathematische Perfektheit* (Alexandra Schwartz)

Diehl, Jasmin, *Optimization of Trusses with Buckling Stabilization by Mixed-Integer Second-Order Cone Programming* (Stefan Ulbrich)

Habeck, Oliver, *Semiglatte Newton-Verfahren für Kontaktprobleme mit Reibung* (Stefan Ulbrich)

Huyen, Chan Bao, *Robust Growth-Optimal Portfolios* (Stefan Ulbrich)

Isufaj, Fatima, *Lösungsmethoden für das 3-dimensionale Packungsproblem mit Nebenbedingungen* (Marc Pfetsch)

Janzen, Kristina, *Optimale Sensorplatzierung in dynamischen Prozessen mit Methoden des optimalen Designs von Experimenten* (Stefan Ulbrich)

Krüger, Thomas, *The Q-Codegree of Lattice Polytopes* (Andreas Paffenholz)

Maasz, Manuel, *Optimales Stabwerkdesign mit globalen Knicknebenbedingungen unter Verwendung des Sequential Semidefinite Programming Verfahrens* (Stefan Ulbrich)

Nowak, Daniel, *Optimale Aktorplatzierung in Stabwerken zur Erhöhung der kritischen Knicklast* (Stefan Ulbrich)

Otterbein, Markus, *Konvexe Relaxationen bei der robusten Stabwerkoptimierung unter dynamischen Lasten* (Stefan Ulbrich)

Salupo, Giuseppe, *Robuste Optimierung des Conditional Value at Risk und Kredit-Portfolio-Management* (Stefan Ulbrich)

Stähler, Maximilian, *Optimale Randsteuerung von hyperbolischen Erhaltungsgleichungen mit Anwendung auf Verkehrsnetze* (Stefan Ulbrich)

Walter, Anna, *Mathematical Programs with Equilibrium Constraints mit Anwendung auf die Optimierung von Kontaktproblemen* (Stefan Ulbrich)

2016

Beck, Pascal, *Untersuchung eines SQP-Algorithmus mit gleichungsrestringierter Phase* (Stefan Ulbrich)

Bergen, Christoph, *Kopositive und vollständig positive Programme und ihre Anwendung auf quadratische Programme* (Stefan Ulbrich)

Bethcke, Johannes, *Synthesis of a Hydrostatic Power Transmission System using MINLP* (Marc Pfetsch)

Brunning, Katharina, *Sherali-Adams Relaxierungen von Graphenisomorphie Polytopen* (Marc Pfetsch)

Carkit, Ercan, *Numerische Methoden der nichtlinearen optimalen Versuchsplanung* (Stefan Ulbrich)

Christoffer, Frauke , *Gültige Relaxierungen der Eulergleichungen durch Diskretisierung zur Lösung von Zulässigkeitsproblemen in der Gasnetzwerkoptimierung* (Stefan Ulbrich)

Eckel, Pascal Roland, *Eine alternative Lösungsmethode für Optimierungsprobleme mit Komplementaritäts- oder Kardinalitätsrestriktionen basierend auf semi-infiniten Programmen* (Alexandra Schwartz)

Gerny, Friedrich, *Numerische Behandlung von Optimalsteuerungsproblemen für skalare Erhaltungsgleichungen mit an-/aus-Schaltungen mit Anwendung auf ein Verkehrsmodell mit Ampelschaltungen* (Stefan Ulbrich)

Grimm, Philip Hans, *Ein kombinatorischer Branch-and-Bound-Algorithmus für die Berechnung der Restricted Isometry Konstanten* (Marc Pfetsch)

Heun, Sebastian, *Globales Optimieren eines robusten Stabwerks mit einem gemischt ganzzahligen Programm* (Stefan Ulbrich)

Hornauer, Miriam, *Ein zweiseitiges Relaxierungsverfahren für mathematische Programme mit Komplementaritätsrestriktionen mit starken Konvergenzeigenschaften* (Alexandra Schwartz)

Ivanov, Bozhidar, *Shortest Paths with Conflicts* (Marc Pfetsch)

Keukoua Wantiep, Guenole, *Portfolio Selection under Distributional Uncertainty: A Relative Robust CVaR Approach* (Stefan Ulbrich)

Kinz, Monika, *Optimale Pausenplanung von LKW-Fahrern mit integrierter Parkplatzwahl* (Marc Pfetsch)

Köhler, Jan, *Schnittebenenverfahren zur Optimierung submodularer Funktionen* (Marc Pfetsch)

Kohrt, Nils, *Zur Portfolio Auswahl unter Verteilungsunsicherheit - Ein robuster CVaR Ansatz* (Stefan Ulbrich)

Kuske, Jan Ferdinand, *Discrete tomography with sparse gradients* (Marc Pfetsch)

Lange, Jan-Hendrik, *Integrality Aspects of Sparse Recovery via l1-Minimization* (Marc Pfetsch)

Maliqi, Beqir, *Eine Anwendung von Fehlerschranken auf Optimierungsprobleme mit Kardinalitätsrestriktionen* (Alexandra Schwartz)

Nattler, Julian, *Über die Aussagekraft von Rankings* (Marc Pfetsch)

Park, Sung-Ho, *Alternating Directions Method of Multipliers - Implementation for L1-problems* (Stefan Ulbrich)

Pfifferling, Lena, *A disjunctive programming approach for the link activation problem* (Stefan Ulbrich)

Pohl, Daniel, *Die Darstellung von QCQPs als verallgemeinerte vollständig positive Programme und ein Approximationsalgorithmus zur Lösung von copositiven Programmen* (Stefan Ulbrich)

Rauls, Anne-Therese, *Optimalsteuerung der semilinearen isothermen Eulergleichungen* (Stefan Ulbrich)

Schäfer Aguilar, Paloma, *Smoothing-type method for a Branch-and-Bound algorithm for Mixed-Integer Semidefinite Programs* (Stefan Ulbrich)

Schmitt, Andreas, *Extended formulations and symmetry handling* (Marc Pfetsch)

Seib, Bianca Mercedes, *Rekonstruktion dünnbesetzter Lösungen mit Ganzzahligkeitsbedingungen* (Marc Pfetsch)

Smolarek, Nadine, *Anwendung der kopositiven Programmierung auf ein Downlink Transmit Beamforming Problem* (Stefan Ulbrich)

Tabbert, Anne Nicola, *Modeling Truss Structures using Vanishing and Cardinality Constraints* (Alexandra Schwartz)

Tille, Lisa, *Portfolio-Optimierung unter Verteilungsunsicherheit: Ein robuster CVaR-Ansatz* (Stefan Ulbrich)

Vogt, Katja, *Gemischt-ganzzahlige Optimierungsmethoden für Klassifikationsprobleme* (Marc Pfetsch)

Weber, Marcel, *Holes in mixed integer problems* (Marc Pfetsch)

Werner, Johannes Manuel Friedemann, *Copositive Programmierung als Ansatz zur Lösung des optimalen Beamformingproblems* (Stefan Ulbrich)

Werner, David, *Nichtlineare robuste Optimierung via sequentieller konvexer bilevel Optimierung* (Stefan Ulbrich)

Weyer, Jonas Helmut, *Reduzierte Modelle auf Basis von POD für die optimale Steuerung der Navier-Stokes-Gleichungen auf veränderlichen Gebieten* (Stefan Ulbrich)

Wittmann, René Marc, *Polynomial Time Approximations for the Cutting Stock Problem* (Marc Pfetsch)

2015

Avramidis, Dimitrios, *Robust Portfolio Optimization by second-order cone programming* (Stefan Ulbrich)

Bahlke, Philipp, *Semismooth Support Vector Machines* (Stefan Ulbrich)

Behrmann, Nadine, *Least Infeasible Flow* (Marc Pfetsch)

Eckel, Pascal Roland, *Truss optimization with buckling constraints* (Stefan Ulbrich)

Fuhrländer, Mona, *MPEC-based heuristics for L0-minimization* (Marc Pfetsch)

Garvert, Linda Christin, *Incremental Network Design with Maximum Flows* (Stefan Ulbrich)

Heininger, Tim Uwe, *Estimation of the implied volatility of american options by mathematical programming with equilibrium constraints* (Stefan Ulbrich)

Hofmann, Adrian, *Sparse Forward Mode of Automatic Differentiation and its Implementation* (Stefan Ulbrich)

Hornauer, Miriam, *Global Linear Convergence of a Non-Interior Path Following Algorithm for Linear Complementarity Problems* (Stefan Ulbrich)

Klimm, Svenja, *Portfolio Optimization with Conditional Value-at-Risk Objective and Constraints* (Stefan Ulbrich)

Knoll, Steven, *Methods to sparsify matrices and their effect on the performance of l1-solvers* (Marc Pfetsch)

Kreß, Johanna, *Robust Portfolio Optimization* (Stefan Ulbrich)

Kullmann, Felix Peter, *Approximation Schemes for Generalized Flow* (Marc Pfetsch)

Liedtke, Aline Maren, *Adaptive constraint reduction for training support vector machines* (Stefan Ulbrich)

Markina, Julia, *Constraint Reduction for Support Vector Machines* (Stefan Ulbrich)

Matei, Alexander, *On Unconstrained Robust Optimization and Its Application to an Elasticity Problem* (Stefan Ulbrich)

Müller, Erik Jörn, *Investigation of a parametric active set method applied to linear programs* (Marc Pfetsch)

Potrikus, Pia, *Truss optimization based on a conic quadratic model with local buckling constraints* (Stefan Ulbrich)

Respondek, Robert Dominique, *Tractable Approximations to Robust Conic Optimization-problems* (Stefan Ulbrich)

Rohrbach, Felix Jonathan, *Robust Optimization Methods for the Tail Assignment Problem* (Marc Pfetsch)

Schier, Roland, *Models for Steiner tree problems* (Marc Pfetsch)

Schnarz, Anna, *Incremental Network Design with Maximum Flows* (Stefan Ulbrich)

Schwab, Michel Johannes, *Optimization of trusses under local buckling constraints* (Stefan Ulbrich)

Schwarzkopf, Marie-Christine Alice, *Robust Optimization of Trusses* (Stefan Ulbrich)

Thoß, Florian, *Balanced Proper Orthogonal Decomposition: Application to a flow control problem* (Stefan Ulbrich)

Trapp, Franziska, *Support Vector Machines and their Application to Breast Cancer Prognosis* (Stefan Ulbrich)

Wörl, Ann-Christin, *Nonzero structures of Hessians and starcolorings* (Marc Pfetsch)

2016

Assing, Charlotte, *Optimal structure of gas transmission trunklines* (Stefan Ulbrich)

Diehl, Katharina, *Semismooth Newton Methods for Second Order Cone Programming* (Stefan Ulbrich)

Gutermann, Jannis, *Compact Flows* (Marc Pfetsch)

Heil, Caroline Esther, *Robust Linear Optimization With Recourse* (Winnifried Wollner)

Himburg, Sandra Michaela, *Relaxations for mathematical programs with vanishing contraints* (Winnifried Wollner)

Hoffmann, Timo, *Free material optimization for stress constraints* (Stefan Ulbrich)

Jäger, Maike Elisa, *The Diameter of Lattice Polytopes* (Andreas Paffenholz)

Klein, Simon, *The Stoer-Wagner algorithm for minimum cuts in undirected graphs* (Marc Pfetsch)

Kohlmeyer, Ines, *The face algorithm for linear optimization problems* (Marc Pfetsch)

Lauber, Felix, *Semidefinite Programming* (Winnifried Wollner)

Leis, Annabel, *The Interior-Point-Method for Linear Programs* (Winnifried Wollner)

Lenhart, Dominic, *Pure-strategy Nash Equilibria in the Tullock Rent-Seeking Games* (Alexandra Schwartz)

Mao, Kevin, *Optimal data fitting with piecewise-affine models* (Marc Pfetsch)

Mohring, Sarah, *A recognition algorithm for unit interval graphs* (Marc Pfetsch)

Moos, Michael Werner, *Low-rank approximation for semidefinite programs* (Winnifried Wollner)

Muth, Julius Friedrich, *Solving Combinatorial Optimization Problems via Inclusion-Exclusion* (Marc Pfetsch)

Polenz, Björn, *Methods for Support Vector Machines and Applications* (Stefan Ulbrich)

Scheffer, Angelo, *Smoothing methods for linear optimization problems* (Stefan Ulbrich)

Tran, Theresa Thanh Mai, *Image Segmentation via Minimum Cuts in Planar Graphs* (Marc Pfetsch)

Zedler, Nora Anna Barbara, *The simplex gradient and noisy optimization problems* (Stefan Ulbrich)

Zinn, Timo, *Weight constrained shortest path problems* (Marc Pfetsch)

5 Presentations

5.1 Talks and Visits

5.1.1 Invited Talks and Addresses

Tobias Fischer

15/07/2015 *Branch-and-Cut for Linear Programs with Overlapping SOS1 Constraints*
International Symposium on Mathematical Programming (ISMP), Pittsburgh

Tristan Gally

14/07/2015 *Solving Mixed-Integer Semidefinite Programs for Robust Truss Topology Design*
International Symposium on Mathematical Programming (ISMP), Pittsburgh

Christopher Hojny

15/07/2015 *Polyhedral Symmetry Handling via Fundamental Domains*
International Symposium on Mathematical Programming (ISMP), Pittsburgh

Benjamin Horn

07/09/2016 *Shape optimization for contact problems based on isogeometric analysis*
International Conference and Workshop on Numerical Simulation of 3D Sheet Metal Forming Processes (NUMISHEET), Bristol

Imke Joormann

26/01/2016 *Unzulässigkeit in Netzwerken*
AG Seminar, RWTH Aachen

08/07/2016 *Optimierung von Gasnetzwerken*
Deutsche Schülerakademie, Jugenddorf-Christopherusschule Braunschweig

Oliver Lass

13/07/2015 *Robust optimization of a permanent magnet synchronous motor geometry*
International Symposium on Mathematical Programming (ISMP), Pittsburgh

21/03/2016 *Robust optimization using a second order approximation technique in parametrized shape optimization*
Conference on Iterative Methods, Copper Mountain

06/06/2016 *Robust optimization using a second order approximation technique and model order reduction*
European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS), Hersonissos

09/08/2016 *A second order approximation technique for robust optimization in parametrized shape optimization*
International Conference on Continuous Optimization (ICCOPT), Tokyo

27/09/2016 *Nonlinear robust optimization using a second order approximation technique and model order reduction*
ALOP Workshop: Reduced Order Models in Optimization, Trier

Francesco Ludovici

06/07/2015 *An overview of optimal control for complex system*
MathMods Summer School: Mathematics as a code of modernity, San Benedetto del Tronto

Hendrik Lüthen

16/07/2015 *Partitioning into Induced Connected Isomorphic Subgraphs*
International Symposium on Mathematical Programming (ISMP), Pittsburgh

Hannes Meinlschmidt

27/01/2015 *Optimalsteuerung des 3D Thermistor-Problems*
Seminar Nonlinear Optimization and Inverse Problems, Weierstraß Institut für Analysis und Stochastik (WIAS), Berlin

13/07/2015 *Optimal Control of PDAEs as Abstract DAEs of Index 1*
International Symposium on Mathematical Programming (ISMP), Pittsburgh

25/08/2015 *Optimal control problems with quasilinear parabolic equations in divergence form*
Kolloquium Lehrstuhl Optimalsteuerung, TU München

13/01/2016 *Hölder estimates for non-autonomous parabolic problems with rough data and applications to quasilinear problems*
Berliner Oberseminar: Nichtlineare partielle Differentialgleichungen (Langenbach-Seminar), Weierstraß Institut für Analysis und Stochastik (WIAS), Berlin

13/07/2016 *The full Keller-Segel model is well-posed*
Berliner Oberseminar: Nichtlineare partielle Differentialgleichungen (Langenbach-Seminar), Weierstraß Institut für Analysis und Stochastik (WIAS), Berlin

11/08/2016 *Optimal control of the 3D Thermistor Problem*
International Conference on Continuous Optimization (ICCOPT), Tokyo

Andreas Paffenholz

04/12/2015 *Structure and Classifications of Lattice Polytopes*
Seminar Geometrie und Visualisierung, TU München

02/08/2016 *Classifications of Lattice Polytopes*
Computational Commutative Algebra and Convex Polytopes, RIMS Kyoto

Sebastian Pfaff

05/07/2016 *Optimal Boundary Control of Scalar Conservation Laws with Switching Controls*
European Conference on Operational Research (EURO), Poznań

Marc Pfetsch

03/06/2015 *Overlapping SOS1 Constraints*
Mixed Integer Programming Workshop (MIP), Chicago

23/06/2015 *Die "diskrete" Seite der Mathematischen Optimierung*
Vorlesungsreihe: "Was steckt dahinter?", TU Darmstadt

29/02/2016 *Compressed Sensing and Discrete Optimization*
Oberseminar, Aachen

Johann Michael Schmitt

08/08/2016 *Optimal control of hyperbolic balance laws with state constraints*
International Conference on Continuous Optimization (ICCOPT), Tokyo

Alexandra Schwartz

11/02/2015 *Rigging the Game: Spieltheorie und Wettbewerbsdesign*
Mathematisches Kolloquium, Darmstadt

04/03/2015 *Eine kontinuierliche Umformulierung von Problemen mit Kardinalitätsrestriktionen*
Workshop "Women in Optimization", Heidelberg

14/10/2015 *Spieltheorie: Alles im Gleichgewicht?*
Schülerinnen- und Schülernachmittag zur Mathematik, Darmstadt

26/01/2016 *NewtonPlag*
Hochschul- und Berufsinformationstage (Hobit), Darmstadt

10/03/2016 *Spieltheorie und Wettbewerbsdesign*
Joint Annual Meeting of GAMM and DMV, Braunschweig

28/10/2016 *Multi-Leader-Follower Games in Function Space*
with Sonja Steffensen, Kickoff-Meeting SPP 1962, Berlin

Stefan Ulbrich

27/01/2015 *Multilevel methods for PDE-constrained optimization based on adaptive discretizations, reduced order models and error estimators*
Colloquium of the Modeling, Numerics, Differential Equations Group, TU Berlin

17/06/2015 *Multilevel methods for PDE-constrained optimization based on adaptive discretizations and reduced order models*
Plenary Talk, British-French-German Conference on Optimization, London

13/07/2015 *Optimization of nonlinear hyperbolic conservation laws with switching controls*
International Symposium on Mathematical Programming (ISMP), Pittsburgh

05/08/2015 *Multilevel methods for PDE-constrained optimization based on adaptive discretizations and reduced order models*
Plenary Talk, 10th Int. Conference on Numerical Optimization and Numerical Linear Algebra (ICNONLA), Yanan, Shaanxi, China

13/08/2015 *Methods for robust PDE-constrained optimization and applications*
International Congress on Industrial and Applied Mathematics (ICIAM), Bejing, China

10/11/2015 *Methods for robust PDE-constrained optimization and applications*
UQ15: Direct and Inverse Problems for PDEs with Random Coefficients, WIAS, Berlin

02/12/2015 *Robust optimization for engineering applications*
Bosch AG, Renningen

21/03/2016 *Preconditioners for time-dependent PDE-constrained optimization and their application based on Parareal time-domain decomposition*
Conference on Iterative Methods, Copper Mountain

14/06/2016 *Efficient methods for PDE-constrained optimization based on adaptive discretizations and reduced order models*
Mathematical Colloquium, Department of Mathematics, FAU Erlangen-Nürnberg

10/08/2016 *Preconditioners for time-dependent PDE-constrained optimization and an implementation based on Parareal time-domain decomposition*
International Conference on Continuous Optimization (ICCOPT), Tokyo

29/09/2016 *Robust PDE-constrained optimization based on approximation techniques and reduced order models*
Invited special lecture, CAAM, Rice University, Houston

Winnifried Wollner

29/01/2015 *Optimal Control for Fracture Propagation Modeled by a Phase-Field Approach*
Colloquium of the EPN, Quito

09/06/2015 *Pointwise convergence of the feasibility violation for Moreau-Yosida regularized optimal control problems*
Kolloquium an der Universität der Bundeswehr, München

18/02/2016 *Optimization of partial differential equations subject to pointwise constraints on the gradient of the state*
Kolloquium an der Universität Bonn

14/04/2016 *Optimization of partial differential equations subject to pointwise constraints on the gradient of the state*
Kolloquium am Weierstraß Institut für Analysis und Stochastik (WIAS), Berlin

20/09/2016 *Adaptive finite elements in numerical optimization*
Autumn School Algorithmic Optimization, Trier

27/09/2016 *Optimal Control of PDEs*
TRR 154 Lecture Series, Darmstadt

11/10/2016 *Optimal L2 Error for a Modified Crouzeix-Raviart Stokes Element*
Symposium on Simulation and Optimization of Extreme Fluids, Heidelberg

5.1.2 Contributed Talks

Paloma Schäfer Aguilar

14/11/2016 *Smoothing-type method for a Branch-and-Bound algorithm for mixed-integer semidefinite programs*
Optimization Seminar, TU Darmstadt

Johanna Biehl

25/04/2016 *Multilevel Optimization based on Reduced Order Models with Application to Fluid Structure Interaction*
Graduate School CE Research Colloquium, TU Darmstadt

Max Bucher

11/02/2015 *Was ist ein Nash-Gleichgewicht?*
Seminar “What is . . . ?”, TU Darmstadt

13/04/2015 *A Continuous Reformulation of Cardinality Constrained Optimization Problems*
Graduate School CE Retreat, Seeheim-Jugenheim

03/08/2015 *A Continuous Reformulation of Cardinality Constrained Optimization Problems*
Graduate School CE Research Colloquium, TU Darmstadt

05/09/2016 *A Continuous Reformulation of Cardinality Constrained Optimization Problems - Optimality Conditions and an Error Bound via Piecewise Decomposition*
Graduate School CE Research Colloquium, TU Darmstadt

Yann Disser

05/01/2015 *The Simplex Algorithm is NP-mighty*
ACM-SIAM Symposium on Discrete Algorithms (SODA), San Diego

04/01/2016 *Undirected Graph Exploration with* $\theta(\log\log n)$ *Pebbles*
Combinatorial Optimization Workshop (COW), Aussois

Thorsten Ederer

10/03/2015 *Experimentelle Validierung einer algorithmischen Systemsynthese*
Technical Operations Research Workshop (TOR), Trifels

16/07/2015 *Benchmarks of Distributed Solvers for Mixed-Integer Linear Programs on a High Performance Computer*
International Symposium on Mathematical Programming (ISMP), Pittsburgh

02/09/2015 *Algorithmic System Design Using Scaling and Affinity Laws*
Annual International Conference of the German Operations Research Society (OR), Wien

26/02/2016 *Technical Operations Research – Optimale Strukturfindung*
HDT-Seminar: Ventilatoren – Von der Produkt-Optimierung zur quantitativen Methode der Systemsynthese, Essen

06/04/2016 *Auslegung von mechanischen Getrieben mittels MINLP*
Technical Operations Research Workshop (TOR), Trifels

06/06/2016 *Gearbox Design via Mixed-Integer Programming*
European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS), Hersonissos

02/09/2016 *A Mixed-Integer Nonlinear Program for the Design of Mechanical Transmission Systems*
Annual International Conference of the German Operations Research Society (OR), Hamburg

Michael Fischer

12/03/2015 *Shape optimization and the stabilized characteristics finite element method*
Japanese-German International Workshop on Mathematical Fluid Dynamics, Waseda University, Tokyo

17/07/2015 *Shape Optimization of the Boussinesq Equations via a Characteristics P1/P1 FE Discretization*
International Symposium on Mathematical Programming (ISMP), Pittsburgh

07/08/2015 *Shape Optimization of the Boussinesq Equations via a Characteristics P1/P1 FE Discretization*
Joint International Conference and Autumn School, TU Darmstadt

30/11/2015 *Shape Optimization of the Navier-Stokes equations*
Optimization Seminar, TU Darmstadt

02/03/2016 *Shape optimization with the Boussinesq equations*
Japanese-German International Workshop on Mathematical Fluid Dynamics, Waseda University, Tokyo

Tobias Fischer

23/11/2015 *Branch-and-Cut for Linear Programs with Overlapping SOS1 Constraints*
Graduate School CE Research Colloquium, TU Darmstadt

27/06/2016 *Branch-and-Cut for Linear Programs with Complementarity and Cardinality Constraints*
Optimization Seminar, TU Darmstadt

Tristan Gally

12/07/2016 *SCIP-SDP: A Framework for Solving Mixed-Integer Semidefinite Programs*
International Congress on Mathematical Software (ICMS), Berlin

31/10/2016 *SCIP-SDP: A Framework for Solving Mixed-Integer Semidefinite Programs*
Optimization Seminar, TU Darmstadt

Thea Göllner

24/03/2015 *Geometry Optimization of Branched Sheet Metal Structures with a Globalization Strategy by Adaptive Cubic Regularization*
Annual Meeting of the International Association of Applied Mathematics and Mechanics (GAMM), Lecce

Oliver Habeck

24/10/2016 *Globale Methoden für stationären Gastransport*
Optimization Seminar, TU Darmstadt

Christopher Hojny

11/05/2015 *Polyhedral Symmetry Handling via Symmetry Breaking Polytopes*
Optimization Seminar, TU Darmstadt

26/05/2015 *Symmetry Handling via Symmetry Breaking Polytopes*
Cologne Twente Workshop (CTW), Marmara University Istanbul

05/01/2016 *Polytopes Associated with Symmetry Handling*
Combinatorial Optimization Workshop (COW), Aussois

14/07/2016 *Symmetry Handling in Binary Programs via Polyhedral Methods*
International Conference on Mathematical Software (ICMS), Berlin

17/10/2016 *Symmetry Handling in Binary Programs via Polyhedral Methods*
Optimization Seminar, TU Darmstadt

Benjamin Horn

11/08/2016 *Shape optimization for contact problems based on isogeometric analysis and nonconvex bundle methods*
International Conference on Continuous Optimization (ICCOPT), Tokyo

Imke Joormann

05/07/2016 *Heuristics for Analyzing Infeasibility in Flow Networks*
European Conference on Operational Research (EURO), Poznań

12/05/2016 *Unzulässigkeitsanalyse in Fluss-Netzwerken*
AG Seminar, TU Braunschweig

26/01/2015 *Irreducible Infeasible Subsystems and their Covers in Flow Networks*
Optimization Seminar, TU Darmstadt

Philip Kolvenbach

16/07/2015 *Robust Geometry Optimization in Elastodynamics with Time-Dependent Uncertainties*
International Symposium on Mathematical Programming (ISMP), Pittsburgh

11/08/2016 *Nonlinear robust optimization using second-order approximations and an application to the shape optimization of hyperelastic load-carrying structures*
International Conference on Continuous Optimization (ICCOPT), Tokyo

13/09/2016 *Nonlinear robust optimization using second-order approximations and an application to the shape optimization of hyperelastic load-carrying structures*
European Conference on Computational Optimization (EUCCO), Leuven

07/11/2016 *Robuste Optimierung PDE-restringierter Probleme mittels quadratischer Approximationen*
Optimization Seminar, TU Darmstadt

Anja Kuttich

25/03/2015 *Robust Optimization of Trusses under Dynamic Loads via Nonlinear Semidefinite Programming*
Annual Meeting of the International Association of Applied Mathematics and Mechanics (GAMM), Lecce

18/07/2015 *Robust Optimization of Trusses under Dynamic Loads via Nonlinear Semidefinite Programming*
International Symposium on Mathematical Programming (ISMP), Pittsburgh

19/11/2015 *Robust Truss Topology Design with Beam Elements via Mixed Integer Nonlinear Semidefinite Programming*
International Conference on Uncertainty in Mechanical Engineering (ICUME), Darmstadt

09/03/2016 *Nonlinear Semidefinite Programming with Application to Robust Truss Topology Design under Uncertain Dynamic Loads*
Joint Annual Meeting of GAMM and DMV, Braunschweig

11/08/2016 *Robust Topology Design of Mechanical Systems under Uncertain Dynamic Loads via Nonlinear Semidefinite Programming*
International Conference on Continuous Optimization (ICCOPT), Tokyo

Oliver Lass

15/06/2015 *Robust optimization of a permanent magnet synchronous motor geometry*
British-French-German Conference on Optimization, London

Francesco Ludovici

27/03/2015 *A priori error estimates for nonstationary optimal control problems with gradient state constraints*
Annual Meeting of the International Association of Applied Mathematics and Mechanics (GAMM), Lecce

15/07/2015 *A priori error estimates for nonstationary optimal control problems with gradient state constraints*
International Symposium on Mathematical Programming (ISMP), Pittsburgh

22/09/2015 *A priori error estimates for nonstationary optimal control problems with state constraints*
Jahrestagung der Deutschen Mathematiker-Vereinigung, Hamburg

07/12/2015 *Optimal control of parabolic PDEs with state constraints*
Optimization Seminar, TU Darmstadt

08/03/2016 *Nonstationary optimal control problems with state constraints*
Joint Annual Meeting of GAMM and DMV, Braunschweig

01/09/2016 *Optimal control of parabolic PDEs with state constraints*
Workshop in applied and industrial mathematics (WIAM16), Hamburg

Hendrik Lüthen

20/06/2016 *Optimierungsprobleme mit farbinduzierten Budget-Bedingungen*
Optimization Seminar, TU Darmstadt

04/08/2016 *Partitioning into Induced Connected Isomorphic Subgraphs*
Future Research in Combinatorial Optimization (FRICO), Osnabrück

Hannes Meinlschmidt

23/02/2015 *Quasilineare und nichtautonome parabolische Optimalsteueraufgaben und Kompaktheit für Steuerungen*
Chemnitzer Seminar zur Optimalsteuerung, Haus im Ennstal

01/07/2015 *PDAEs and Optimal Control*
IFIP TC7 Conference on System Modelling and Optimization, Sophia Antipolis

01/03/2016 *Hölder-Schranken für nichtautonome parabolische Probleme und Anwendung für quasilineare Probleme*
Chemnitzer Seminar zur Optimalsteuerung, Haus im Ennstal

11/04/2016 *Hölder-Schranken für nichtautonome parabolische Probleme und Anwendung für quasilineare Probleme*
Optimization Seminar, TU Darmstadt

Marc Pfetsch

16/07/2015 *Polyhedral Descriptions of Star Colorings*
International Symposium on Mathematical Programming (ISMP), Pittsburgh

08/03/2016 *Polytopes Associated With Symmetry Handling*
Joint Annual Meeting of GAMM and DMV, Braunschweig

Johann Michael Schmitt

14/12/2015 *Optimal control of hyperbolic balance laws with state constraints*
Optimization Seminar, TU Darmstadt

01/03/2016 *Optimal control of hyperbolic balance laws with state constraints*
Chemnitzer-Seminar zur Optimalsteuerung, Haus im Ennstal

19/12/2016 *Optimalsteuerung von Systemen hyperbolischer Bilanzgleichungen am Beispiel verallgemeinerter Riemann Probleme*
Optimization Seminar, TU Darmstadt

Alexandra Schwartz

09/03/2016 *A Reformulation of Sparse Optimization Problems using Complementarity Constraints*
Joint Annual Meeting of GAMM and DMV, Braunschweig

04/05/2016 *A Reformulation of Sparse Optimization Problems using Complementarity Constraints*
International Conference on Bilevel Optimization and Related Topics, Dresden

02/07/2016 *A Reformulation of Sparse Optimization Problems using Complementarity Constraints*
EUROPT Workshop on Advances in Continuous Optimization, Warsaw

09/08/2016 *A Reformulation of Sparse Optimization Problems using Complementarity Constraints*
International Conference on Continuous Optimization (ICCOPT), Tokyo

Cedric Sehrt

09/08/2016 *Optimal Control of Scalar Transport in Incompressible Fluid Flow*
International Conference on Continuous Optimization (ICCOPT), Tokyo

28/11/2016 *Optimal Control of Scalar Transport in Incompressible Fluid Flow*
Optimization Seminar, TU Darmstadt

Anna Walter

04/03/2016 *Simulation-based optimization methods for the deep drawing of branched structures*
Summer School, Geelong

Winnifried Wollner

11/03/2015 *Optimal Control for Fracture Propagation Modeled by a Phase-Field Approach*
Recent Trends and Future Developments in Computational Science and Engineering Workshop (CSE), Plön

19/03/2015 *Differentiability of Fluid-Structure Interaction Problems with Respect to the Data*
International Conference on High Performance Scientific Computing (HPSC), Hanoi

22/03/2015 *Optimal Control for Fracture Propagation Modeled by a Phase-Field Approach*
Chemnitzer Seminar zur Optimalsteuerung, Haus im Ennstal

24/03/2015 *Adaptive Optimal Control of the Obstacle Problem*
Annual Meeting of the International Association of Applied Mathematics and Mechanics (GAMM), Lecce

13/05/2015 *Optimal Control for Fracture Propagation Modeled by a Phase-Field Approach*
Viennese Workshop on Optimal Control and Dynamic Games, Wien

11/06/2015 *Optimization Problems subject to PDEs and Pointwise Constraints on the Gradient of the State*
IFIP TC7 Conference on System Modelling and Optimization, Sophia Antipolis

24/08/2015 *Discretization error analysis of optimal control problems with PDEs*
Workshop: Partial differential equations, optimal design and numerics, Benasque

15/09/2015 *Finite Element Error Analysis for Elliptic and Parabolic Optimization Problems with Gradient State Constraints*
European Conference on Numerical Mathematics and Advanced Applications (ENUMATH), Ankara

24/09/2015 *Adaptive Optimal Control of the Obstacle Problem*
Chinese-German Workshop on Computational and Applied Mathematics, Augsburg

28/02/2016 *Gradientenschranken in der Optimierung mit nicht-stationären PDGen*
Chemnitzer-Seminar zur Optimalsteuerung, Haus im Ennstal

09/03/2016 *Optimal Control for Fracture Propagation Modeled by a Phase-Field Approach*
Joint Annual Meeting of GAMM and DMV, Braunschweig

18/03/2016 *Optimal L^2-Error for a Modified Crouzeix-Raviart Stokes Element*
Variational Multiscale and Stabilized Finite Elements (VMS), Magdeburg

16/06/2016 *Discretization of Parabolic Optimization Problems with Constraints on the Spatial Gradient of the State*
The Mathematics of Finite Elements and Applications (MAFELAP), Brunel

15/06/2016 *Finite Element Approximation of Gradient Constraint Elliptic Optimization Problems on Non-Smooth Domains*
The Mathematics of Finite Elements and Applications (MAFELAP), Brunel

11/08/2016 *PDE Constrained Optimization with Pointwise Gradient Constraints*
International Conference on Continuous Optimization (ICCOPT), Tokyo

5.1.3 Visits

Tobias Fischer, Zuse-Institut Berlin, February 2015

Tobias Fischer, TU Ilmenau, April 2016

Tobias Fischer, Zuse-Institut Berlin, September 2016

Tristan Gally, Zuse-Institut Berlin, February 2015

Tristan Gally, Kyushu University, Fukuoka, March 2015

Tristan Gally, Zuse-Institut Berlin, May 2016

Tristan Gally, Zuse-Institut Berlin, September 2016

Christopher Hojny, TU Braunschweig, June 2016

Christopher Hojny, Zuse-Institut Berlin, September 2016

Hendrik Lüthen, RWTH Aachen, March 2015

Hannes Meinlschmidt, Weierstraß Institut für Analysis und Stochastik (WIAS), Berlin, January 2015

Hannes Meinlschmidt, TU München, August 2015

Hannes Meinlschmidt, Weierstraß Institut für Analysis und Stochastik (WIAS), Berlin, January 2016

Hannes Meinlschmidt, Weierstraß Institut für Analysis und Stochastik (WIAS), Berlin, July 2016

Hannes Meinlschmidt, TU Dortmund, December 2016

Andreas Paffenholz, Universität Magdeburg, March 2016

Marc Pfetsch, Kyushu University, Fukuoka, March 2015

Marc Pfetsch, RWTH Aachen, February 2016

Johann Michael Schmitt, FAU Erlangen-Nürnberg, July 2016

Stefan Ulbrich, INP ENSEEIHT, Toulouse, October 2016

Stefan Ulbrich, Rice University, Houston, September 2016

Stefan Ulbrich, FAU Erlangen-Nürnberg, June 2016

Stefan Ulbrich, Rice University, Houston, May 2016

Stefan Ulbrich, TU München, September 2015

Winnifried Wollner, FAU Erlangen-Nürnberg, December 2016

Winnifried Wollner, Universität Bochum, December 2016

Winnifried Wollner, Universität Heidelberg, November 2016

Winnifried Wollner, TU München, September 2016

Winnifried Wollner, Weierstraß Institut für Analysis und Stochastik (WIAS), Berlin, July 2016

Winnifried Wollner, Universität Bonn, June 2016

Winnifried Wollner, CAU Kiel, May 2016

Winnifried Wollner, Weierstraß Institut für Analysis und Stochastik (WIAS), Berlin, April 2016

Winnifried Wollner, Universität Bonn, February 2016

Winnifried Wollner, TU München, September 2015

Winnifried Wollner, Universität der Bundeswehr, München, June 2015

Winnifried Wollner, EPN, Quito, January–February 2015

5.2 Organization and Program Commitees of Conferences and Workshops

Yann Disser

- Member of program committee, International Conference on Algorithms and Complexity (CIAC), 2015, Paris
- Member of program committee, European Symposium on Algorithms (ESA), 2016, Aarhus

Marc Pfetsch

- Session "Polyhedral Methods in Geometry and Optimization" at the International Congress on Mathematical Software (ICMS), 2016, Berlin
- A Frankfurt-Darmstadt Afternoon on Discrete Mathematics (jointly with Thorsten Theobald), July 3, 2015, Frankfurt

Alexandra Schwartz

- Section "Optimization" (jointly with Anton Schiela) at the Joint Annual Meeting of GAMM and DMV, 2016, Braunschweig
- Session "Solutions of Equilibrium Problems: Computation and Stability" at the International Conference on Continuous Optimization (ICCOPT), 2016, Tokyo

Stefan Ulbrich

- Session "Recent Advances in PDE-Constrained Optimization" at the International Symposium on Mathematical Programming (ISMP), 2015, Pittsburgh
- Session "Recent Developments in PDE-constrained Optimization I and II" at the Iternational Conference on Continuous Optimization (ICCOPT), 2016, Tokyo

Winnifried Wollner

- Minisymposium "Numerical Analysis and Methods for Problems with Singularities" at the European Conference on Numerical Mathematics and Advanced Applications (ENUMATH), 2015, Ankara
- Young-Researchers Minisymposium "Discretization aspects in PDE constrained optimization" at the Annual Meeting of the International Association of Applied Mathematics and Mechanics (GAMM), 2015, Lecce

6 Workshops and Visitors at the Department

6.1 Guest Talks at the Department

21/01/2016 Prof. Dr. Ira Neitzel (Universität Bonn), *Finite element error estimates for elliptic Dirichlet-boundary control problems with pointwise state constraints* (Winnifried Wollner)

07/07/2016 Prof. Dr. Andreas Veeser (University of Milan), *Oscillation in a posteriori error estimation* (Winnifried Wollner)

19/09/2016 Dr. Christina Burt (The University of Melbourne), *Little Missed Opportunities* (Johann Michael Schmitt)

19/09/2016 Dr. Christina Burt (The University of Melbourne), *The power-p Steiner tree problem: leveraging geometric properties to aid a math programming approach* (Johann Michael Schmitt)

19/10/2016 Prof. Dr. Christoph Ortner (University of Warwick), *Atomistische und mehrskalige Materialmodellierung* (Winnifried Wollner)

6.2 Visitors at the Department

Prof. Dr. Günter Leugering (FAU Erlangen-Nürnberg), June 2015.

Prof. Dr. Ira Neitzel (Universität Bonn), January 2016.

Prof. Dr. Andreas Veeser (University of Milan), July 2016.

Prof. Dr. Christoph Ortner (University of Warwick), October 2016.

6.3 Workshops and Conferences at the Department

– A Darmstadt–Frankfurt Afternoon on Optimization, June 10, 2016 (organized by Marc E. Pfetsch, Thorsten Theobald, and Stefan Ulbrich)

7 Other scientific and organisational activities

7.1 Memberships in Scientific Boards and Committees

Marc Pfetsch

- BMBF-Gutachterausschuss “Mathematik für Innovationen in Industrie und Dienstleistungen”
- Forschungsrat der Rhein-Main Universitäten

Stefan Ulbrich

- Member of the IFIP Technical Committee TC 7, WG 7.2 “Computational Techniques in Distributed Systems”, since 2003
- Universitätsversammlung TU Darmstadt
- Senat TU Darmstadt

Winnifried Wollner

- Vice Speaker of GAMM Activity Group on “Optimization with Partial Differential Equations”

7.2 Awards and Offers

Awards

Yann Disser: Best Paper Award, DFG Priority Program “Algorithms for Big Data” (2016)

Imke Joormann: EURO Excellence in Practice Award 2016 (Association of European Operational Research Societies), July 6, 2016

Marc Pfetsch: EURO Excellence in Practice Award 2016 (Association of European Operational Research Societies), July 6, 2016

Stefan Ulbrich: Athene Award for Excellent Teaching 2016, TU Darmstadt

Offers of Appointments

Winnifried Wollner: Professorship (W3) for Scientific Computing, Universität Hannover

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Fachbereich Mathematik
AG Optimierung
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