Biannual Report

Department of Mathematics – Research Group Optimization
2013 and 2014

TECHNISCHE
UNIVERSITÄT
DARMSTADT

Introduction

This document contains a subset of the information contained in the biannual report of the Department of Mathematics at TU Darmstadt for 2013 and 2014. 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, November 2015

Contents

1 Research Group

This section gives a brief overview of the research done in the research groups.

1.1 Optimization

The research group **Optimization** consists of the groups **Algorithmic Discrete Mathematics**, **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 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.

Algorithmic Discrete Mathematics combines aspects of pure and applied mathematics. The group focuses on geometric combinatorics with links to graph algorithms, linear and integer programming, toric and tropical algebraic geometry and related areas.
We develop mathematical software for research in mathematics and beyond.

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.
Experiences of the group are, 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, which 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, preconditioning, global optimization, and relaxation of discrete problems.

The research group Optimization is engaged among others in the Excellence Cluster EXC 259 *Center of Smart Interfaces*, the Graduate School (Excellence Initiative) GSC 233 *Computational Engineering: Beyond Traditional Sciences*, the Collaborative Research Center (SFB) 666 *Integral Sheet Metal Design with Higher Order Bifurcations – Development, Production, Evaluation*, the Collaborative Research Center (SFB) 805 *Control of Uncertainties in Load Carrying Systems of Mechanical Engineering*, the Transregional Collaborative Research Center (Transregio/SFB) 154 *Mathematical Modelling, Simulation and Optimization on the Example of Gas Networks*, the LOEWE-Center *AdRIA: Adaptronic: Research, Innovation, Application*, the International Research Training Group IRTG 1529 *Mathematical Fluid Dynamics*, and the Deutsche Forschungsgemeinschaft (DFG) Priority Program SPP 1253 *Optimization with Partial Differential Equations*. In addition, the group has various industry partners, including cooperations with Open Grid Europe and Schenck.

Members of the research group

Professors

Michael Joswig, Marc Pfetsch, Alexandra Schwartz, Stefan Ulbrich, Irwin Yousept

Postdocs

Oliver Lass, Ulf Lorenz, Andreas Paffenholz, Andreas Tillmann

Research Associates

Benjamin Assarf, Vera Bommer, Stefanie Bott, Daniela Bratzke, Thorsten Ederer, Sarah Essert, Michael Fischer, Tobias Fischer, Tristan Gally, Jane Ghiglieri, Thea Göllner, Christopher Hojny, Kai Habermehl, Katrin Herr, Benjamin Horn, Silke Horn, Imke Joormann, Philipp Kolvenbach, Anja Kuttich, Madeline Lips, Hendrik Lüthen, Sonja Mars, Hannes Meinlschmidt, Thomas Opfer, Sebastian Pfaff, Anne Philipp, Rolf Roth, Johann Michael Schmitt, Carsten Schäfer, Cedric Sehrt, Adrian Sichau, Jan Wolf

Secretaries

Kirsten Hessenmüller, Ursula Röder

Project: Numerical analysis and fast solvers for the optimal control of electromagnetic processes governed by the time-domain 3D Maxwell equations

Electromagnetism plays an important role in many modern high-technological applications. They include applications in the magnetic connement fusion, transportation based on the magnetic levitation technology, microwave heating, sensor and signal technology, and many more. The mathematical and numerical analysis of the electromagnetic field control is highly challenging and calls for a careful study. This project is aimed at the numerical analysis and the development of fast and efficient solvers for the optimal control of electromagnetic processes governed by the time-domain 3D Maxwell equations. This project is original and has not been investigated by any other authors. In fact, the optimal control theory in electromagnetism is a rather new research area, and there is only a small number of studies devoted to the static or time-harmonics cases.

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

Support: DFG

Contact: Vera Bommer, Irwin Yousept

Project: Adaptive Multilevel SQP Methods for PDAE-Constrained Optimization with Restrictions on Control and State

The project is part of the DFG-Priority Program SPP 1253 “Optimization with Partial Differential Equations”.
The adaptive multilevel SQP method for control constrained optimal control problems of Ziems and Ulbrich, see [4], [7], is extended to state constrained optimal control problems governed by PDAEs. To this end, we combine the Moreau Yosida regularization with the adaptive SQP method. The refinement conditions and the penalty parameter update are modified specifically. We ensure that the regularized subproblems satisfy the assumptions of the adaptive SQP method and that the combined algorithm is well-posed. Based on the convergence theory for the Moreau Yosida regularization of Meyer and Yousept [5] and the SQP method of Ziems and Ulbrich [6], [7], we show a new first order necessary optimality result for the output of the combined algorithm, see [1] and [2].
Additionally we include a reduced-order model based on POD combined with DEIM in the adaptive SQP method. This reduces the computational effort significantly. The algorithm is implemented for an application in glass manufacturing by Clever, Lang and Schröder, see [2].

Partner: Graduate School of Computational Engineering (GSC 233); speaker Prof. Dr. Michael Schäfer (Department of Mechanical Engineering, TU Darmstadt), D. Clever, J. Lang, D. Schröder (TU Darmstadt)

Support: DFG

Contact: Stefanie Bott, Stefan Ulbrich

References

[1] S. Bott. *Adaptive Multilevel SQP Method for State Constrained Optimization with PDEs*. Diploma thesis, TU Darmstadt, 2012.

[2] S. Bott, D. Clever, J. Lang, S. Ulbrich, J. C. Ziems, and D. Schröder. On a Fully Adaptive SQP Method for PDAE-Constrained Optimal Control Problems with Control and State Constraints. In *Trends in PDE Constrained Optimization*, volume 165 of *International Series of Numerical Mathematics*, pages 85–108. Springer International Publishing, 2014.

[3] D. Clever, J. Lang, S. Ulbrich, and J. C. Ziems. Combination of an adaptive multilevel SQP method and a space-time adaptive PDAE solver for optimal control problems. *Procedia Computer Science*, 1(1):1435–1443, 2010.

[4] D. Clever, J. Lang, S. Ulbrich, and J. C. Ziems. Generalized multilevel SQP-methods for PDAE-constrained optimization based on space-time adaptive PDAE solvers. In *Constrained optimization and optimal control for partial differential equations*, pages 51–74. Springer, 2012.

[5] C. Meyer and I. Yousept. Regularization of state-constrained elliptic optimal control problems with nonlocal radiation interface conditions. *Computational Optimization and Applications*, 44(2):183–212, 2009.

[6] S. Ulbrich and J. C. Ziems. Adaptive multilevel generalized SQP-methods for PDE-constrained optimization. *submitted*, 2011.

[7] J. C. Ziems. *Adaptive multilevel SQP-methods for PDE-constrained optimization*. Dissertation, TU Darmstadt, 2010.

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 hydro-forming. 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.

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: Daniela Bratzke, Stefan Ulbrich

References

[1] D. Bratzke and S. Ulbrich. Optimierungsverfahren zur optimalen Steuerung von Tiefziehprozessen basierend auf reduzierten Modellen. In P. Groche, editor, *Tagungsband 5. Zwischenkolloquium Sonderforschungsbereich 666*, pages 41–48, Bamberg, Nov. 2014. Meisenbach Verlag.

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 plan 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 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.

Similarly, the adjoint equation is also considered in an ALE framework and in a strongly coupled way.

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

Support: DFG

Contact: Sarah Essert, Stefan Ulbrich, Michael Schäfer

Project: Shape optimization with the Boussinesq equations

The project is part of the DFG supported International Research Training Group 1529 “Mathematical Fluid Dynamics”.

The analytical and numerical results on shape optimization problems governed by the Navier Stokes equations by Brandenburg and Lindemann et al. [1] are extended to the more general Boussinesq equations. To this end, we extend the differentiability results from Lindemann et al. [2] to the case of the Boussinesq equations. Additionally to the investigation of the problem in the infinite dimensional case, we consider suitable P2/P1 and P1/P1 discretizations of the differential equation to apply the theory in a practical example. Here, the research concerning the P1/P1 discretization is done in cooperation with the the numerics group of Prof. Notsu at Waseda University during a six month exchange program.

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 and Japan Society for the promotion of science

Contact: Michael Fischer, Stefan Ulbrich

References

[1] C. Brandenburg, F. Lindemann, M. Ulbrich, and S. Ulbrich. A Continuous Adjoint Approach to Shape Optimization for Navier Stokes Flow. In K. Kunisch, J. Sprekels, G. Leugering, and F. Tröltzsch, editors, *Optimal Control of Coupled Systems of Partial Differential Equations*, volume 158 of *International Series of Numerical Mathematics*, pages 35–56. Birkhäuser Basel, 2009.

[2] F. Lindemann, M. Ulbrich, and S. Ulbrich. Fréchet differentiability of time-dependent incompressible Navier-Stokes flow with respect to domain variations. Technical report, Fakultät für Mathematik, TU München, 2010.

Project: Optimization with Complementarity Constraints

Complementarity constraints require that at most one of two variables is nonzero. They are a well known tool for the modeling of logical relations expressing that from a set of possible events not more than one is allowed to occur. The applications of such relations are abundant, e.g., in machine learning, communication systems, finance or scheduling.

The aim of this project is to investigate a branch-and-cut algorithm for complementarity constrained optimization problems, including presolving techniques, branching rules, primal heuristics and cutting planes. The implemented software has to deal with problem instances involving large data in a robust manner. Furthermore, it should recognize and exploit special structures of a given problem instance automatically. As a tool, we use the software SCIP (see `scip.zib.de`) which provides a framework for solving discrete and combinatorial optimization problems. The purpose is to include further components to SCIP and to make them freely available for academic use.

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

Support: DFG

Contact: Tobias Fischer, Marc Pfetsch

Project: Optimal Flow Control based on Reduced Models

Tollmien-Schlichting waves are responsible for the laminar-turbulent transition in a flat plate boundary layer. By damping these waves, a significant reduction of drag can be achieved. Motivated by an experiment conducted in the windtunnel at the institute SLA, the objective is to dampen Tollmien-Schlichting waves by using a body force which is induced by a plasma actuator. These actuators induce a body force which leads to a fluid acceleration, so the velocity profile is changed next to the surface. By optimal control of the plasma actuator parameters it is possible to reduce or even cancel the Tollmien-Schlichting waves and delay the turbulence transition.

We use a Model Predictive Control (MPC) approach for the cancellation of Tollmien-Schlichting waves in the boundary layer of a flat plate. The model that predicts the next flow field in a time horizon, has to fulfill the Navier-Stokes equations. Instead of solving a high-dimensional system, a low-order model description is used to perform the optimization. The reduced-order model is obtained with a Galerkin projection and an appropriate basis. We use Proper Orthogonal Decomposition (POD) in which the basis function are generated from numerical solutions for carefully chosen initial data and control inputs. The optimization of the control parameters is performed within the reduced system. The efficiency of the reduced-order controller is demonstrated for the damping of Tollmien-Schlichting waves by plasma actuators.

Partner: Graduate School of Computational Engineering (GSC 233); speaker Prof. Dr. Michael Schäfer (Department of Mechanical Engineering, TU Darmstadt), Institute of Fluid Mechanics and Aerodynamics (SLA), Institute of Numerical Methods in Mechanical Engineering

Support: DFG

Contact: Jane Ghiglieri, Stefan Ulbrich

References

[1] J. Ghiglieri and S. Ulbrich. Optimal flow control based on POD and MPC and an application to the cancellation of Tollmien-Schlichting waves. *Optimization Methods and Software*, 29(5):1042–1074, 2014.

Project: Polyhedral Description of Star Colorings

Star colorings are node colorings of an undirected graph which ensure that adjacent nodes are not colored equally, and additionally, that no path on four nodes is colored with exactly two colors. The computation of star colorings which minimize the number of colors are important for the efficient computation of sparse Hessian matrices. The smallest number of colors which is needed for a star coloring of a graph is called the star chromatic number. In the literature, however, the number of colors is mostly determined heuristically which leads to an upper bound on the star chromatic number.

The aim of this project is to develop polyhedral models which allow for the exact computation of the star chromatic number. 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 determine the star chromatic number. Furthermore, we investigate complete linear descriptions for the polytopes corresponding to our models for several graph classes to detect structural properties which can be adapted to further graph classes.

Contact: Christopher Hojny, Marc Pfetsch

Partner: Andrea Walther, Universität Paderborn

Project: Generation of Certificates for the Infeasibility of Technical Capacities

This project was part of the BMWi cooperative project "Investigation of the technical capacities of gas networks", in which six research partners, the gas transportation company Open Grid Europe, and the German Federal Network Agency (Bundesnetzagentur) were involved. The technical capacities determine bounds on the amount of gas that can be charged into or discharged from a gas network. Therefore, a central aspect was to compute these technical capacities.
In our sub-project, we determined so-called certificates for the infeasibility of certain gas nominations. For the analysis of technical capacities one has to decide which requests can be handled by the network. If a certain nomination cannot be transported, one wants to know the reason why this nomination is infeasible. Thus a justification is required, i.e., a certificate that is easy to understand. This should be possible without the need for involved simulations or computations. We concentrated on the development of methods to find such certificates and applied them to the analysis of technical capacities.

Partner: Zuse-Institut Berlin; Universität Hannover; Universität Duisburg-Essen; HU Berlin; Universität Erlangen-Nürnberg; German Federal Network Agency (Bundesnetzagentur); Open Grid Europe

Support: German Federal Ministry of Economics and Technology (BMWi)

Contact: Imke Joormann, Marc Pfetsch

Project: FORNE

In this project, we dealt with gas network optimization, together with our industrial partner Open Grid Europe (OGE). The goal was to provide tools for the mid to long term planning of gas networks. One main step dealt with the question to decide whether a given amount of gas and given bounds on the pressure can be transported in a stationary gas network. Furthermore, the extension of the existing gas network topology was considered. We developed algorithms that provide solutions to the corresponding mixed-integer nonconvex, nonlinear optimization problems. The methods were tested on the real-world instances of OGE.

Partner: Zuse-Insitut Berlin; Universität Hannover; Universität Duisburg-Essen; HU Berlin; Universität Erlangen-Nürnberg; WIAS Berlin; Open Grid Europe

Contact: Imke Joormann, Marc Pfetsch

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

The presence of uncertainty is a prevalent characteristic in mechanical engineering, which can lead to severe economical and safety consequences. This applies particularly to fields like lightweight design, e.g., aircraft construction, where high load-bearing capacity has to be combined with low weight and where system failure is not tolerable at any point.
As part of the Collaborative Research Centre (SFB) 805: "Control of uncertainty of load

carrying systems in mechanical engineering" we want to find - for load-carrying mechanical systems - the optimal robust design regarding uncertainty of parameters, e.g., material properties and loading scenarios, as well as uncertainty of the manufacturing quality.
This is achieved by simulation-based optimization of geometry, topology and the placement of actuators, at which modern techniques of robust optimization are applied and extended. In particular we choose a worst-case approach to incorporate the existing uncertainty into our optimization model. This leads to a computationally intractable problem formulation since we consider nonlinear nonconvex objective functions and further employ complex PDE constraints in order to model the mechanical behaviour of the considered structures. Hence, this so-called robust counterpart is approximated by means of a second order Taylor expansion which is solved by an efficient SQP method.

Partner: Collaborative Research Centre (SFB) 805: "Control of uncertainty of load carrying systems in mechanical engineering"; speaker Prof. Dr.-Ing. Peter Pelz (Department of Mechanical Engineering, TU Darmstadt)

Support: DFG

Contact: Philip Kolvenbach, Adrian Sichau, Stefan Ulbrich

References

[1] A. Sichau. *Robust Nonlinear Programming with Discretized PDE Constraints using Second-order Approximations*. Dissertation, TU Darmstadt, 2013.

[2] A. Sichau and S. Ulbrich. A Second Order Approximation Technique for Robust Shape Optimization. *Applied Mechanics and Materials*, 104:1–40, 2011.

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 of 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 on 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 exist no solvers that exploit 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 lies 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 Center (SFB) 805: "Control of Uncertainty of load carrying structures in mechanical engineering"; speaker Prof. Dr.-Ing. Peter Pelz (Department of Mechanical Engineering, TU Darmstadt)

Support: DFG

Contact: Tristan Gally, Kai Habermehl, Anja Kuttich, Sonja Mars, Marc Pfetsch, Stefan Ulbrich

References

[1] K. Habermehl. *Robust Optimization of Active Trusses via Mixed-Integer Semidefinite Programming*. Dissertation, TU Darmstadt, 2013.

[2] K. Habermehl and S. Ulbrich. Achilles High Heel – Mach einen Schuh draus! *Mitteilungen der Deutschen Mathematiker Vereinigung (DMV)*, 21:79–83, 2013.

[3] S. Mars. *Mixed-Integer Semidefinite Programming with an Application to Truss Topology Design*. Dissertation, Friedrich-Alexander Universität Erlangen-Nürnberg, 2013.

[4] L. Mosch, S. Adolph, R. Betz, J. Eckhardt, A. Tizi, J. Mathias, A. Bohn, K. Habermehl, and S. Ulbrich. Control of uncertainties within an interdisciplinary design approach of a robust high heel. In *Uncertainties 2012 – 1st international symposium on Uncertainty Quantification and Stochastic Modeling. Maresias, Sao Sebastiao, SP, Brazil*, 2012.

[5] R. Platz, S. Ondoua, K. Habermehl, T. Bedarff, T. Hauer, S. Schmitt, and H. Hanselka. Approach to validate the influences of uncertainties in manufacturing on using load-carrying structures. In *3rd International Conference on Uncertainty in Structural Dynamics, USD 2010, Leuven, Belgium*, 2010.

[6] M. Wiebel, R. Engelhardt, and K. Habermehl. Uncertainty in process chains and the calculation of their propagation via monte-carlo simulation. In *12th International Dependency and Structure Modelling Conference, DSM 2010, Cambridge, UK*, 2010.

Project: Robust optimization (Subproject AP 4 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, 2]. To solve the resulting nonlinear PDE constraint optimization problems, efficient algorithms are needed. To achieve this, different model order reduction techniques [3], adaptive multilevel methods [4] and possible extensions are investigated.

Partner: Prof. Dr. Sebastian Schöps (Graduate School for CE and Institut für Theorie Elektromagnetischer Felder, TU Darmstadt); Dr. Andreas Bartel (Angewandte Mathematik, Bergische Universität Wuppertal); Prof. Dr. Michael Hinze (Fachbereich Mathematik, Universität Hamburg); Dr. Oliver Rain (Robert Bosch GmbH); Dr. Markus Brunk (Robert Bosch GmbH); Dr.-Ing. Enno Lange (CST – Computer Simulation Technology AG)

Support: Federal Ministry of Education and Research (BMBF)

Contact: Oliver Lass, Stefan Ulbrich

References

[1] M. Diel, H. G. Bock, and E. Kostina. An approximation technique for robust nonlinear optimization. *Mathematical Programming*, 107(1-2):213–230, 2006.

[2] A. Sichau and S. Ulbrich. A Second Order Approximation Technique for Robust Shape Optimization. *Applied Mechanics and Materials*, 104(13):13–22, 2011.

[3] T. Tonn, K. Urban, and S. Volkwein. Comparison of the reduced-basis and POD a posteriori error estimators for an elliptic linear-quadratic optimal control problem. *Applied Mechanics and Materials*, 17(4):355–369, 2011.

[4] S. Ulbrich and J. C. Ziems. Adaptive multilevel inexact SQP methods for PDE-constrained optimization. *SIAM Journal on Optimization*, 23:1257–1283, 2011.

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 profile-cross-sections as well as optimal decompositions 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 multi body models including contact constraints are used. 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 optimization 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. Peter Groche (Department of Mechanical Engineering, TU Darmstadt)

Support: DFG

Contact: Thea Göllner, Katrin Herr, Benjamin Horn, Hendrik Lüthen, Marc Pfetsch, Stefan Ulbrich

References

[1] T. Göllner. *Geometry Optimization of Branched Sheet Metal Structures with a Globalization Strategy by Adaptive Cubic Regularization*. Dissertation, TU Darmstadt, Dec. 2014.

[2] T. Göllner, H. Lüthen, M. Pfetsch, and S. Ulbrich. Profiloptimierung im Rahmen eines durchgängigen Produktentstehungsprozesses. In P. Groche, editor, *Tagungsband 5. Zwischenkolloquium Sonderforschungsbereich 666*, pages 15–24. Meisenbach Verlag, Bamberg, Nov. 2014.

Project: Optimal Control of Quasilinear PDAEs

Partial Differential Algebraic Equations (PDAEs) have received increased attention in the recent years because of their versatility in modeling dynamics in systems. In this project, we consider optimal control problems subject to quasilinear PDAEs.

PDAEs or DAEs in general are used to model dynamics in which parts of the system states are subject to (partial-) differential equations, and the other parts of the system states are given by purely algebraic constraints. The project is concerned mainly with PDAEs in the form of abstract DAEs in Banach spaces, in the simplest form of one evolutionary PDE for one searched-for state, and one (quasi-) stationary PDE for the other. Here, the PDEs may be of up to quasilinear type with full coupling.

These problems then serve as the constraints in an optimal control problem, where the set of admissible solutions is further restricted by state- and control constraints. Especially the state constraints and the quasilinear structure give rise to particular difficulties in the theoretical handling of the optimal control problems, which makes the considered problems both interesting and challenging.

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

Contact: Hannes Meinlschmidt, Stefan Ulbrich

Project: Triangulations and other decompositions of lattice polytopes in toric and tropical geometry

Lattice polytopes are objects at a junction between combinatorics and algebraic geometry. The study of their triangulations, coarsest subdivisions, mixed subdivisions, and other decompositions is motivated by the mutual interaction between these fields as well as by applications in number theory, optimization, statistics, mathematical physics, and algorithmic biology.

Attacking fundamental open problems in this area requires to combine theoretical insight with algorithmic ingenuity and computer experiments. Specific topics addressed in this project include the following: unimodular triangulations of lattice polytopes (in particular, matroid polytopes), the relationship between smoothness and normality of a toric variety, combinatorial and geometric interpretations of h^*-polynomials, and symmetric lattice polytopes.

Partner: Priority Program 1489 “Algorithmic and Experimental Methods in Geometry, Algebra, and Number Theory”; speaker: Wolfram Decker (Department of Mathematics, TU Kaiserslautern)

Support: DFG

Contact: Andreas Paffenholz

References

[1] B. Assarf, M. Joswig, and A. Paffenholz. Smooth Fano Polytopes With Many Vertices. *Discrete & Computational Geometry*, 52:153–194, Sept. 2014.

[2] S. Di Rocco, C. Haase, B. Nill, and A. Paffenholz. Polyhedral adjunction theory. *Algebra & Number Theory*, 7(10):2417–2446, 2013.

[3] A. Dochtermann, M. Joswig, and R. Sanyal. Tropical types and associated cellular resolutions. *Journal of Algebra*, 356:304–324, 2012.

[4] S. Herrmann, M. Joswig, and D. Speyer. Dressians, tropical Grassmannians, and their rays. *Forum Mathematicum*, 2012. published online, doi:10.1515/forum-2012-0030.

[5] B. Nill and A. Paffenholz. On the equality case in Ehrhart's volume conjecture. *Advances in Geometry*, 14(4):579–586, 2014.

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 2.14 can be downloaded freely from `www.polymake.org`.

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

Contact: Andreas Paffenholz

References

[1] B. Assarf, E. Gawrilow, K. Herr, M. Joswig, B. Lorenz, A. Paffenholz, and T. Rehn. polymake in linear and integer programming. August 2014.

[2] E. Gawrilow and M. Joswig. polymake: a framework for analyzing convex polytopes. In G. Kalai and G. M. Ziegler, editors, *Polytopes — Combinatorics and Computation*, pages 43–74. Birkhäuser, 2000.

[3] M. Joswig, B. Müller, and A. Paffenholz. `polymake` and lattice polytopes. In *21st International Conference on Formal Power Series and Algebraic Combinatorics (FPSAC 2009)*, Discrete Mathematics & Theoretical Computer Science Proceedings, pages 491–502. Assoc. Discrete Math. Theor. Comput. Sci., Nancy, 2009.

[4] M. Joswig and A. Paffenholz. Defect polytopes and counter-examples with `polymake`. *ACM Communications in Computer Algebra*, 45(3/4):177–179, 2011.

Project: Optimal control of switched networks for nonlinear hyperbolic conservation laws

The project is part of the DFG-Priority Program SPP 1253 "Optimization with Partial Differential Equations". Its aim is the analysis of optimal control problems for hyperbolic balance laws on networks under modal switching, where the switchings are considered in the source terms as well as at boundary nodes and junctions. This type of problems arises for example in traffic flow models or in models for water and gas networks. The main difficulty of the analysis of conservation laws stems 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 control-to-state operator not to 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 project focuses on the investigation of the existence of optimal controls, the differentiability properties of the reduced objective function w.r.t. the initial and boundary data, the node conditions (at junctions) and switching times as well as the corresponding sensitivity and adjoint equations.

Partner: Günter Leugering (Universität Erlangen-Nürnberg)

Support: DFG

Contact: Sebastian Pfaff, Stefan Ulbrich

References

[1] M. Giles and S. Ulbrich. Convergence of linearized and adjoint approximations for discontinuous solutions of conservation laws. part 1: Linearized approximations and linearized output functionals. *SIAM J. Numer. Anal.*, 48(3):882–904, 2010.

[2] M. Giles and S. Ulbrich. Convergence of Linearized and Adjoint Approximations for Discontinuous Solutions of Conservation Laws. Part 2: Adjoint Approximations and Extensions. *SIAM J. Numer. Anal.*, 48(3):905–921, 2010.

[3] S. Pfaff, S. Ulbrich, and G. Leugering. Optimal control of nonlinear hyperbolic conservation laws with switching. In *Trends in PDE Constrained Optimization*, volume 165 of *International Series of Numerical Mathematics*, pages 109–131. Springer International Publishing, 2014.

Project: Global Methods for Stationary Gastransport (Project 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".
This project develops adaptive methods for the global solution of nonlinear integer optimization problems with ODEs, on the example of stationary gastransport. One main issue is the construction of convex relaxations based on a priori error bounds. Here, the adaptivity with respect to the approximation of the ODEs and convex relaxations have to be handled by integrated means. Moreover, integral decisions, e.g., arising at valves in a gas network, are handled via branch-and-bound. The solution process should be improved via infeasibility cuts and the development of primal heuristics with a posteriori error bounds. Furthermore model reduction techniques need to be applied.

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

Support: DFG

Contact: Marc Pfetsch, Stefan Ulbrich

Project: Mixed-Integer nonlinear models in wireless networks

This project is part of the LOEWE Priority Program Cocoon (Cooperative Sensor Communication) supported by the LOEWE research initiative of the state of Hesse/Germany. In this project we explore the utilization of mixed-integer optimization in wireless telecommunication networks. Typical for problems occurring in this context is the simultaneous consideration of continuous optimization variables, e.g., like beamforming vectors and combinatorial aspects, like the assignment of base stations to mobile users. Mathematical models are derived that account both for the requirements of the application and the solvability. Usually one has to deal with NP-hard problems in this context that cannot be solved by standard software. We investigate convex approximations as well as heuristics to derive reasonable good solutions. We use these approximations as primal heuristics in connection with convex SDP-based relaxations within a branch-and-bound method to solve the mixed integer nonlinear optimization model to global optimality. The global optimal solution can also be used to evaluate heuristic and approximation approaches.

Partner: LOEWE Priority Program Cocoon (Cooperative Sensor Communication); speaker Prof. Dr.-Ing. Abdelhak Zoubir (Department of Electrical Engineering and Information Technology, TU Darmstadt)

Support: Landes-Offensive zur Entwicklung Wissenschaftlich-ökonomischer Exzellenz (LOEWE)

Contact: Anne Philipp, Stefan Ulbrich

References

[1] Y. Cheng, M. Pesavento, and A. Philipp. Joint network optimization and downlink beamforming for CoMP transmissions using mixed integer conic programming. *IEEE Transactions on Signal Processing*, 61(16):3972–3987, 2013.

[2] A. Philipp, S. Ulbrich, Y. Cheng, and M. Pesavento. Multiuser downlink beamforming with interference cancellation using a SDP-based branch-and-bound algorithm. In *IEEE Int. Conf. on Acoustics, Speech and Signal Process. (ICASSP)*, pages 7724–7728, 2014.

Project: Optimal design and control of adaptronic systems

This project is part of the LOEWE-Center AdRIA, which is a collaborative reserach initiative of the Fraunhofer Institute for Structural Durability and System Reliability LBF, the TU Darmstadt and the Hochschule Darmstadt to create a leading international research center for adaptronic systems. Two demonstrators were developed which provides an appropriate platform to interpret, implement and evaluate the approaches, methods and solutions for vibration reduction. The *truss structure* provides a modular model of a lightweight structure, e.g., ships, aircraft, cars, wind turbines or bridges. The *vibrating plate* is representative for flat building elements (windows, facades, partition walls), technical installations (pipes, heating and air conditioning), office equipment (projectors, printers, copiers), machine covers, sound insulation cabinets, robotic arms, rotor blades of helicopters and aircraft wings.
As part of the technology area *simulation tools*, we determine the optimal position and number of actuators and sensors for dynamical systems. An FE model was developed for these demonstrators and approximated by model order reduction. Using controllability and observability measures, a method for determining the optimal actuator and sensor placement is designed, which leads to an optimization problem with binary and continuous variables and linear matrix inequalities. It was shown that an LQR or MPC controller provides a better vibration reduction with the optimal actuator and sensor positions than with the actuator and sensor positions, which were determined heuristically.

Partner: LOEWE-Center AdRIA; speaker Prof. Dr.-Ing. Tobias Melz (Department of Mechanical Engineering, TU Darmstadt), Technology Division Simulation; speaker Dr. Sven Herold (LBF Fraunhofer)

Support: Landes-Offensive zur Entwicklung Wissenschaftlich-ökonomischer Exzellenz (LOEWE)

Contact: Carsten Schäfer, Stefan Ulbrich

References

[1] S. Herold, D. Mayer, J. Pöllmann, , C. Schäfer, and G. L. Stein. Optimization and realization of distributed vibration absorber. *26th International Conference on Noise and Vibration Engineering (ISMA)*, 14, 2014.

[2] C. Schäfer and S. Ulbrich. Optimal actuator placement for dynamical systems. *Proceedings in Applied Mathematics and Mechanics (PAMM)*, 2:469–470, 2013.

Project: Adaptive Multilevel Methods for the Optimal Control of Hyperbolic Equations in Gas Networks (project 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 want to 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 plan to use Moreau-Yosida regularizations to approximate (P) in order to derive optimality conditions. 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, Universität Erlangen-Nürnberg)

Support: DFG

Contact: Johann Michael Schmitt, Stefan Ulbrich

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 flamet-generated-manifold (FGM) method.

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

Support: DFG

Contact: Cedric Sehrt, Stefan Ulbrich

References

[1] R. Roth and S. Ulbrich. A discrete adjoint approach for the optimization of unsteady turbulent flows. *Flow, Turbulence and Combustion*, 90(4), June 2013.

Project: SPEAR – Sparse Exact and Approximate Recovery

The research project "SPEAR – Sparse Exact and Approximate Recovery" deals with the problem to recover a sparse solution of an underdetermined linear (equality) system. This topic has many applications and is a very active research area. It is located at the border between analysis and combinatorial optimization. The main goal of our project is to obtain a better understanding of the conditions under which (efficiently) finding such a sparse solution, i.e., recovery, is possible. Our project is characterized by both theoretical and computational aspects as well as the interplay of continuous and discrete methods.

The SPEAR project is a collaboration of the Research Group Optimization at the TU Darmstadt (since 2012, previously: Institute for Mathematical Optimization at the TU Braunschweig) and the Institute for Analysis and Algebra at the TU Braunschweig. The project is funded by a DFG research grant. Project period: 2011–2014.

Partner: Dirk Lorenz and Christian Kruschel, TU Braunschweig

Support: DFG

Contact: Marc Pfetsch, Andreas Tillmann

References

[1] D. Lorenz, M. Pfetsch, and A. Tillmann. An infeasible-point subgradient method using adaptive approximate projections. *Computational Optimization and Applications*, 57(2):271–306, 2014.

[2] D. A. Lorenz, M. E. Pfetsch, and A. M. Tillmann. Solving basis pursuit: Heuristic optimality check and solver comparison. *ACM Transactions on Mathematical Software*, 41(2):Article 8, 29 pages, 2015.

[3] A. Tillmann. *Computational Aspects of Compressed Sensing*. Dissertation, TU Darmstadt, 2013.

[4] A. Tillmann, R. Gribonval, and M. Pfetsch. Projection Onto The Cosparse Set is NP-Hard. In *IEEE Int. Conf. on Acoustics, Speech and Signal Process. (ICASSP)*, pages 7148–7152, 2014.

[5] A. Tillmann and M. Pfetsch. The computational complexity of the restricted isometry property, the nullspace property, and related concepts in compressed sensing. *IEEE Transactions on Information Theory*, 60(2):1248–1259, 2014.

2 Collaborative Research Projects and Cooperations

The department 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 Center of Smart Interfaces

The Center of Smart Interfaces (CSI) started as a Cluster of Excellence (EXC 259), funded by the German Research Foundation (DFG). The DFG funding period began in November 2008 and lasted until October 2014, having a total volume of about € 42 million.

From November 2014 on, the Center of Smart Interfaces continues as one of the Research Clusters of the TU Darmstadt.

The CSI is an international center for interdisciplinary research, focusing on the scientific areas “static and dynamic wettability”, “heat and mass transfer enhancement”, “near wall reactive flows”, “near wall multiphase flows” and “drag and circulation control” with the aim to understand and design fluid boundaries.

The CSI has 24 Principal Investigators, combining the expertise of the departments of Mechanical Engineering, Physics, Chemistry, Mathematics, and Material Sciences at the TU Darmstadt with four non-University research institutes in Darmstadt and Mainz. In addition, six research professors and three young research group leaders were newly appointed at the Cluster of Excellence.

With the four Principal Investigators Reinhard Farwig, Matthias Hieber, Jens Lang and Stefan Ulbrich and the two newly appointed professors Dieter Bothe and Jürgen Saal, the Department of Mathematics is strongly involved in the CSI. Scientifically, mathematics also plays an eminent role for the fundamental research in all of the above mentioned areas which is performed at the CSI. The involved mathematical disciplines are Mathematical Modeling, Analysis of Partial Differential Equations, Numerical Analysis, and Optimization. This enables relevant contributions to the understanding of continuum mechanical flow models via their mathematical analysis, numerical simulation and the solution of inverse problems such as the optimization concerning complex model parameters.

In 2014, Jürgen Saal obtained and accepted an offer for a full professorship at the Heinrich-Heine Universität Düsseldorf. At least partly, this offer was due to the interdisciplinary expertise which Jürgen Saal had gained during his time at the CSI - a strong proof of the success of the interdisciplinary concept.

The CSI was also involved in several activities in mathematics, the most prominent one in the report period being the co-funding and co-organization of the International Conference on Numerical Methods in Multiphase Flows (ICNMMF-II) hold in Darmstadt June 2014. This outstanding event with main speaker including H. Jasak, D. Juric, S. Popinet, A. Prosperetti, M. Shashkov, M. Sussman, S. Takagi and B. van Wachem attracted about 150 participants.

2.2 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. After a very successful evaluation, the collaborative research centre SFB 666 is currently in its third funding period.

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.

2.3 Collaborative Research Centre SFB 805

The Collaborative Research Centre SFB 805 "Control of Uncertainties in Load-Carrying Structures in Mechanical Engineering" was established in January 2009. The second funding period started January 2013. 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 life-cycle – 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; and Lorenz until October 2014). 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.

2.4 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 contacts 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, and Ulbrich 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 study engineering applications and to engineer 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.

Six professors of the Department of Mathematics are Principal Investigators within the Graduate School Computational Engineering (Aurzada, Bothe, Egger, Lang, Pfetsch, Ulbrich) 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. Three more members of the department are Research Group Leaders (Erath, Schwartz, Ullmann) with scientific focus on 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 Geissert, 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 2013 and 2014 includes leading experts of the field, e.g., L. Brandolese, P. Constantin, R. Danchin, G. Galdi, M. Lopes Filho, G. Karch, J. Kelliher, Y. Maekawa, S. Monniaux, Š. Nečasová, P. Mucha, J. Prüss, L. Székelyhidi, E. Titi.

Highlights of the program were altogether 8 conferences or bigger workshops in 2013 and 2014, e.g., the "International Workshops on Mathematical Fluid Dynamics" at Waseda University, Tokyo, in June and November 2013 and the "Autumn School on Mathematical Fluid Dynamics" in Bad Boll in October 2014.

The "Information Days on Mathematical Fluid Dynamics" in December 2013 were selforganized by our PhD students and attracted other PhD students to apply for a PhD position within the IRTG.

A "Winter Seminar and Klausurtagung on Fluids and Snow" took place in January 2014 in La Clusaz, France.

2.9 LOEWE Centre AdRIA

The LOEWE Centre "AdRIA: Adaptronics: Research, Innovation, Application" was established in 2008 and is funded with an amount of 34 million Euro for 6 years by the State of Hesse within the research support program LOEWE-Landes-Offensive zur Entwicklung Wissenschaftlich-ökonomischer Exzellenz. It is an interdisciplinary collaboration of Fraunhofer LBF, TU Darmstadt and Hochschule Darmstadt.

The aim of the LOEWE Centre AdRIA is the scientific and technological study of adaptronic systems in order to ensure a systematic and holistic development of advanced adaptronic products. A particular emphasis is the development of light weight structures based on

adaptronic systems with improved energy efficiency, functionality and performance. The LOEWE Centre AdRIA is structured into several technology areas in order to advance basic research as well as three exemplary technological demonstrator applications.
The Department of Mathematics participates in the LOEWE Centre AdRIA within the technology area “Simulation Tools” (Ulbrich) and contributes to the development of optimization methods for adaptronic systems, in particular the optimal placement and control of sensors, actuators and active absorbers.

2.10 LOEWE Research Priority Program Cocoon

The LOEWE Priority Program “Cooperative sensor communication (Cocoon)” was established in January 2011 and is funded with an amount of 4.5 million Euro for 3 years by the State of Hesse. The grant was secured within the frame of the third round of the research support program LOEWE-Landes-Offensive zur Entwicklung Wissenschaftlich-ökonomischer Exzellenz.
Research in the field of wireless sensor communication will enable us to make an essential contribution to the improvement of our daily life. Sensors we consider in our research include environmental sensors, mobile phones, PDAs, navigation equipment, car keys, electronic purses or pulse rate measurement devices. New diverse applications, which can be integrated into the context of a smart city, will arise. This concept requires an intelligent environment in which daily life supporting services are ubiquitous.
The Department of Mathematics participates in the LOEWE Priority Program within a sub-project (Ulbrich). The mathematical research considers the development of efficient discrete-continuous optimization methods for the optimal design of wireless communication networks, which leads to challenging nonconvex mixed-integer polynomial optimization problems.

2.12 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.

Tobias Fischer

- Group of Prof. Dr. Anja Klein (TU Darmstadt): Multihop Wireless Networks.

Imke Joormann

- Group of Dr. René Henrion, WIAS Berlin: Gas Transport Optimization.
- Group of Dr. Thorsten Koch (Zuse-Institut Berlin): Gas Transport Optimization.
- Group of Prof. Dr. Alexander Martin (Universität Erlangen-Nürnberg): Gas Transport Optimization.
- Group of Prof. Dr. Werner Römisch (HU Berlin): Gas Transport Optimization.
- Group of Prof. Dr. Rüdiger Schultz (Universität Duisburg-Essen): Gas Transport Optimization.

– Group of Prof. Dr. Marc Steinbach (Universität Hannover): Gas Transport Optimization.

– German Federal Network Agency (Bundesnetzagentur): Project “Technical Capacities of Gas Networks”.

– Open Grid Europe GmbH, formerly E.ON Gastransport GmbH: Project FORNE.

Hannes Meinlschmidt

– Prof. Christian Meyer (TU Dortmund): Optimal control of the thermistor problem.

– Dr. Joachim Rehberg (WIAS Berlin): Optimal control of the thermistor problem.

– Dr. Joachim Rehberg (WIAS Berlin): Hölder-estimates for non-autonomous parabolic problems with rough data.

Andreas Paffenholz

– PD Dr. Barbara Baumeister (Universität Bielefeld): Permutation Polytopes.

– Prof. Sandra Di Rocco (KTH Stockholm): Polyhedral Adjunction Theory.

– Prof. Dr. Christian Haase (FU Berlin): Permutation, Cut, and Marginal Polytopes; Polyhedral Adjunction Theory; Unimodular Triangulations.

– Prof. Dr. Benjamin Nill (University of Stockholm): Polyhedral Adjunction Theory.

– Prof. Francisco Santos (University of Cantabria): Unimodular Triangulations.

– Hung P. Tong-Viet (University of Pretoria): Permutation Polytopes.

– Priority Program 1489 (DFG) “Algorithmic and Experimental Methods in Geometry, Algebra, and Number Theory”: Speaker: Prof. Dr. Wolfram Decker.

Marc Pfetsch

– Group of Dr. René Henrion, WIAS Berlin: Gas Transport Optimization.

– Group of Dr. Thorsten Koch (Zuse-Institut Berlin): Gas Transport Optimization.

– Prof. Dr. Dirk Lorenz (TU Braunschweig): Compressed Sensing.

– Group of Prof. Dr. Alexander Martin (Universität Erlangen-Nürnberg): Gas Transport Optimization.

– Prof. Dr. Sebastian Pokutta (Georgia Institute of Technology, Atlanta, USA): Augmentation 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.

– Group of Prof. Dr. Marc Steinbach (Universität Hannover): Gas Transport Optimization.

– German Federal Network Agency (Bundesnetzagentur): Project "Technical Capacities of Gas Networks".

– Open Grid Europe (OGE): Project FORNE.

Alexandra Schwartz

– Group of Prof. Dr. Wolfgang Leininger (TU Dortmund): Optimal Design of Contests.

– Prof. Oleg Burdakov, Ph.D. (Linköping University, Sweden): Reformulation and Numerical Methods for Cardinality Constraints and Sparse Optimization.

– Michal Červinka, Ph.D. (Czech Academy of Sciences and Charles University, Prague): Optimality Conditions and Stability of Reformulated Cardinality Constraints.

– Prof. Dr. Christian Kanzow (JMU Würzburg): Complementarity-type Reformulation of Cardinality Constraints and Sparse Optimization Problems.

Andreas Tillmann

– Yonina Eldar (Technion, Israel), Julien Mairal (INRIA, France): Dictionary Learning for Phase Retrieval.

– Dirk Lorenz, Christoph Brauer (TU Braunschweig): Heuristic Optimality Checks for ℓ_1-Minimization.

– Rémi Gribonval (INRIA, France), Marc Pfetsch (TU Darmstadt): Complexity of Cosparse Projection.

– Dirk Lorenz, Christian Kruschel (TU Braunschweig), Marc Pfetsch (TU Darmstadt): SPEAR project.

Stefan Ulbrich

– Group of Prof. Dr. Michael Hintermüller (HU Berlin): Gas Transport Optimization.

– Group of Prof. Dr. Günter Leugering (Universität Erlangen-Nürnberg): Gas Transport Optimization.

– Group of Prof. Dr. Alexander Martin (Universität Erlangen-Nürnberg): Gas Transport Optimization.

– Prof. Dr. Marius Pesavento (TU Darmstadt): Mixed-integer programs in communication systems.

– Prof. Dr. Matthias Heinkenschloss (Rice University, Houston): PDE-Constrained Optimization, Model Reduction.

– Dr. Anton Schiela (TU Berlin): Preconditioning Techniques for PDE-Constrained Optimization.

– Prof. Dr. Michael Ulbrich (TU München): Multilevel Methods for PDE-constrained Optimization.

4 Publications

4.1 Co-Editors of Publications

4.1.1 Editors of Journals

Michael Joswig

– *Mitteilungen der Deutschen Mathematiker Vereinigung (DMV)* (Editor-in-chief)

– *Electronic Geometry Models* (Co-Managing Editor)

Marc Pfetsch

– *Operations Research Letters* (Associate Editor)

– *Mathematical Programming Computation* (Technical 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)

4.2 Monographs and Books

[1] J. Ghiglieri. *Optimal flow control based on POD and MPC and an application to the cancellation of Tollmien-Schlichting waves*. Dr. Hut Verlag, 2014.

[2] T. Göllner. *Geometry Optimization of Branched Sheet Metal Structures with a Globalization Strategy by Adaptive Cubic Regularization*. Dr. Hut Verlag, 2014.

[3] K. Habermehl. *Robust Optimization of Active Trusses via Mixed-Integer Semidefinite Programming*. Dr. Hut Verlag, 2014.

[4] K. Herr. *Core Sets and Symmetric Convex Optimization*. Dr. Hut Verlag, 2013.

[5] M. Joswig and T. Theobald. *Polyhedral and Algebraic Methods in Computational Geometry*. Universitext. Springer, London, 2013.

[6] S. Mars. *Mixed-Integer Semidefinite Programming with an Application to Truss Topology Design*. Dr. Hut Verlag, 2013.

[7] A. Sichau. *Robust Nonlinear Programming with Discretized PDE Constraints using Second-order Approximations*. Dr. Hut Verlag, 2013.

[8] A. Tillmann. *Computational Aspects of Compressed Sensing*. Dr. Hut Verlag, Germany, 2013.

4.3 Publications in Journals and Proceedings

4.3.1 Journals

[1] B. Assarf, M. Joswig, and A. Paffenholz. Smooth Fano Polytopes With Many Vertices. *Discrete & Computational Geometry*, 52:153–194, 2014.

[2] B. Baumeister, C. Haase, B. Nill, and A. Paffenholz. Polytopes associated to Dihedral Groups. *Ars Mathematica Contemporanea*, 7(1):30–38, 2014.

[3] R. Bödi, K. Herr, and M. Joswig. Algorithms for highly symmetric linear and integer programs. *Mathematical Programming, Series A*, 137(1):65–90, 2013.

[4] T. Bogart, C. Haase, M. Hering, B. Lorenz, B. Nill, A. Paffenholz, F. Santos, and H. Schenck. Few smooth d-polytopes with N lattice points. *Israel Journal of Mathematics*, 2015. To appear.

[5] R. Borndörfer, M. Karbstein, and M. E. Pfetsch. The Steiner connectivity problem. *Mathematical Programming*, 142(1-2):133–167, 2012.

[6] O. Burdakov, C. Kanzow, and A. Schwartz. On a reformulation of mathematical programs with cardinality constraints. In D. Gao, N. Ruan, and W. Xing, editors, *Advances in Global Optimization*, pages 3–14. Springer International Publishing, 2015.

[7] Y. Cheng, M. Pesavento, and A. Philipp. Joint network optimization and downlink beamforming for CoMP transmissions using mixed integer conic programming. *IEEE Transactions on Signal Processing*, 61(16):3972–3987, 2013.

[8] L. De Giovanni, G. Massi, F. Pezzella, M. Pfetsch, G. Rinaldi, and P. Ventura. A heuristic and an exact method for the gate matrix connection cost minimization problem. *International Transactions in Operational Research*, 20(5):627–643, 2013.

[9] S. Di Rocco, C. Haase, B. Nill, and A. Paffenholz. Polyhedral adjunction theory. *Algebra & Number Theory*, 7(10):2417–2446, 2013.

[10] J. Franke, C. Kanzow, W. Leininger, and A. Schwartz. Lottery versus all-pay auction contests: A revenue dominance theorem. *Games and Economic Behavior*, 83:116–126, 2014.

[11] J. Ghiglieri and S. Ulbrich. Optimal flow control based on POD and MPC and an application to the cancellation of Tollmien-Schlichting waves. *Optimization Methods and Software*, 29(5):1042–1074, 2014.

[12] S. Herold, D. Mayer, J. Pöllmann, C. Schäfer, and G. L. Stein. Optimization and realization of distributed vibration absorber. *26th International Conference on Noise and Vibration Engineering (ISMA)*, 14, 2014.

[13] K. Herr, T. Rehn, and A. Schürmann. Exploiting symmetry in convex optimization using core points. *Operations Research Letters*, 41(3):298–304, 2013.

[14] K. Herr, T. Rehn, and A. Schürmann. On lattice-free orbit polytopes, 2015.

[15] S. Herrmann, M. Joswig, and M. E. Pfetsch. Computing the bounded subcomplex of an unbounded polyhedron. *Computational Geometry*, 46:541–551, 2013.

[16] W. Hess and S. Ulbrich. An inexact ℓ_1 penalty SQP algorithm for PDE-constrained optimization with an application to shape optimization in linear elasticity. *Optimization Methods and Software*, 28(5):943–968, 2013.

[17] C. Kanzow and A. Schwartz. Convergence properties of the inexact Lin-Fukushima relaxation method for mathematical programs with equilibrium constraints. *Computational Optimization and Applications*, 59:249–262, 2014.

[18] C. Kanzow and A. Schwartz. The price of inexactness: Convergence properties of relaxation methods for mathematical programs with complementarity constraints revisited. *Mathematics of Operations Research*, 40(2):253–275, 2015.

[19] O. Lass and S. Volkwein. Adaptive POD basis computation for parametrized nonlinear systems using optimal snapshot location. *Computational Optimization and Applications*, 58(3):645–677, 2014.

[20] D. Lorenz, M. Pfetsch, and A. Tillmann. An Infeasible-Point Subgradient Method Using Adaptive Approximate Projections. *Computational Optimization and Applications*, 57(2):271–306, 2014.

[21] B. Nill and A. Paffenholz. On the equality case in Ehrhart's volume conjecture. *Advances in Geometry*, 14(4):579–586, 2014.

[22] A. Paffenholz. Finiteness of the Polyhedral $\mathbb{Q}$-Codegree Spectrum. *Proceedings of the American Mathematical Society*, 2015. To appear.

[23] S. Pfaff and S. Ulbrich. Optimal boundary control of nonlinear hyperbolic conservation laws with switched boundary data. *SIAM Journal on Control and Optimization*, 2015. To appear.

[24] M. E. Pfetsch, A. Fügenschuh, B. Geißler, N. Geißler, R. Gollmer, B. Hiller, J. Humpola, T. Koch, T. Lehmann, A. Martin, A. Morsi, J. Rövekamp, L. Schewe, M. Schmidt, R. Schultz, R. Schwarz, J. Schweiger, C. Stangl, M. C. Steinbach, S. Vigerske, and B. M. Willert. Validation of nominations in gas network optimization: models, methods, and solutions. *Optimization Methods and Software*, 30(1):15–53, 2015.

[25] R. Roth and S. Ulbrich. A discrete adjoint approach for the optimization of unsteady turbulent flows. *Flow, Turbulence and Combustion*, 90(4):763–783, 2013.

[26] C. Schäfer and S. Ulbrich. Optimal actuator placement for dynamical systems. *Proceedings in Applied Mathematics and Mechanics (PAMM)*, 2:469–470, 2013.

[27] A. Schiela and S. Ulbrich. Operator preconditioning for a class of inequality constrained optimal control problems. *SIAM Journal on Optimization*, 24(1):435–466, 2014.

[28] A. Tillmann. On the computational intractability of exact and approximate dictionary learning. *IEEE Signal Processing Letters*, 2015. To appear.

[29] A. Tillmann and M. Pfetsch. The Computational Complexity of the Restricted Isometry Property, the Nullspace Property, and Related Concepts in Compressed Sensing. *IEEE Transactions on Information Theory*, 60(2):1248–1259, 2014.

[30] I. Yousept. Optimal control of quasilinear H(curl)-elliptic partial differential equations in magnetostatic field problems. *SIAM Journal on Control and Optimization*, 51(5):3624–3651, 2013.

4.3.2 Proceedings and Chapters in Collections

[1] B. Assarf, E. Gawrilow, K. Herr, M. Joswig, B. Lorenz, A. Paffenholz, and T. Rehn. polymake in linear and integer programming. Preprint arxiv:1408.4653, August 2014.

[2] S. Bott, D. Clever, J. Lang, S. Ulbrich, J. C. Ziems, and D. Schröder. On a Fully Adaptive SQP Method for PDAE-Constrained Optimal Control Problems with Control and State Constraints. In *Trends in PDE Constrained Optimization*, volume 165 of *Internat. Ser. Numer. Math.*, pages 85–108. Springer International Publishing, 2014.

[3] D. Bratzke and S. Ulbrich. Optimierungsverfahren zur optimalen Steuerung von Tiefziehprozessen basierend auf reduzierten Modellen. In P. Groche, editor, *Tagungsband 5. Zwischenkolloquium Sonderforschungsbereich 666*, pages 41–48. Meisenbach Verlag, Bamberg, Nov. 2014.

[4] T. Ederer, U. Lorenz, and T. Opfer. Quantified combinatorial optimization. In *Operations Research Proceedings 2013*, pages 121–128. Springer, 2014.

[5] T. Göllner, H. Lüthen, M. Pfetsch, and S. Ulbrich. Profiloptimierung im Rahmen eines durchgängigen Produktentstehungsprozesses. In P. Groche, editor, *Tagungsband 5. Zwischenkolloquium Sonderforschungsbereich 666*, pages 15–24. Meisenbach Verlag, Bamberg, Nov. 2014.

[6] C. Haase, A. Paffenholz, L. C. Piechnik, and F. Santos. Existence of unimodular triangulations - positive results. Preprint arxiv:1405.1687, May 2014.

[7] K. Habermehl and S. Ulbrich. Achilles High Heel - Mach einen Schuh draus! *Mitteilungen der Deutschen Mathematiker Vereinigung (DMV)*, 21:79–83, 2013.

[8] T. Koch, A. Martin, and M. E. Pfetsch. Progress in Academic Computational Integer Programming. In M. Jünger and G. Reinelt, editors, *Facets of Combinatorial Optimization*, chapter 14, pages 483–506. Springer-Verlag, 2013.

[9] U. Lorenz, T. Opfer, and J. Wolf. Solution techniques for quantified linear programs and the links to gaming. In *Computers and Games*, pages 110–124. Springer, 2014.

[10] S. Pfaff, S. Ulbrich, and G. Leugering. Optimal control of nonlinear hyperbolic conservation laws with switching. In *Trends in PDE Constrained Optimization*, volume 165 of *International Series of Numerical Mathematics*, pages 109–131. Springer International Publishing, 2014.

[11] A. Philipp, S. Ulbrich, Y. Cheng, and M. Pesavento. Multiuser downlink beamforming with interference cancellation using a SDP-based branch-and-bound algorithm. In *IEEE Int. Conf. on Acoustics, Speech and Signal Process. (ICASSP)*, pages 7724–7728, 2014.

[12] A. Tillmann, R. Gribonval, and M. Pfetsch. Projection onto the Cosparse Set is NP-Hard. In *IEEE Int. Conf. on Acoustics, Speech and Signal Process. (ICASSP)*, pages 7148–7152, 2014.

4.4 Preprints

[1] X. Allamigeon, P. Benchimol, S. Gaubert, and M. Joswig. Combinatorial simplex algorithms can solve mean payoff games. Preprint arXiv:1309.5925, 2013.

[2] X. Allamigeon, P. Benchimol, S. Gaubert, and M. Joswig. Tropicalizing the simplex algorithm. Preprint arXiv:1308.0454, 2013.

[3] O. Burdakov, C. Kanzow, and A. Schwartz. Mathematical programs with cardinality constraints: reformulation by complementarity-type constraints and a regularization method. Technical report, 2014. Submitted to SIAM Journal on Optimization.

[4] M. Červinka, C. Kanzow, and A. Schwartz. Constraint qualifications and optimality conditions for optimization problems with cardinality constraints. Technical report, 2014. Submitted to Mathematical Programming.

[5] A. Paffenholz. Faces of Birkhoff Polytopes. Preprint arxiv: 1304.3984, 2013.

4.5 Reviewing and Refereeing

Silke Horn: Linear Algebra and its Applications

Oliver Lass: International Journal for Numerical Methods in Engineering, Journal of Mathematical Analysis and Applications, Journal of Optimization Theory and Applications

Andreas Paffenholz: International Symposium on Computational Geometry, Advances in Geometry, European Journal of Combinatorics, Mathematical Programming SERIES A and B, Journal of Combinatorial Theory, Series A

Marc Pfetsch: ATMOS 2013, Discrete and Computational Geometry, 16th Conference on Integer Programming (IPCO) 2013, IEEE International Symposium on Information Theory (ISIT) 2013, Journal of the OR Society of China, Linear Algebra and its Applications, Mathematical Programming Computation, Mathematical Programming, Operations Research Letters, Optimization Methods and Software, Transactions on Mathematical Software, Transactions on Signal Processing

Alexandra Schwartz: Mathematical Programming, Numerical Algorithms, Applied Mathematics and Computation, Annals of Operations Research, Journal of Optimization Theory and Applications

Andreas Tillmann: IEEE 8th Sensor Array and Multichannel Signal Processing Workshop (SAM) 2014, 22nd European Signal Processing Conference (EUSIPCO) 2014; IEEE Transactions on Information Theory

Stefan Ulbrich: Applied Numerical Mathematics, Computational Optimization and Applications, ESAIM: Control, Optimisation and Calculus of Variations, Journal of Optimization Theory and Applications, Mathematical Programming, Numerische Mathematik, Optimization Methods and Software, SIAM Journal on Numeriscal Analysis, SIAM Journal on Control and Optimization, SIAM Journal on Optimization

Irwin Yousept: Mathematical Reviews, SIAM Journal on Scientific Computing, ESAIM Control Optimisation and Calculus of Variations, IMA Journal of Numerical Analysis, Computational Optimization and Applications, Mathematical Methods in the Applied Sciences, Acta Applicandae Mathematicae, Mathematical and Computer Modelling of Dynamical Systems

4.6 Software

SDP Package for SCIP: *Solving mixed integer semidefinite programs using SCIP*
The SDP Package is a plug-in for the non-commercial software SCIP for solving general MISDPs. It combines the branch-and-bound framework of SCIP with interfaces to interior-point SDP-solvers.
For more information, see `http://www.opt.tu-darmstadt.de/scipsdp/`

Contributor at TU Darmstadt: Tristan Gally, Marc Pfetsch, Sonja Mars

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: Benjamin Assarf, Katrin Herr, Silke Horn, Michael Joswig, Andreas Paffenholz, Benjamin Schröter

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 the Zuse Institut Berlin and the Universität Erlangen-Nürnberg.
For more information, see `scip.zib.de`

Contributor at TU Darmstadt: Tobias Fischer, Marc Pfetsch

HOC Suite: *Matlab package: Heuristic Optimality Checks for ℓ_1-norm minimization problems.*
For more information, see `http://wwwopt.mathematik.tu-darmstadt.de/spear/`

Contributor at TU Darmstadt: Andreas Tillmann

ISAL1: *Matlab implementation of a subgradient solver for Basis Pursuit.*
For more information, see `http://wwwopt.mathematik.tu-darmstadt.de/spear/`

Contributor at TU Darmstadt: Andreas Tillmann

L1-Testset: *Data set and handling methods for rigorous Basis Pursuit solver benchmarking.*
For more information, see `http://wwwopt.mathematik.tu-darmstadt.de/spear/`

Contributor at TU Darmstadt: Andreas Tillmann

5 Theses

5.1 Habilitations

2014

Paffenholz, Andreas, *Lattice Polytopes in Geometry and Algebra* (Michael Joswig)

5.2 PhD Dissertations

2013

Herr, Katrin, *Core Sets and Symmetric Convex Optimization* (Michael Joswig)

Sichau, Adrian, *Robust Nonlinear Programming with Discretized PDE Constraints using Second-order Approximations* (Stefan Ulbrich)

Tillmann, Andreas M., *Computational Aspects of Compressed Sensing* (Marc Pfetsch)

2014

Ghiglieri, Jane, *Optimal Flow Control based on POD and MPC and an Application to the Cancellation of Tollmien-Schlichting Waves* (Stefan Ulbrich)

Göllner, Thea, *Geometry Optimization of Branched Sheet Metal Structures with a Globalization Strategy by Adaptive Cubic Regularization* (Stefan Ulbrich)

Habermehl, Kai, *Robust optimization of active trusses via Mixed-Integer Semidefinite Programming* (Stefan Ulbrich)

5.3 Diplom Theses

2013

Ederer, Thorsten, *Entwicklung eines Frameworks zur Optimierung von Thermofluidsystemen am Beispiel einer Heizungsanlage* (Ulf Lorenz)

Kolvenbach, Philip, *Ein ableitungsfreier Online-Optimierungsalgorithmus zur Auslöschung von Tollmien-Schlichting-Wellen* (Stefan Ulbrich)

Lüdicke, Nina Maria, *Optimization for Joint Modulation and Coding Scheme (MCS) Selection and Beamforming in Multiuser Downlink Systems* (Stefan Ulbrich)

Madmar, Mohamed, *Anwendung mathematischer Optimierung zur optimalen Budgetallokation im Direktmarketing* (Alexander Martin)

Polkehn, Maurice, *Graphen-Clustering für medizinische Netzwerke* (Marc Pfetsch)

Reiffert, Michel, *Eine Momentenmethode zur Bewertung von pfadunabhängigen und pfadabhängigen Optionen* (Stefan Ulbrich)

Sehrt, Cedric Gregor, *Optimale Steuerung partieller Differentialgleichungen im Rahmen linearer Elastizität mit punktweiser Beschränkung des Zustands* (Christian Meyer)

Straube, Ruben, *Konfliktanalyse für quantifizierte binäre Programmierung* (Ulf Lorenz)

Terentiev, Boris, *Ressourceneinsatzplanung im Projektmanagement* (Marc Pfetsch)

2014

Fabritius, Norbert, *Solving linear programs with complementarity constraints using an indicator approach* (Marc Pfetsch)

5.4 Master Theses

2013

Bauer, Rachel, *Optimale Platzierung von Aktuatoren zur Dämpfung schwingender Strukturen* (Stefan Ulbrich)

Burkhardt, Sina, *Optimale Lagerhaltung unter autoregressiver Nachfrage: Modellierung am Beispiel der Medikamentenversorgung in der Katastrophenlogistik* (Gernot Kaiser, Marc Pfetsch)

Dick, Christoph Ruthard, *"Ägyptische Brüche" und deren Behandlung im Mathematikunterricht* (Werner Krabs)

Fickinger, Till, *Optimierung von Flugplänen im Störfall unter Berücksichtigung von Passagierinformationen* (Hans-Christian Pfohl, Marc Pfetsch)

Fischer, Michael Helmut, *Formoptimierung elastischer Strukturen mit Kontaktbedingung* (Stefan Ulbrich)

Gally, Tristan, *Semidefinite Relaxierungen für RIP und NSP im Compressed Sensing* (Marc Pfetsch)

Hildmann, Valentina, *Robuste Optimierung aktiver Stabwerke als Min-Max-Formulierung* (Stefan Ulbrich)

Hojny, Christopher, *Polyhedral description of star colourings* (Marc Pfetsch)

Kamlah, Iris, *Optimale Steuerung von Plasma-Aktuatoren zur Dämpfung von Tollmien-Schlichting-Wellen auf Basis von reduzierten Modellen basierend auf Balanced POD und Model Predictive Control* (Stefan Ulbrich)

Kopp, Sonja, *Semiglatte Mehrgitter-Newton-Verfahren für elastische Kontaktprobleme* (Stefan Ulbrich)

Kuttich, Anja, *Optimierung von robusten Stabwerken mit lokalen Knickbedingungen* (Stefan Ulbrich)

Lescevska, Elzbieta, *Evaluierung und Erweiterung geometrischer Schnittebenen* (Marc Pfetsch)

Lück, Stefanie, *Optimales Downlink Beamforming mit IC: Globale und lokale Lösung nichtkonvexer QCQPs mittels Momentenmethode und SOCP* (Stefan Ulbrich)

Mack, Julia Katharina, *Wege in Zellzerlegungen von Flächen* (Michael Joswig)

Neis, Ilona, *Diskrete Darstellung von Vektoren unter Sektor- und Abstandsnebenbedingungen* (Marc Pfetsch)

Rausch, Lea, *Optimale Planung des Energieeinsatzes eines aktiv gedämpften Elektro-Fahrzeugs* (Ulf Lorenz)

Ristl, Konstantin, *Portfoliooptimierung unter diskreten Bedingungen des realen Marktes* (Stefan Ulbrich)

Schwan, Lena Maria, *Konstruktion von Fahrplänen mit Hilfe der Recoverable Robustness Techniken* (Ulf Lorenz)

Schwarzkopf, Stefan, *Lösungsansätze für quantifizierte gemischt-ganzzahlige Probleme* (Ulf Lorenz)

Sowadzki, Claudia, *Faltbare Triangulierungen von Gitterpolytopen* (Michael Joswig)

Späth, Johannes, *Gerichtete Kreise in der tropischen Geometrie* (Michael Joswig)

Uhl, Florian Hans Eckehard, *Linienplanung auf speziellen zugrundeliegenden Netzstrukturen* (Marc Pfetsch)

Walter, Philipp, *Erweiterung eines QIP-Solvers durch Schnittebenenverfahren* (Ulf Lorenz)

Zinovyeva, Alexandra, *Optimierung von "Fare Families" und ähnlichen Preisstrukturen im Airline Revenue Management* (Ulf Lorenz)

2014

Barbehön, Janine, *The car sequencing problem under uncertainty* (Ulf Lorenz)

Biehl, Johanna Katharina, *Die Alternating Direction Method of Multipliers mit Anwendung auf Kommunikationsnetzwerke* (Stefan Ulbrich)

Debski, Piotr, *Robuste Portfoliooptimierung mit Wertpapieren und Optionen: Ein mehrstufiger Ansatz* (Stefan Ulbrich)

Heßler, Katrin, *Modelle für Störungsmanagement im ÖPNV* (Marc Pfetsch)

Horn, Benjamin Manfred, *Formoptimierung für Kontaktprobleme* (Stefan Ulbrich)

Lukassen, Axel Ariaan, *Nichtlineare CG-Verfahren für restringierte Optimierungsprobleme* (Irwin Yousept)

Lumpp, Jennifer, *Wahrscheinlichkeitsrestriktionen mit Überdeckungsformulierungen* (Marc Pfetsch)

Müller, Sabrina, *Power Minimization in Wireless Networks with Probabilistic Constraints* (Stefan Ulbrich)

Nietz, Sandra, *Kombinierte Optimierung von Zugrouten und Fahrplänen mit Orientierungsbedingungen* (Marc Pfetsch)

Reiser, Thomas, *Untersuchung des mehrstufigen RWA-Problems unter Unsicherheit* (Ulf Lorenz)

Rothenbächer, Ann-Kathrin, *Standortplanung und Netzwerkdesign im kombinierten Güterverkehr* (Marc Pfetsch)

Ruhmann, Iris, *Analyse von XOR-Polytopen* (Marc Pfetsch)

Schmitt, Michael Johann, *Multilevel Verfahren mit Modellen reduzierter Ordnung* (Stefan Ulbrich)

Stang, Olga, *Untersuchung des elementaren Abschlusses von {0,1/2}-Ungleichungen* (Marc Pfetsch)

Talebi, Taher, *Optimale Steuerung nichtlinearer Erwärmungsprozesse* (Irwin Yousept)

Utz, Marlene Luka, *Algorithmische Optimierung von Fluidsystemen* (Ulf Lorenz)

Will, Karsten, *Optimierungsverfahren für dünne Rekonstruktion in der Bildverarbeitung* (Irwin Yousept)

5.6 Bachelor Theses

2013

Abt, Fabian Ferdinand Erich, *Projektionen zur Lösung von ℓ_1-Problemen* (Marc Pfetsch)

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

Beian, Abraham, *Der Kern eines kooperativen Spiels* (Werner Krabs)

Bethcke, Johannes, *Production Planning under Uncertainty using Quantified Integer Programming* (Ulf Lorenz)

Butschek, Christian, *Untersuchung der Eindeutigkeit der dünn besetztesten Lösungen linearer Gleichungssysteme* (Marc Pfetsch)

Comis, Martin, *Adaptive Constraint Reduction for Training Support Vector Machines* (Stefan Ulbrich)

Diehl, Elisabeth Andrea Gertrud, *Vergleich des Orthogonal Matching und Basis Pursuit* (Marc Pfetsch)

Fenrich, Daniel Marcel, *Modellierung eines Heizungskreislaufs* (Ulf Lorenz)

Göttmann, Sabrina, *Interior-Point Methods and Smoothing-Type Methods for Semidefinite Programs* (Stefan Ulbrich)

Grab, Sabrina Rita, *Optimales Schätzen von OD-Matrizen* (Marc Pfetsch)

Herbst, Alexander, *Analyse und praktische Tests für Nesterov's Algorithmus (NESTA)* (Marc Pfetsch)

Herrmann, Sabine Johanna, *Paritätsbedingungs-Codes mit geringer Dichte und Compressed Sensing* (Marc Pfetsch)

Heun, Sebastian, *Robuste Optimierung von mehrstufigen Portfolios* (Stefan Ulbrich)

Horn, Benjamin Manfred, *Dünnbesetzte Repräsentationen in Paaren von Basen* (Marc Pfetsch)

Kreis, Mathias, *Robuste Optimierung von Kreditportfolios* (Stefan Ulbrich)

Maliqi, Beqir, *Robuste Lösungen von unsicheren linearen Programmen* (Stefan Ulbrich)

Otterbein, Markus, *Preprocessing für Robuste Stabwerksoptimierung* (Stefan Ulbrich)

Penzel, Nils, *Verallgemeinerung geometrischer Schnittebenen* (Marc Pfetsch)

Rothermel, Nina Karin, *f-Vektoren von Minkowski-Summen konvexer Polytope* (Michael Joswig)

Schwinn, Sebastian, *Robuste Stabwerksoptimierung mit lokalen Knicknebenbedingungen* (Stefan Ulbrich)

Seib, Bianca Mercedes, *Experimentelle Untersuchung des Verfahrens von Juditsky und Nemirovski* (Marc Pfetsch)

Stähler, Maximilian, *Global Minimization of Nonconvex Functions* (Stefan Ulbrich)

Stock, Christian, *Kreditrisiko Optimierung mit Conditional Value at Risk* (Stefan Ulbrich)

Tsiolas, Christos, *Terminierungskriterien bei SPGL1 und CPLEX* (Marc Pfetsch)

Vonk, Johannes Cornelis, *Ein nichtlineares Best-Approximationsproblem mit Unterschranken aus der Industrie und ein Lösungsansatz durch Nichtlineare Optimierung* (Stefan Ulbrich)

Wasmayr, Viktoria, *Primal-dual Interior-Point Methods with Redundancy Control* (Stefan Ulbrich)

2014

Antons, Yannic, *Grundlagen und Vergleich von Innere-Punkte-Methoden, Glättungsverfahren und semiglatten Newton-Verfahren in Anwendung auf lineare Optimierungsprobleme* (Stefan Ulbrich)

Berndt, Aileen, *Der Algorithmus von Truemper für verallgemeinerte Netzwerke* (Marc Pfetsch)

Brunning, Katharina, *Incremental Network Design with Shortest Paths* (Stefan Ulbrich)

Carkit, Ercan, *Innere-Punkte-Methoden und Glättungsverfahren* (Stefan Ulbrich)

Chojnowska, Lars, *Semiglatte Methoden für lineare und nichtlineare Second Order Cone Programme* (Stefan Ulbrich)

Dosch, Christina, *Neue Algorithmen für verallgemeinerte Netzwerkflüsse* (Marc Pfetsch)

Fladung, Marc, *Optimales Stabwerksdesign unter einer nichtkonvexen globalen Knick-Nebenbedingung* (Stefan Ulbrich)

Follert, Felix, *Dekompositionsmethoden zur parallelen Optimierung von Multiagenten-Systemen* (Stefan Ulbrich)

Füchtenhans, Marc, *Brickpolytope und Zerlegungen von Assoziadern* (Andreas Paffenholz)

Grohmann, Leonard, *Laplacian Eigenpolytopes* (Andreas Paffenholz)

Heldmann, Anica, *Inkrementelles Netzwerk-Design mit kürzesten Wegen* (Stefan Ulbrich)

Herzog, Janine, *Algorithmen für Flüsse über die Zeit* (Marc Pfetsch)

Hubert, Daniela Katharina, *Optimierung des Conditional Value at Risk unter Unsicherheit als robustes Optimierungsproblem* (Stefan Ulbrich)

Kalsen, Ali, *Separable Semidefinite Optimierung mit Anwendung auf Optimales Downlink Beamforming* (Stefan Ulbrich)

Kang, Ji-Young, *Optimization of Conditional Value-at-Risk for General Loss Distributions Based on Robust Solutions of Uncertain Linear Programs* (Stefan Ulbrich)

Keukoua Wantiep, Guenole, *Robust Portfolio Selection Problems* (Stefan Ulbrich)

Kinz, Monika, *Decomposition by Partial Linearization: Parallel Optimization of Multi-Agent Systems* (Stefan Ulbrich)

Knoff, Peter, *Lösung von konvexen Mehrgüterflussproblemen* (Marc Pfetsch)

Köhler, Jan, *Glättungsverfahren für Semidefinite Optimierungsprobleme* (Stefan Ulbrich)

Lange, Jan-Hendrik, *Reducing Linear Programs to Basis Pursuit* (Marc Pfetsch)

Loiero, Mirjam, *Ägyptische Brüche* (Werner Krabs)

Luu, Thuy Linh, *Theorie von Compressive Sensing via ℓ_1-Minimierung: eine RIP-freie Analyse und Erweiterung* (Stefan Ulbrich)

Mauthe, Axinja Laura, *Robust Portfolio Optimization with Value-At-Risk Adjusted Sharpe Ratios* (Stefan Ulbrich)

Menche, Julian, *Robuste Modellierung von mehrstufigen Portfolio-Problemen* (Stefan Ulbrich)

Nguyen, Mau Duong, *Der Core eines Produktionsspieles* (Werner Krabs)

Park, Sung-Ho, *Robust Modeling of Two-periodic Option Portfolios* (Stefan Ulbrich)

Pohl, Daniel, *Eine duale Sicht auf separierbare Semidefinite Programmierung im optimalen Downlink Beamforming* (Stefan Ulbrich)

Prager, Monika Simone Renate, *Applications of Minimal Cuts in Graphs in Image Segmentation* (Marc Pfetsch)

Radu, Bogdan, *Compressive Sensing and Signal Reconstruction Algorithms* (Stefan Ulbrich)

Schorr, Robert, *Ein Innere-Punkte-Verfahren mit adaptiver Nebenbedingungsreduktion für das Training von Support Vector Machines* (Stefan Ulbrich)

Vogt, Katja, *Heuristische Ansätze zum Auffinden von Cliquen* (Ulf Lorenz)

Werner, David, *Robuste Lösung unsicherer linearer Programme* (Stefan Ulbrich)

Werner, Johannes Manuel Friedemann, *Rangbeschränkte, separable, semidefinite Programmierung mit Anwendung beim optimalen Beamformingproblem* (Stefan Ulbrich)

Wickel, Sebastian, *Globale Minimierung mittels linearer und quadratischer Approximation* (Stefan Ulbrich)

Zelch, Christoph, *Sparsification of matrices* (Marc Pfetsch)

6 Presentations

6.1 Talks and Visits

6.1.1 Invited Talks and Addresses

Daniela Bratzke

12/09/2013 *Optimal control of hydroforming processes based on reduced order models*
IFIP TC7 Conference on System Modelling and Optimization, Klagenfurt

Hannes Meinlschmidt

03/07/2013 *Das Thermistor-Problem in 3D: Analysis und ein wenig optimale Steuerung*
Oberseminar Angewandte Analysis, Martin-Luther Universität Halle-Wittenberg

Andreas Paffenholz

25/05/2013 *Polyhedral Adjunction Theory*
Colloquium of the Graduate School "Methods in Discrete Structures", FU Berlin

21/03/2014 *Structure and Classifications of Fano Polytopes*
Oberseminar Gruppen und Geometrie, Universität Bielefeld

25/06/2014 *Structure and Classifications of Fano Polytopes*
Oberseminar Diskrete Mathematik, Universität Frankfurt

26/10/2014 *Finiteness of the polyhedral Q-codegree spectrum*
AMS Western Sectional Fall Meeting, San Francisco

Sebastian Pfaff

21/02/2013 *Optimal boundary control for nonlinear hyperbolic conservation laws with source terms*
Symposium on Variational Inequalities and PDE-constrained Optimization (VIS), HU Berlin

Marc Pfetsch

27/03/2013 *Compressed Sensing and Discrete Optimization*
Colloquium, IASI, Rome

29/10/2013 *Compressed Sensing and Discrete Optimization*
Colloquium, Erlangen

Alexandra Schwartz

05/06/2014 *Mathe-Professorin – Wie kam es dazu?*
Series of Talks "I did it my way", Internatsschule Schloss Hansenberg, Geisenheim

03/09/2014 *A Reformulation of Mathematical Programs with Cardinality Constraints using a Complementarity-type Condition*
International Conference on Operations Research, RWTH Aachen

Stefan Ulbrich

29/01/2013 *Robust optimization with PDE-constraints based on linear and quadratic approximations*
Oberwolfach Workshop

22/03/2013 *Multilevel methods for PDE-constrained optimization based on adaptive discretizations and reduced order models*
Plenary Talk, 84th GAMM Annual Meeting, Novi Sad

07/05/2013 *Combining multilevel and time domain decomposition techniques for time-dependent PDE-constrained optimization*
Invited Talk, Multiple Shooting and Time Domain Decom-position Methods (MuS-TDD), IWR, Heidelberg

04/07/2013 *Multilevel methods for PDE-constrained optimization based on adaptive discretizations and reduced order models*
Colloquium, Konstanz

18/07/2013 *Multilevel methods for PDE-constrained optimization based on adaptive discretizations and reduced order models*
Invited Minisymposium, EUCCO 2013, Chemnitz

30/07/2013 *Optimization of deep drawing processes*
Invited Minisymposium, ICCOPT 2013, Lisbon

11/09/2013 *Multilevel methods for PDE-constrained optimization based on adaptive discretizations and reduced order models*
Invited Minisymposium, IFIP 2013, Klagenfurt

30/09/2013 *Multilevel methods for PDE-constrained optimization based on adaptive discretizations and reduced order models*
Colloquium, BMBF-DGHPOPT, Trier

06/04/2014 *Multilevel methods for PDE-constrained optimization based on adaptive discretizations and reduced order models*
Invited Minisymposium, 13th Copper Mountain Conference on Iterative Methods, Copper Mountain

24/04/2014 *Multilevel methods for PDE-constrained optimization based on adaptive discretizations and reduced order models*
Colloquium, IWR, Heidelberg

19/05/2014 *Multilevel methods for very large scale NLPs resulting from PDE constrained optimization*
Invited Minisymposium, SIAM OP14, San Diego

04/08/2014 *Short course on multilevel methods for PDE-constrained optimization and variational inequalities*
Invited Short Course, ICCP 2014, Berlin

07/08/2014 *Multigrid semismooth Newton methods for elastic contact problems*
Invited Talk, ICCP 2014, Berlin

11/09/2014 *Convergence of discrete adjoints for flows with shocks*
Dagstuhl Workshop

Irwin Yousept

21/02/2013 *Numerical Analysis of Optimal Control of Electromagnetic Processes*
Universität Würzburg

13/03/2013 *Optimal Control of quasilinear H(curl)-elliptic PDEs arising from electromagnetic phenomena*
Workshop on Numerical Methods for Optimal Control and Inverse Problems (OCIP), Garching

06/05/2013 *Optimization of magnetic fields and its advanced applications*
Universität Konstanz

15/05/2013 *Nonlinear electromagnetic field control*
IFIP TC7.2 Workshop "Electromagnetics – Modelling, Simulation, Control", WIAS Berlin

06/06/2013 *Optimal control of nonlinear magnetostatic field problems*
9th International Conference on "Large-Scale Scientific Computation", Sozopol

03/07/2013 *Mathematische Analyse nichtlinearer Magnetfeldoptimierung*
Analysis Oberseminar, TU Darmstadt

09/07/2013 *Optimal control of quasilinear H(curl)-elliptic partial differential equations in magnetostatic field problems*
6th Workshop on Analysis and Advanced Numerical Methods for PDEs, St. Wolfgang

20/08/2013 *Helmholtz-Zerlegung*
TU Berlin

31/08/2013 *Optimal control of quasilinear H(curl)-elliptic PDEs*
International Conference on Continuous Optimization (ICCOPT), Lisbon

03/09/2013 *Optimal control of quasilinear H(curl)-elliptic partial differential equations in magnetostatic field problmes*
Domain Decomposition Methods for Optimization with PDE constraints, Monte Veritá, Ascona

05/11/2013 *Magnetfeldoptimierung im H(curl)-Funktionenraum*
TU Chemnitz

12/03/2014 *Optimal control of electromagnetic processes governed by Maxwell's equations*
Annual Meeting of the International Association of Applied Mathematics and Mechanics (GAMM), Richard-von-Mises Lecture, Erlangen

09/05/2014 *Optimale Steuerung elektromagnetischer Felder*
Special Colloquium "Control and Optimization" in honor of Prof. Dr. Werner Krabs' 80th birthday, Erlangen

6.1.2 Contributed Talks

Vera Bommer

02/12/2013 *A-priori-Fehlerabschätzung für ein parabolisches Optimalsteuerungsproblem*
Optimization Seminar, TU Darmstadt

03/03/2014 *A Priori Error Estimates for Parabolic Optimal Control Problems with Sparsity in Time*
Workshop on Numerical Methods for Optimal Control and Inverse Problems (OCIP), Garching

Stefanie Bott

18/03/2013 *Adaptive Multilevel SQP Methods for PDAE-constrained Optimization with Restrictions on Control and State. Theory and Applications*
Final Meeting of SPP 1253, Banz

10/09/2013 *Adaptive Multilevel SQP Method for State Constrained Optimization with Navier-Stokes Equations*
International Conference on Continuous Optimization (ICCOPT), Lisbon

05/03/2014 *Convergence Results for an Adaptive Multilevel SQP Method for Problems with State Constraint*
Workshop on Numerical Methods for Optimal Control and Inverse Problems (OCIP), Garching

08/04/2014 *Convergence Results for an Adaptive Multilevel SQP Method for Problems with State Constraints*
Graduate School CE Retreat, Seeheim-Jugenheim

12/05/2014 *Multilevel Methods for PDE-constrained Optimization with State Constraints*
Graduate School CE Research Colloquium, Darmstadt

19/05/2014 *Adaptive Multilevel SQP Method for State Constrained Optimization with Navier-Stokes Equations*
SIAM Conference on Optimization (SIOPT), San Diego

Daniela Bratzke

19/03/2013 *Optimal control of hydroforming processes based on POD*
Annual Meeting of the International Association of Applied Mathematics and Mechanics (GAMM), Novi Sad

15/04/2013 *Optimierung im SFB 666 - Teil 1*
Joint talk with T. Göllner and H. Lüthen, Optimization Seminar, TU Darmstadt

22/04/2013 *Optimierung im SFB 666 - Teil 2*
Joint talk with T. Göllner and H. Lüthen, Optimization Seminar, TU Darmstadt

29/07/2013 *Reduced order models for the optimal control of contact problems*
International Conference on Continuous Optimization (ICCOPT), Lisbon

03/03/2014 *Reduced order models for the optimal control of deep drawing processes*
Workshop on Numerical Methods for Optimal Control and Inverse Problems (OCIP), Garching

Thorsten Ederer

11/03/2013 *Optimierung der Heizungsanlage im Darmstadtium*
Optimization Seminar, TU Darmstadt

Michael Fischer

20/12/2014 *The adjoint approach for shape optimization with an example on the Boussinesq equations*
2014 Joint Conference on Applied Mathematics, Ryukoku Universität, Kyoto

Tobias Fischer

08/04/2013 *Discrete Optimization and Applications in Communication Technology*
Joint talk with Alexey Buzuverov, Graduate School CE Retreat, Seeheim-Jugenheim

11/11/2013 *Optimierung mit Komplementaritätsnebenbedingungen*
Optimization Seminar, TU Darmstadt

15/11/2013 *Optimization with Complementarity Constraints*
Graduate School CE Research Colloquium, Darmstadt

28/07/2014 *Optimization with Complementarity Constraints: Structure and Algorithms*
Graduate School CE Research Colloquium, Darmstadt

01/08/2014 *Optimization with Complementarity Constraints: Structure and Algorithms*
Future Research in Combinatorial Optimization (FRICO), Magdeburg

02/10/2014 *Using SCIP to Solve Linear Programs with Complementarity Constraints*
SCIP Workshop, Berlin

Tristan Gally

02/10/2014 *Mixed integer semidefinite programming with SCIP*
SCIP Workshop, Berlin

17/11/2014 *Behandlung von Unsicherheit mit robuster mathematischer Optimierung am Beispiel von Stabwerken*
Joint talk with A. Kuttich, Optimization Seminar, TU Darmstadt

21/11/2014 *Behandlung von Unsicherheit mit robuster mathematischer Optimierung am Beispiel von Stabwerken*
Joint talk with A. Kuttich, Kolloquium SFB 805, Darmstadt

Jane Ghiglieri

12/03/2014 *Optimal Flow Control based on POD and MPC and an Application to the Cancellation of Tollmien-Schlichting Waves*
Annual Meeting of the International Association of Applied Mathematics and Mechanics (GAMM), Erlangen

08/10/2014 *Optimal Flow Control based on POD and MPC and an Application to the Cancellation of Tollmien-Schlichting Waves*
International Workshop on Computational Engineering (ICCE), Universität Stuttgart

Thea Göllner

20/03/2013 *Optimizing the Geometry of Branched Sheet Metal Structures*
Annual Meeting of the International Association of Applied Mathematics and Mechanics (GAMM), Novi Sad

15/04/2013 *Optimierung im SFB 666 - Teil 1*
Joint talk with D. Bratzke and H. Lüthen, Optimization Seminar, TU Darmstadt

22/04/2013 *Optimierung im SFB 666 - Teil 2*
Joint talk with D. Bratzke and H. Lüthen, Optimization Seminar, TU Darmstadt

01/08/2013 *Optimizing the Geometry of Branched Sheet Metal Structures using Cubic Regularization*
International Conference on Continuous Optimization (ICCOPT), Lisbon

20/10/2014 *Geometrieoptimierung verzweigter Blechbauteile mit Adaptiven Kubischen Regularisierungstermen als Globalisierungsstrategie*
Optimization Seminar, TU Darmstadt

Christopher Hojny

10/02/2014 *Polyedrische Beschreibung von Sternfärbungen*
Optimization Seminar, TU Darmstadt

30/07/2014 *Polyhedral description of star colorings*
Future Research in Combinatorial Optimization (FRICO), Magdeburg

Benjamin Horn

10/11/2014 *Formoptimierung für Kontaktprobleme*
Optimization Seminar, TU Darmstadt

Imke Joormann

21/01/2013 *Analyzing infeasibility in natural gas networks*
Optimization Seminar, TU Darmstadt

07/07/2014 *On the Relation of Flow Cuts and Irreducible Infeasible Subsystems*
Optimization Seminar, TU Darmstadt

17/07/2014 *On the Relation of Flow Cuts and Irreducible Infeasible Subsystems*
Conference of the International Federation of Operational Research Societies (IFORS), Barcelona

Anja Kuttich

28/10/2013 *Optimierung von robusten Stabwerken mit lokalen Knickbedingungen*
Optimization Seminar, TU Darmstadt

17/11/2014 *Behandlung von Unsicherheit mit robuster mathematischer Optimierung am Beispiel von Stabwerken*
Joint talk with T. Gally, Optimization Seminar, TU Darmstadt

21/11/2014 *Behandlung von Unsicherheit mit robuster mathematischer Optimierung am Beispiel von Stabwerken*
Joint talk with T. Gally, Kolloquium SFB 805, Darmstadt

Oliver Lass

17/06/2014 *Parameter identification for nonlinear elliptic parabolic systems with application in lithium-ion battery modeling*
European Conference on Mathematics for Industry, Taormina

23/06/2014 *Modellreduktion und Parameteridentifikation für gekoppelte nichtlineare Systeme von partiellen Differentialgleichungen*
Optimization Seminar, TU Darmstadt

08/10/2014 *Parameter identification for nonlinear elliptic parabolic systems*
3rd International Workshop on Computational Engineering (ICCE), Universität Stuttgart

Madeline Lips

07/03/2013 *Stochastic Optimization – a short introduction*
Math across the Main workshop, Darmstadt

Hendrik Lüthen

15/04/2013 *Optimierung im SFB 666 - Teil 1*
Joint talk with D. Bratzke and T. Göllner, Optimization Seminar, TU Darmstadt

22/04/2013 *Optimierung im SFB 666 - Teil 2*
Joint talk with D. Bratzke and T. Göllner, Optimization Seminar, TU Darmstadt

Sonja Mars

25/02/2013 *Lösen von gemischt-ganzzahligen semidefiniten Problemen*
Optimization Seminar, TU Darmstadt

Hannes Meinlschmidt

11/02/2013 *Optimalsteuerung von PDAEs (und Thermistoren)*
Optimization Seminar, TU Darmstadt

30/07/2013 *Optimal Control of PDAEs*
International Conference on Continuous Optimization (ICCOPT), Lisbon

10/09/2013 *Optimal Control of PDAEs*
IFIP TC7 Conference on System Modelling and Optimization, Klagenfurt

10/02/2014 *Das Thermistorproblem in 3D*
Chemnitzer Seminar zur Optimalen Steuerung, Haus im Ennstal

19/05/2014 *Optimal Control of Index 1 PDAEs*
SIAM Conference on Optimization (SIOPT), San Diego

Andreas Paffenholz

20/03/2013 *Fano Polytopes with Many Vertices*
Annual conference of the DFG Priority Project SPP 1489, Konstanz

Sebastian Pfaff

30/07/2013 *Optimal Control of Nonlinear Hyperbolic Conservation Laws at a Junction*
International Conference on Continuous Optimization (ICCOPT), Lisbon

10/09/2013 *Optimal Control of Networks of Nonlinear Hyperbolic Conservation Laws*
IFIP TC7 Conference on System Modelling and Optimization, Klagenfurt

03/02/2014 *Hyperbolische Erhaltungsgleichungen und Straßenverkehr*
Optimization Seminar, TU Darmstadt

19/05/2014 *Optimal Control of Nonlinear Hyperbolic Conservation Laws with Switching*
SIAM Conference on Optimization (SIOPT), San Diego

31/07/2014 *Optimal Control of a Nonlinear Hyperbolic Conservation Law with Switching*
International Conference on Hyperbolic Problems (HYP), Rio de Janeiro

Marc Pfetsch

25/06/2013 *Vom Simulieren zum Optimieren*
Workshop "Langfristige Kapazitätsberechnung", Berlin

Anne Philipp

31/07/2013 *Mixed integer nonlinear models in wireless networks*
International Conference on Continuous Optimization (ICCOPT), Lisbon

09/05/2014 *Multiuser downlink beamforming with interference cancellation using a SDP-Based Branch-and-Bound Algorithm*
IEEE Int. Conf. on Acoustics, Speech and Signal Process. (ICASSP), Florence

21/05/2014 *Quadratically Constrained Quadratic Programs with On/off Constraints and Applications in Signal Processing*
SIAM Conference on Optimization (SIOPT), San Diego

Carsten Schäfer

20/03/2013 *Optimal Actuator Placement for Dynamic Systems*
Annual Meeting of the International Association of Applied Mathematics and Mechanics (GAMM), Novi Sad

29/07/2013 *Optimal Actuator and Sensor Placement for Dynamical Systems*
International Conference on Continuous Optimization (ICCOPT), Lisbon

20/01/2014 *Attenuation of Dynamical Systems using Model Predictive Control*
Optimization Seminar, TU Darmstadt

14/03/2014 *Optimal Actuator and Sensor Placement for Dynamical Systems*
Annual Meeting of the International Association of Applied Mathematics and Mechanics (GAMM), Erlangen

21/05/2014 *Optimal Actuator and Sensor Placement for Dynamical Systems*
SIAM Conference on Optimization (SIOPT), San Diego

Adrian Sichau

31/07/2013 *Robust nonlinear programming with discretized PDE constraint using quadratic approximations*
International Conference on Continuous Optimization (ICCOPT), Lisbon

21/10/2013 *Robust Nonlinear Programming with Discretized PDE Constraints using Second-order Approximations*
Optimization Seminar, TU Darmstadt

Andreas Tillmann

14/01/2013 *Branch & Cut for L0-Minimization*
Optimization Seminar, TU Darmstadt

08/07/2013 *The Computational Complexity of Spark, RIP, and NSP*
Signal Processing with Adaptive Sparse Structured Representations (SPARS), EPFL, Lausanne

16/12/2013 *Computational Aspects of Compressed Sensing*
Optimization Seminar, TU Darmstadt

Stefan Ulbrich

12/03/2014 *Optimization of deep drawing processes*
85th GAMM Annual Meeting, Erlangen

6.1.3 Visits

Vera Bommer, TU München, November 2013

Tristan Gally, Zuse-Institut Berlin, May 5–9, 2014

Oliver Lass, Universität Konstanz, October 2014

Hendrik Lüthen, RWTH Aachen, March 2014

Hendrik Lüthen, Universität Bonn, June 2014

Hannes Meinlschmidt, Martin-Luther Universität Halle-Wittenberg, July 2013

Hannes Meinlschmidt, TU Dortmund, August 2014

Andreas Paffenholz, Universität Bielefeld, May 2014

Andreas Paffenholz, SFSU, San Francisco, October 2014

Marc Pfetsch, Georgia Insitute of Technology, Atlanta, May 2013

Marc Pfetsch, ISAI Rome, April 2013

Andreas Tillmann, Technion, Haifa, Israel, April 2014

6.2 Organization and Program Commitees of Conferences and Workshops

Jane Ghiglieri

- Minisymposium: Optimal Control Based on Reduced Order Models (jointly with S. Ulbrich) at the 3rd International Workshop on Computational Engineering (ICCE), Oct 6–10, 2014, Universität Stuttgart

Silke Horn

- Math across the Main Workshop, March 7, 2013 (with Timo de Wolff)

Michael Joswig

- Local Committee, MEGA 2013 (Methods for Effective Algebraic Computation), Frankfurt (Main)

Andreas Paffenholz

- Organizing committee, Effective Methods in Algebraic Geometry (MEGA) 2013, June 3–7, Frankfurt (Main)

Marc Pfetsch

- Programm committee, 13th Workshop on Algorithmic Approaches for Transportation Modelling, Optimization, and Systems (ATMOS) 2013, September 5, Sophia Antipolis, France

Stefan Ulbrich

- Program committee, Fourth International Conference on Continuous Optimization ICCOPT 2013, July 27–August 1, Lisbon
- Program committee, 16th French-German-Polish Conference on Optimization FGP 13, September 23–27, 2013, Krakow
- Invited minisymposium, Advances and Applications in PDE Constrained Optimization, SIAM Conference on Optimization 2014, May 19–22, San Diego

7.2 Guest Talks at the Department

14/05/2013 Simon Hampe (Universität des Saarlandes), *a-tint: Eine polymake-Erweiterung für tropische Schnitttheorie* (Michael Joswig)

12/06/2013 Dr. Jonathan Spreer (University of Queensland), *Parameterized Complexity of Discrete Morse Theory* (Andreas Paffenholz)

10/07/2013 Prof. Dr. Julian Pfeifle (UPC Barcelona), *A Polyhedral Proof of the Matrix-Tree Theorem* (Michael Joswig)

15/07/2013 Björn Geißler (Universität Erlangen-Nürnberg), *A New Algorithm for MINLP Applied to Gas Transport Energy Cost Minimization* (Marc Pfetsch)

16/09/2013 Réne Henrion (WIAS Berlin), *Optimierungsprobleme mit Wahrscheinlichkeitsrestriktionen* (Stefan Ulbrich)

26/09/2013 Sergio Alejandro González Andrade (Escuela Politécnica Nacional), *Numerical simulation of Bingham fluids by semismooth Newton methods: a general survey* (Irwin Yousept)

04/11/2013 Dr. Matthias Mnich (MPI Saarbrücken), *Multivariate Algorithmen für schwere Optimierungsprobleme* (Marc Pfetsch)

17/12/2013 Prof. Dr. Harbir Antil (George Mason University, Fairfax), *Optimal Control of a Free Boundary Problem with Surface Tension Effects* (Irwin Yousept)

28/03/2014 Zhonghao Gu (Gurobi), *Disconnected or Almost Disconnected MIP* (Marc Pfetsch)

29/04/2014 Prof. Dr. Ekaterina Kostina (Universität Marburg), *Robustheitsaspekte bei Problemen der nichtlinearen beschränkten Optimierung und Optimalen Steuerung unter Unsicherheiten* (Marc Pfetsch)

20/06/2014 Dr. Yuri Faenza (École polytechnique fédérale de Lausanne), *On finding the largest simplex contained in a polytope* (Marc Pfetsch)

01/09/2014 Michal Červinka, Ph.D. (Czech Academy of Sciences and Charles University, Prague), *On Stability of Stationary Points in MPCCs* (Alexandra Schwartz)

27/10/2014 Dr. Tobias Achterberg (Gurobi), *Multi-Row Presolve Reductions in Mixed Integer Programming* (Marc Pfetsch)

09/12/2014 Benjamin Assarf (TU Berlin), *On Classification of Smooth Fano polytopes* (Andreas Paffenholz)

7.3 Visitors at the Department

Prof. Dr. Benjamin Nill (University of Stockholm), May 2014.

Dr. Yuri Faenza (École polytechnique fédérale de Lausanne), June 2014.

Michal Červinka, Ph.D. (Czech Academy of Sciences and Charles University, Prague), September 2014.

Prof. Dr. Matthias Heinkenschloss (Rice University, Houston, USA), October 2014.

8 Other scientific and organisational activities

8.1 Memberships in Scientific Boards and Committees

Michael Joswig

- Board Member of the DMV

Stefan Ulbrich

- Member of the IFIP Technical Committee TC 7, WG 7.2 "Computational Techniques in Distributed Systems", since 2003
- Chair Selection Committee, MOS Best Paper Prize for Young Researchers in Continuous Optimization 2013, Mathematical Optimization Society

8.2 Awards and Offers

Awards

Jane Ghiglieri: Ruth-Moufang-Preis (Fachbereich Mathematik, TU Darmstadt), 2014

Anja Kuttich: Datenlotsen-Preis (Datenlotsen Informationssysteme GmbH, Hamburg), November 19, 2014

Andreas Tillmann: Best Student Paper Award (SPARS 2013, Lausanne, Switzerland), July 10, 2013

Irwin Yousept: Dimitrie Pompeiu Prize (Academy of Romanian Scientists), 2013

Irwin Yousept: Richard-von-Mises-Preis (85th Annual Meeting of the International Association of Applied Mathematics and Mechanics (GAMM) 2014, Erlangen), March 12, 2014

Offers of Appointments

Michael Joswig: Professorship (W3) for Discrete Mathematics/Geometry, TU Berlin

Irwin Yousept: Professorship (W3) for Numerical Mathematics, Universität Duisburg-Essen

9 Contact

Address

Fachbereich Mathematik
Arbeitsgruppe Optimierung
Dolivostraße 15
D-64293 Darmstadt
Building: S4|10
Homepage: http://www.opt.tu-darmstadt.de

For the full biannual report of the department of mathematics at TU Darmstadt see
http://www3.mathematik.tu-darmstadt.de/fb/mathe/forschung/jahresberichte.html