SIGOPT 2016

International Conference on Optimization
&
Official Opening of the
Research Training Group (Graduiertenkolleg)
ALOP
Algorithmic Optimization

6-8 April 2016

University of Trier, Germany

Universität Trier

SIGOPT 2016

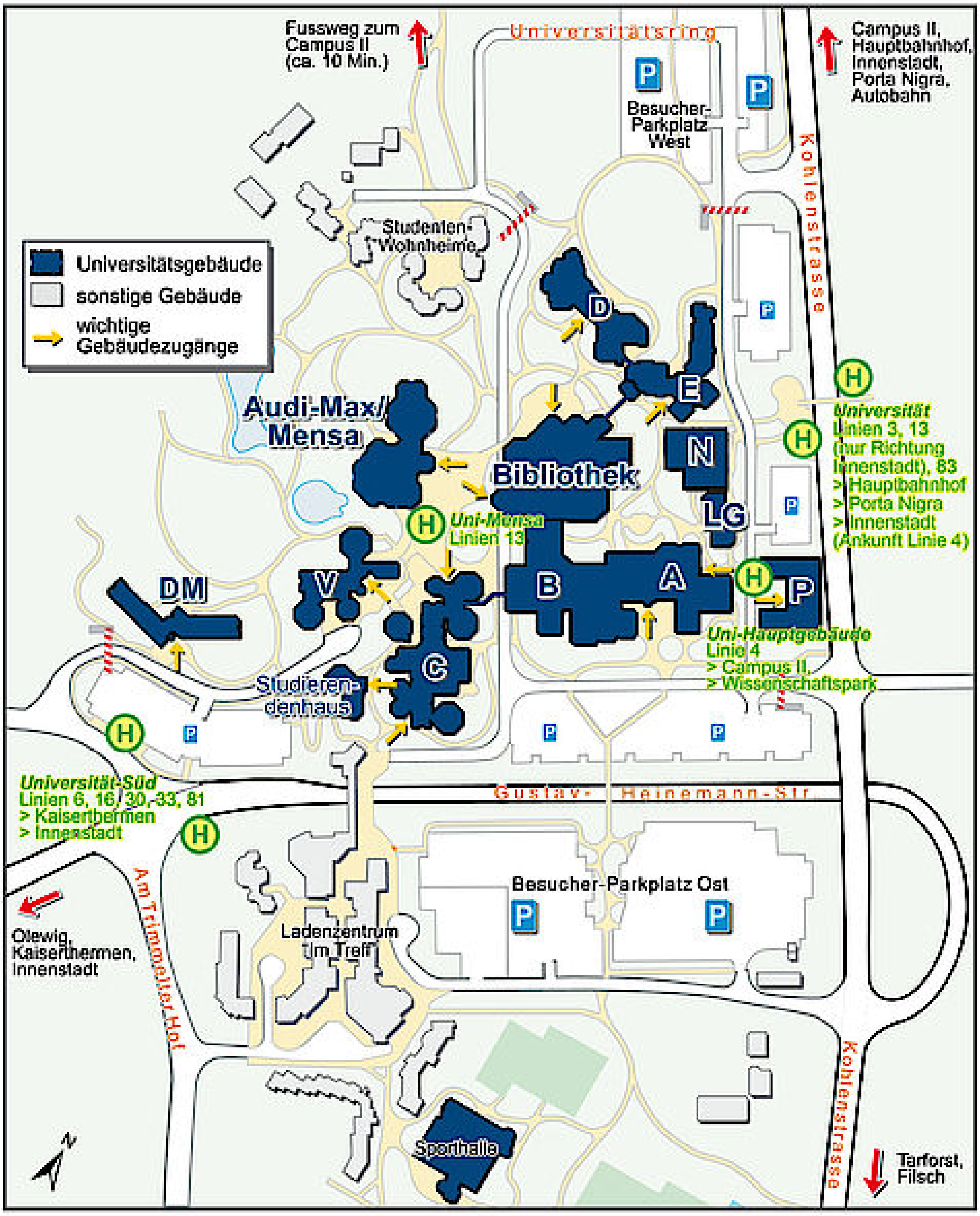
6-8 April 2016

Building E,
University of Trier
Germany

Organizers:
Mirjam Dür, Sven de Vries, Volker Schulz

Location

The conference takes place in **building E** of Campus I of the University of Trier. Lunches can be taken in the **Mensa**.



Program: Wednesday 6. April 2016

9:25 9:30–10:30	HS 9	Opening **Plenary talk** Volker Kaibel: *Describing Integer Points in Polyhedra* **Chair:** Sven de Vries
10:30–11:00		*Coffee Break*
11:00–12:30	HS 9	**Parallel session:** *Optimization with Applications* **Chair:** Anita Schöbel Laura Somorowsky: *Pareto Optimization and Optimal Control in the Ramsey Equilibrium Model* Claus Teuber: *The Optimization of Power Networks via Space Mapping* Dirk Banholzer: *A RBF Method for Noisy Global Optimisation with Applications to Financial Model Calibration*
11:00–12:30	HS 10	**Parallel session:** *Copositive Optimization* **Chair:** Mirjam Dür Roland Hildebrand: *Periodic discrete dynamical systems and copositive matrices with circulant zero patterns* Patrick Groetzner: *A factorization heuristic for completely positive matrices*
12:30–14:00		*Lunch Break*
14:00–15:00	HS 9	**Parallel session:** *Matrix games and bilevel optimization* **Chair:** Vladimir Shikhman Andreas Löhne: *A set-valued approach to matrix games with vector payoffs* Stephan Dempe: *Pessimistic linear bilevel optimization*
14:00–15:00	HS 10	**Parallel session:** *Combinatorial optimization* **Chair:** Ulf Friedrich Anja Fischer: *On the traveling salesman problem with forbidden neighborhoods* Bernd Perscheid: *An Extended Formulation for Wheel Inequalities in the Stable Set Polytope*
15:00–15:40		*Coffee Break*
15:40–16:40	HS 9	**Parallel session:** *Multiobjective robust optimization* **Chair:** Ralf Werner Gabriele Eichfelder: *Multi-Objective Regularization Robustness* Anita Schöbel: *Multi-objective robust optimization*
15:40–16:40	HS 10	**Parallel session:** *MINLP and discrete bilevel optimization* **Chair:** Matthias Claus Sönke Behrends: *On Nonlinear Cutting Planes for Mixed Integer Nonlinear Optimization* Floriane Mefo Kue: *Discrete linear bilevel optimization problems*

Program: Thursday 7. April 2016

9:30–10:30	HS 9	**Plenary talk** Oliver Stein: *Coercive polynomials and their Newton polytopes* **Chair:** Martin Siebenborn
10:30–11:00		*Coffee Break*
11:00–12:30	HS 9	**Parallel session:** *Variational Inequalities* **Chair:** Kathrin Welker Ursula Felgenhauer: *Variational Inequalities related to Bang-Singular-Bang Controls* Axel Dreves: *Uniqueness for Quasi-Variational Inequalities* Carola Schrage: *Set–Valued Variational Inequalities in Vector Optimization*
11:00–12:30	HS 10	**Parallel session:** *Stochastic optimization and optimization under uncertainty* **Chair:** Christina Schenk Marc C. Steinbach: *A distributed interior point method for multistage stochastic NLPs* Ralf Werner: *Consistent uncertainty sets and consistent robust estimators* Matthias Claus: *Stability in bilevel programming under stochastic uncertainty*
12:30–14:00		*Lunch Break*
14:00–15:00	HS 9	**Parallel session:** *Sparse optimization* **Chair:** Marc Steinbach Christian Kanzow: *From Cardinality-Constrained to Sparse Optimization* Daniel Rose: *An elastic Active Set approach for large structured QPs*
14:00–15:00	HS 10	**Parallel session:** *Packing and allocation problems* **Chair:** Volker Kaibel Maria Dostert: *New upper bounds for the density of translative packings of three-dimensional convex bodies with tetrahedral symmetry* Ulf Friedrich: *Fast algorithms for optimal sample sizes allocation*
15:00–15:40		*Coffee Break*
15:40–16:40	HS 10	**Session:** *Multilinear and polynomial optimization* **Chair:** Anja Fischer Mareike Dressler: *An Approach to Constrained Polynomial Optimization via Nonnegative Circuit Polynomials and Geometric Programming* Kai Kellner: *A Semidefinite Hierarchy for Multilinear Programming*

18:30		*Conference Dinner at Weinstube Kesselstatt* (opposite the Cathedral of Trier in the city center, `http://www.weinstube-kesselstatt.de/`)

Program: Friday 8. April 2016 (morning)

9:30–11:00	HS 9	**Parallel session:** *PDE optimization and optimal control* **Chair:** Ekkehard Sachs Matthias Heinkenschloss: *A Parallel-in-Time Gradient-Type Method for Optimal Control Problems* Tommy Etling: *Optimum Experimental Design by Shape Optimization of Specimens in Linear Elasticity* Martin Siebenborn: *High performance optimization algorithms for interface identification problems*
9:30–11:00	HS 10	**Parallel session:** *Nonsmooth optimization* **Chair:** Stephan Dempe Vladimir Shikhman: *Dual subgradient method with averaging for optimal resource allocation* Martin Knossalla: *Continuous Outer Subdifferentials in Nonsmooth Optimization* Andrea Walther: *Optimality Conditions for Nonsmooth Optimization Problems*
11:00–11:30		*Coffee Break*
11:30–12:30	HS 9	**Plenary talk** Kathrin Klamroth: *Multiple Objective Counterparts: Trading-Off between Optimization Criteria and Constraints* **Chair:** Volker Schulz
12:30		Closing

Program: Friday 8. April 2016 (afternoon)

Official Opening of the
Research Training Group (Graduiertenkolleg)
ALOP
Algorithmic Optimization

Note:
The official opening of the Research Training Group will be held **in German**.

Raum: Hörsaal 9 (Gebäude E)

14:00	Grußworte: Prof. Dr. Michael Jäckel, Präsident der Universität Trier Prof. Dr. Martin Endreß, Dekan des Fachbereichs IV Prof. Dr. Volker Schulz, Sprecher des Graduiertenkollegs Algorithmische Optimierung
anschließend	Festvortrag: Prof. Dr. Günter Leugering *Optimierung und Steuerung von Materialien und Prozessen*
anschließend	Empfang, Gebäude P, Raum P3

ALGORITHMIC
OPTIMIZATION

Announcement:

SIGOPT 2018

will take place

21-23 March 2018 in Kloster Irsee

Organizers:
Tobias Harks and Ralf Werner (Augsburg University).

Abstracts

A RBF Method for Noisy Global Optimisation with Applications to Financial Model Calibration

Dirk Banholzer

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Financial derivatives play an essential role in today's financial industry and are typically valuated by means of sophisticated mathematical pricing models. The calibration of these models to market prices, i.e. the estimation of appropriate model parameters, is a crucial procedure for making them applicable to real markets which requires advanced optimisation techniques.

In this talk, we present a method for global optimisation problems arising from the calibration of financial models to market data, where the underlying model prices are approximated by Monte Carlo simulations. The method extends Gutmann's RBF method for deterministic objective functions, see [1], to account for a noisy setup in which the level of noise can be controlled adequately. To illustrate the practicability of our method, we apply the algorithm to calibrate the Hull-White interest rate model to available market data and compare the obtained results with their deterministic counterparts.

Joint work with: Jörg Fliege (University of Southampton) and Ralf Werner (Universität Augsburg)

References

[1] Gutmann, H.-M., "A Radial Basis Function Method for Global Optimization", Journal of Global Optimization, Vol. 19 (2001), pp. 201–227.

On Nonlinear Cutting Planes for Mixed Integer Nonlinear Optimization

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For mixed-integer problems with polynomial objective and constraints, we investigate the algorithmic generation of valid – but not necessarily linear or quadratic – inequalities. For example, these inequalities can be related to ellipsoids, semi-norms, or affine subspaces. Our approach consists of the following steps: We model the problem of finding a valid nonlinear inequality as a continuous polynomial problem. This auxiliary problem in turn is made tractable by approximating it with sum-of-squares (sos) programming. For these sos programs, we give necessary and sufficient conditions for convergence of their optimal solutions towards the optimal solution of the auxiliary problem. Also, in the cases we consider, a feasible solution to the sos program is feasible for the auxiliary problem. Finally, using integrality and ideas from (elementary) number theory, we may turn the thus generated feasible solutions to the auxiliary problem into nonlinear cutting planes, i.e., we cut off feasible solutions of the continuous relaxation. Apart from conceptual insights, the inequalities entail properties that are desirable in applications: For instance, in case of the seminorms, given a feasible solution, there are conditions that ensure that the method turns (possibly) unbounded integer variables into bounded ones, making them accessible to branch and bound. Also, the problem to find a tight linear inequality – tight at some known feasible solution – can be approached with this method.

Joint work with: Anita Schöbel

Stability in bilevel programming under stochastic uncertainty

Matthias Claus

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From a conceptual point of view, two-stage stochastic programs and bilevel problems under stochastic uncertainty are closely related. However, the step from the first to the latter mirrors the step from optimal values to optimal solutions and entails a loss of desirable analytical properties. The talk focuses on mean risk formulations of stochastic bilevel programs. Based on a growth condition, weak continuity of the objective function with respect to perturbations of the underlying measure is derived. Implications regarding stability for a comprehensive class of risk averse models are pointed out.

Pessimistic linear bilevel optimization

Stephan Dempe

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Bilevel optimization problems consist in minimizing an objective function subject to the graph of the solution set mapping of a second, parametric optimization problem. Since the variables of this (upper level) problem are only the parameters for the second (lower level) problem but the objective function depends also on the solution of the lower level problem, it is not well-defined in the case when the lower level problem does not have a unique optimal solution for all parameters. One way out in this situation is to consider the pessimistic bilevel optimization problem.

Topic of the presentation is the problem when the objective function of both levels and the constraints of the lower level problem are all linear functions. Using linear optimization duality and parametric optimization, especially so-called regions of stability, the problem is reduced to a combinatorial linear optimization problem. Then it is possible to formulate algorithms for computing a global or a local optimal solution.

Joint work with: G. Luo, Applied Mathematics Department, Guangdong University of Finance, Guangzhou, PR China

New upper bounds for the density of translative packings of three-dimensional convex bodies with tetrahedral symmetry

Maria Dostert

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In this talk I will present new upper bounds for the maximum density of translative packings of superballs in three dimensions (unit balls for the l^p-norm) and of Platonic and Archimedean solids having tetrahedral symmetry.

These bounds will give some strong indications that the lattice packings experimentally found in 2009 by Jiao, Stillinger, and Torquato are indeed optimal among all translative packings. We improve Zong's recent upper bounds for the maximal density of translative packings of regular tetrahedra from $0.3849\ldots$ to $0.3745\ldots$ getting closer to the best known lower bounds of $0.3673\ldots$

For this we apply the linear programming bound of Cohn and Elkies which originally was designed for the classical problem of packings of round spheres. The proof of our new upper bounds is computational and rigorous. Our main technical contribution is the use of invariant theory of pseudo-reflection groups in polynomial optimization.

Joint work with: Cristóbal Guzmán, Fernando Mário de Oliveira Filho, Frank Vallentin

An Approach to Constrained Polynomial Optimization via Nonnegative Circuit Polynomials and Geometric Programming

Mareike Dressler

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Finding lower bounds for real polynomials is a central problem in polynomial optimization. It is well-known that in general these problems are NP-hard both in the constrained and in the unconstrained case. The best known lower bounds are provided by Lasserre relaxations using semidefinite programming. A major drawback of this approach is the long running time of the computations for large numbers of variables or high degree polynomials.

In this talk I will present some recent developments in polynomial optimization. Namely, I will consider the cone of sums of nonnegative circuit polynomials leading to a nonnegativity certificate for polynomials. Combining this with geometric programming methods for constrained polynomial optimization problems I will present an efficient new method to solve constrained polynomial optimization problems with many variables or with high degree polynomials. Furthermore, I will provide examples, for which this method is both faster and often even better than semidefinite programming.

Joint work with: Sadik Iliman and Timo de Wolff

Uniqueness for Quasi-Variational Inequalities

Axel Dreves

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We are interested in a uniqueness result for a quasi-variational inequality QVI(1) that, in contrast to existing results, does not require the projection mapping on a variable closed and convex set to be a contraction. The basic idea is to find a simple QVI(0), for example a variational inequality, for which we can show the existence of a unique solution. Further, exploiting some nonsingularity condition, we will guarantee the existence of a continuous solution path from the unique solution of QVI(0) to a solution of QVI(1). Finally, we can show that the existence of a second different solution of QVI(1) contradicts the nonsingularity condition.

Moreover, some matrix-based sufficient conditions for the nonsingularity assumption are presented, and we discuss these assumptions in the context of some generalized Nash equilibrium problems.

Multi-Objective Regularization Robustness

Gabriele Eichfelder

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Whenever values of decision variables cannot be put into practice exactly, we encounter variable uncertainty in optimization problems. For instance, in the design of a magnetic system magnets with an optimally determined magnetic direction cannot be realized in the desired accuracy.

We present a robust optimization concept called regularization robust efficient solutions to handle variable uncertainty in multi-objective optimization problems. For each solution, we consider the set of all of its possible realizations instead of the solution itself. Thus we have to compare sets instead of points in order to find non-dominated solutions. Thereby, we extend a concept that was introduced for single-objective optimization. We also discuss the relation of this new concept to set-valued optimization of supremal sets and present some interesting properties of regularization robust efficient solutions.

Joint work with: Corinna Krüger and Anita Schöbel

Optimum Experimental Design by Shape Optimization of Specimens in Linear Elasticity

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Optimum Experimental Design (OED) is an established technique in various scientific disciplines in order to optimize the parameter identification by experiments, e.g., in the modeling of chemical processes. In this talk we consider the identification of the material parameters in linear elasticity, i.e., Young's modulus and the Poisson ratio. A novelty of our approach is that we use the geometry of the specimens in order to optimize the precision of the parameter estimation. We formulate an associated shape optimization problem and derive an appropriate volume representation of the shape derivative using the Lagrange method and a material derivative free approach. Numerical experiments are included.

Joint work with: Roland Herzog and Gerd Wachsmuth

Variational Inequalities related to Bang-Singular-Bang Controls

Ursula Felgenhauer

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The paper is related to optimal control problems for control-affine systems where the optimal control is a concatenation of bang arcs at the interval ends, and one singular arc in the interior. For this benchmark situation, in a first step, necessary optimality conditions are written in variational inequality form. In a second step, we analyze the solution properties like (i) existence and uniqueness, (ii) stability of solutions (as elements of appropriate function spaces) and control structure w.r.t. data perturbation, (iii) approximability of solutions by means of linearized problems with or without discretization. The theoretical results use regularity and structural assumptions as well as strong second-order optimality conditions. It will be shortly discussed further, how the latter could be checked e.g. numerically once a stationary solution has been found.

On the traveling salesman problem with forbidden neighborhoods

Anja Fischer

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Motivated by an application in laser beam melting we consider an extended Euclidean traveling salesman problem (TSP). Given points in the plane we look for a shortest tour over these points where edges between two points are forbidden if they are too close to each other. We study the structure of optimal solutions on regular grids in dependence on the given minimal distance and present optimal solutions in several cases. Furthermore we consider an extension of our problem where it is not allowed to come close to some previously visited point over several steps, leading to the so called TSP with memory. Finally, we present some computational results for real-world instances and give suggestions for future work.

Joint work with: Michael Firstein and Philipp Hungerländer

Fast algorithms for optimal sample sizes allocation

Ulf Friedrich

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In stratified random sampling, minimizing the variance of a total estimate leads to the optimal allocation by Neyman and Tschuprow. Classical algorithms for this problem yield real-valued rather than integer-valued solutions.

We presents three integer-valued optimization algorithms which solve the problem of minimizing a separable convex function with upper and lower boundary conditions. We begin by identifying the polymatroid structure of the feasible region and show that it can be solved by Greedy-type strategies. Subsequently, we develop a polynomial-time algorithm using a binary search based on medians.

As an application, the algorithms are used to solve the German Census 2011 allocation problem, an optimal allocation problem in stratified random sampling respecting box constraints. Numerical results show the practical relevance of this approach.

Joint work with: Sven de Vries, Ralf Münnich and Matthias Wagner

A factorization heuristic for completely positive matrices

Patrick Groetzner

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Many combinatorial and nonlinear problems can be reformulated as convex problems using the copositive cone and its dual, the completely positive cone. Therefore, it is of interest to be able to test whether a matrix is completely positive or copositive.

There exist characterizations for completely positive matrices based on given factorizations. In general, however, a factorization is not known and difficult to compute. The main goal of this talk is to introduce a heuristic method to derive a factorization for arbitrary completely positive matrices using certain orthogonal transformations.

Characterizing the interior of the completely positive cone is of interest since it enables us to verify Slater's condition. There exist sufficient conditions for a matrix to be in the interior, but unfortunately these conditions are not necessary. Given a matrix in the interior of the completely positive cone, we show that our method enables us to transform a given factorization in a way that certifies this property.

Joint work with: Mirjam Dür

A Parallel-in-Time Gradient-Type Method for Optimal Control Problems

Matthias Heinkenschloss

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A new parallel-in-time gradient type method for the solution of time dependent optimal control problems is introduced. Each iteration of the classical gradient method requires the solution of the forward-in-time state equation followed by the solution of the backward-in-time adjoint equation to compute the gradient. To introduce parallelism, the time steps are split into N groups corresponding to time subintervals. At the time subinterval boundaries state and adjoint information from the previous iteration is used. On each time subinterval the forward-in-time state equation is solved, the backward-in-time adjoint equation is solved, gradient-type information is generated, and the control are updated. These computations can be performed in parallel across time subintervals. State and adjoint information at time subinterval boundaries is then exchanged with neighboring subintervals and the process is repeated. Applied to a finite dimensional convex linear quadratic discrete time optimal control (DTOC) problem, this method can be interpreted as a so-called (2N-1)-part iteration scheme. Convergence of this new method applied to convex linear quadratic DTOC problems is proven for sufficiently small step sizes. Numerical examples on a 3D parabolic advection diffusion control problem and on a well rate optimization problem for a two-phase immiscible reservoir show good speed-up of the new method.

Joint work with: Xiaodi Deng

Periodic discrete dynamical systems and copositive matrices with circulant zero patterns

Roland Hildebrand

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We construct families of exceptional extreme rays of the copositive cone in arbitrary dimension which generalize the Horn form and the T-matrices, respectively. The involved copositive matrices have a circulant zero pattern and their properties are closely linked to the properties of certain periodic discrete dynamical systems which are defined by their zeros.

Describing Integer Points in Polyhedra

Volker Kaibel

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Linear mixed integer models are fundamental in treating combinatorial problems via Mathematical Programming. In this lecture we are going to discuss the question how small such formulations one can obtain for different problems. It turns out that for several problems including, e.g., the traveling salesman problem and the spanning tree problem, the use of additional variables is essential for the design of polynomial sized integer programming formulations. In fact, we prove that their standard exponential size formulations are asymptotically minimal among the formulations based on incidence vectors only. We also treat bounds for general sets of 0/1-points and briefly discuss the question for the role of rationality of coefficients in formulations.

Joint work with: Stefan Weltge

From Cardinality-Constrained to Sparse Optimization

Christian Kanzow

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We consider both the cardinality-constrained and the sparse(st) optimization problem. The former seeks for a solution with a pre-determined sparsity, the latter tries to find the sparsest solution. While most authors use the ℓ_1-norm to approximate sparse solutions, we deal with the ℓ_0-quasi-norm. The main idea for both types of problems is to use a smooth reformulation of the corresponding optimization problem in continuous variables. We then discuss the main theoretical properties of this reformulation like the relation between local and global minima, suitable constraint qualifications, and optimality conditions. The presented reformulation is also the basis for appropriate algorithms in order to solve cardinality-constrained and sparse optimization problems, and we present some of the basic ideas together with some numerical results.

Joint work with: Oleg Burdakov, Michal Červinka, and Alexandra Schwartz

A Semidefinite Hierarchy for Multilinear Programming

Kai Kellner

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A disjointly constrained multilinear programming problem is the problem of maximizing a l-linear function on the product of l disjoint polyhedra. If $l = 1$, this reduces to linear programming. While linear programming is known to be solvable in polynomial time, for $l \geq 2$ multilinear programming is NP-hard. Note that bilinear programming (i.e. $l = 2$) lies in-between linear and quadratic optimization.

We consider multilinear programming from an algebraic geometry or polynomial optimization point of view. A particular question is whether the multilinear structure can be used in sum of squares certificates. For generic cases, we answer this question in the affirmative by stating convergence results for the hierarchy of semidefinite programs coming out of the sum of squares approach.

Multilinear programming is motivated by a various of applications, including constrained games, 0/1 integer programming, and geometric containment problems. We have a look at some of them in connection with our results.

Multiple Objective Counterparts: Trading-Off between Optimization Criteria and Constraints

Kathrin Klamroth

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From a practical point of view, multiple objective optimization is a ver- satile tool to model conflicting goals in complex decision making situations, with a multitude of applications in economics and in industry. From a theoretical perspective, multiple objective optimization provides a general modelling framework that gives rise to a different perspective on classical optimization models like constrained programming and optimization under uncertainty.

In this talk, we link different concepts of constraint handling, robust op- timization and stochastic programming through the formulation of multiple objective counterparts. We argue that, by providing trade-off information be- tween alternative efficient solutions, the multiple objective counterpart can facilitate the decision making process when deciding for a most preferred solution.

We discuss scalarization based solution methods for discrete as well as for continuous multiple objective optimization problems that aim at a concise representation of the nondominated set, and that rely on the iterative update of a geometric structure called the search region. Given a finite set of already computed nondominated points, the search region corresponds to that part of the objective space that potentially contains additional nondominated points. While the search region can be easily determined in the bi-objective case, its computation in higher dimensions is considerably more difficult and gives rise to an interesting relation to computational geometry.

Continuous Outer Subdifferentials in Nonsmooth Optimization

Martin Knossalla

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The theory of subdifferentials provides adequate methods and tools to put descent methods for nonsmooth optimization problems into practice. But in application it is often difficult to decide on a suitable subdifferential to construct a descent method. Furthermore there is often no exact information about the whole subdifferential for local Lipschitz continuous functions, e.g. for marginal functions of the type $\varphi(x) := \inf\{\vartheta(x,y) \,|\, y \in \Omega(x)\}$ for real-valued functions ϑ and sets $\Omega(x) \subseteq \mathbb{R}^m$. In this cases the semismoothness of the cost functions cannot be proven or is violated.
Basing on the continuous outer subdifferentials $G^f : \mathbb{R}^n \rightrightarrows \mathbb{R}^n$ we developed, this talk presents a new strategy for optimization problems with local Lipschitz continuous cost functions $f : \mathbb{R}^n \to \mathbb{R}$. Especially the semismoothness of the cost function will not be taken for granted. A descent method based on this continuous subdifferentials will be developed and its global convergence will be proven.

Optimierung und Steuerung von Materialien und Prozessen (Optimization and control of materials and processes)

Günter Leugering

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Note: This **talk will be in German**, since it is part of the official opening of the research training group "Algorithmic Optimization".

Die Konfiguration neuer Materialen und Materialverbünden spielt eine große Rolle in modernen Anwendungen z.B. im Leichtbau, optischen Materialien und Katalysatoren. In der Regel werden Materialien mathematisch durch die Gleichungen der (nichtlinearen) Elastizitätstheorie beschrieben, wobei die Materialcharakteristika durch die Elastizitätstensoren repräsentiert werden, die ihrerseits als Koeffizienten in den höchsten Ableitungen vorkommen. Materialoptimierung lässt sich daher einordnen in das Problem der Optimierung in den Koeffizienten von elliptischen PDGLn. Optimale Materialkonfigurationen können im Zuge der Lösung von Topologie- oder Formoptimierungsproblemen ermittelt werden. Die optimale Beeinflussung von zeitabhängigen Prozessen wird typischerweise durch Parametersteuerung, Feedback-, Rand- oder Volumensteuerung realisiert. Auch hier sind es gerade die nichtlinearen (oft quasilinearen) Prozesse, die von großer technischer Bedeutung sind. In diesem Vortrag sollen einerseits analytische Resultate zur Optimierung und Steuerung von Materialien und Prozessen dargestellt, als auch konkrete Anwendungsszenarien diskutiert werden.

Abstract in English: Material design concerns the optimization of coefficients included in the material tensors which, in turn, appear in the leading terms of the differential operators describing the underlying physics. Optimization of such coefficients can be considered by the values or via the shape of their level sets. Thus, material design can be seen as control-in-the-coefficients or as shape-design of composites. In this sense, we provide examples of quasilinear elliptic problems where the control acts in the coefficients and those where the shape/topology-optimization of inclusions is focused. We then consider boundary control problems for quasilinear hyperbolic problems appearing in mechanics, as well as gas-, water- and blood flow.

A set-valued approach to matrix games with vector payoffs

Andreas Löhne

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Based on set relations, a new solution concept for matrix games with zero sum vector payoffs is introduced. It is compared with notions from the literature such as Pareto optimal security strategies (POSS) as well as with Shapley equilibria. We demonstrate by examples how to choose optimal strategies in practice and we present an algorithm to compute optimal strategies.

Joint work with: Andreas H. Hamel (Free University of Bozen, Italy)

Discrete linear bilevel optimization problems

Floriane Mefo Kue

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This talk is devoted to the study of a particular case of bilevel programming problem with linear discrete lower level and continuous upper level problems. We derive its properties and some conditions of existence of solutions are given. After reducing the problem into a one level programming problem, some optimality conditions are discussed.

Joint work with: Stephan Dempe

An Extended Formulation for Wheel Inequalities in the Stable Set Polytope

Bernd Perscheid

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If it is possible to describe the convex hull of feasible integral points in a polytope by linear constraints, the optimization problem over this set can easily be solved. Since the task of finding a maximum stable set in a graph is NP-hard, it is unlikely that there exists a formulation of polynomial size for the stable set polytope. However, although cycle inequalities are an exponential class of valid stable set inequalities Yannakakis [1] shows how the separation problem for cycles can be solved with an extended formulation. Here, polynomial many additional variables and inequalities are used to solve the problem in a higher dimension. Afterwards the solution that has been found has to be projected onto the original space.

Cheng and Cunningham [2] investigate the wheel inequalities, that are frequently facet inducing and present a polynomial separation algorithm.

In this talk we present an extended formulation that encodes the (potentially exponentially many) wheel inequalities by just adding a polynomial number of variables and inequalities.

Joint work with: Sven de Vries, Ulf Friedrich

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An elastic Active Set approach for large structured QPs

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We consider SQP methods for large structured QPs where a specialized sparse solver is available for the KKT system in an active set QP solver. Our goal is a generic active set algorithm that employs any custom KKT solver in a slack relaxation of the QP to avoid a phase 1. This involves a partial projection that preserves the NLP sparse structure in the KKT system. The talk discusses the structural properties of our approach and of the subproblems on several levels. As a concrete example we consider NLPs on trees arising, e.g., in robust model predictive control. We also discuss relevant aspects of the software design.

Joint work with: Marc C. Steinbach

Multi-objective robust optimization

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Robust (single-objective) optimization has been grown to an important field which is both, practically important and mathematically challenging. In this talk we consider robustness for *multi-objective* optimization problems. We present possible concepts on how robustness for a Pareto solution may be defined. In particular, we will introduce the concepts of flimsily and highly robust efficiency, different variants of set-based minmax efficiency and also present a generalization of the recent concept of light robustness to multi-objective problems. We illustrate and discuss the different concepts and show how they are related.

For the case of polyhedral uncertainty sets, we will show reduction results: Under mild assumptions the infinite uncertainty set can be replaced by its extreme points. Furthermore, solution approaches on how robust efficient solutions can be computed will be shown. These are based on robust scalarizations of the uncertain multi-objective problem. The concepts are illustrated on the example of planning short and secure flight routes.

Joint work with: Jonas Ide, Kenny Kuhn, Marie Schmidt, Andrea Raith

Set–Valued Variational Inequalities in Vector Optimization

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Variational inequalities of directional derivatives are widely used to solve vector optimization problems. Since the ordering in vector spaces generally lacks completeness, the introduced methods typically turn out to be somewhat awkward; Either, the derivatives attain 'infinite values' which are defined in some way or other, or derivatives are defined as set–valued functions, thus the type of function under consideration is changed.

We propose to follow a different approach by introducing the set–valued extension of a vector–valued function. Applying the Complete Lattice Approach to set–valued functions, we develop a coherent system of variational inequalities characterizing solutions to the set optimization problem, containing the vector optimization problem as a special case.

Joint work with: Giovanni P. Crespi

Dual subgradient method with averaging for optimal resource allocation

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A dual subgradient method is proposed for solving convex optimization problems with linear constraints. As novelty, the recovering of primal solutions can be avoided. Instead, the optimal convergence rate for the whole sequence of primal-dual iterates is obtained. This is due to the primal-dual averaging strategies which are incorporated into the iterative scheme. We apply our dual subgradient method with averaging to optimal resource allocation within a multi-agent environment. The proposed dual subgradient method naturally corresponds to a distributed process of production/price adjustments and effectively leads to a market equilibrium.

Joint work with: Yurii Nesterov

High performance optimization algorithms for interface identification problems

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In many applications, which are modeled by partial differential equations, there is a small number of spatially distributed materials or parameters distinguished by interfaces. The problem is then to optimize the shape of these interfaces such that given measurements are reflected by the model. Depending on the application the parameter distribution may form complex contours. Thus, high resolutions are required in the underlying finite element discretizations. The challenge here is to combine methods from PDE constraint shape optimization with HPC techniques and prepare algorithms for supercomputing.

In this talk we present an algorithm that utilizes multigrid strategies and limited memory BFGS updates in order to achieve scalability on very large shape optimization problems. We also show how this can be implemented into an augmented Lagrangian method such that geometric constraints on the shape can be incorporated additionally. In this context optimizing shapes automatically means to deform finite element meshes iteratively. This usually deteriorates the quality of the discretization and thus affects the performance of the solver. We therefore introduce novel shape metrics that show good performance in retaining aspect ratios of discretization elements.

The presented algorithm is shown to perform on two applications. A standard test case is to identify the shape that minimizes energy dissipation in a Stokes flow. Here we demonstrate that the proposed algorithm retains good mesh quality. Furthermore, it is shown how geometric constraints are incorporated. The second application is the identification of the shape of human skin cells. It is demonstrated how the distribution of permeability coefficients in a computational model for the human skin are fitted to measurements.

Joint work with: Arne Nägel, Volker Schulz and Kathrin Welker

Pareto Optimization and Optimal Control in the Ramsey Equilibrium Model

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The Ramsey model is one of the most common growth models in economics, where economic growth refers to the increase of GDP. In this model, the optimal saving rate is determined endogenously via lifetime utility maximization in the consuming sector. A dynamic equilibrium model is formed by combining the intention of maximizing the gain in every point in time of the producing sector and the aim of the consumers [4]. We consider two modifications of the standard Ramsey model. In the first part, we introduce a discrete Ramsey model with a finite time horizon and a set of heterogeneous households that are connected via capital borrowing constraints. We follow the modelling of Becker in [1] and add a new capital borrowing constraint. The resulting multiobjective optimization problem is embedded in the theory of vector optimization. In the second part, we consider a continuous time model where standardly capital accumulation is a process in time only. In the last few years, the Ramsey model has been expanded by a spatial dimension. Like [2, 3], we assume that capital accumulation via space is a distributional process but we expand it by a nonlocal effect of surrounding areas on every consumer's capital stock development. This yields an optimal control problem with a partial integro-differential equation and volume constraints.

Joint work with: Leonhard Frerick, Georg Müller-Fürstenberger and Ekkehard Sachs

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Coercive polynomials and their Newton polytopes

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Many interesting properties of polynomials are closely related to the geometry of their Newton polytopes. In this talk we analyze the coercivity on $\mathbb{R}^n$ of multivariate polynomials $f \in \mathbb{R}[x]$ in terms of their so-called Newton polytopes at infinity. In fact, we introduce the broad class of so-called gem regular polynomials and characterize their coercivity via conditions solely containing information about the geometry of the vertex set of the Newton polytope at infinity, as well as sign conditions on the corresponding polynomial coefficients.

For gem irregular polynomials, we introduce sufficient and, in some cases, also necessary conditions for coercivity based on so-called circuit numbers. Using these techniques, the problem of deciding the coercivity of a polynomial may often be reduced to the analysis of its Newton polytope at infinity.

The above approach also allows us to introduce and analyze a stability concept for the coercivity of multivariate polynomials. In particular, in terms of the corresponding Newton polytopes at infinity we study perturbations of f by polynomials up to the so-called degree of stable coercivity. Finally, we measure the growth behavior of coercive polynomials by the so-called order of coercivity, and we identify a broad class of polynomials for which the order of coercivity coincides with the degree of stable coercivity.

Joint work with: Tomáš Bajbar

A distributed interior point method for multistage stochastic NLPs

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Interior point methods are well-suited for solving multistage stochastic NLPs when an efficient algorithm for the huge structured KKT systems is available. This is the case for large scenario trees with a moderate number of variables per node: we present a distributed "tree-sparse" solution algorithm based on a static partitioning of the tree and featuring low memory and communication overheads. We also address structured quasi-Newton updates for the sparse Hessian as well as structured inertia corrections to address non-convexity or rank-deficiency of the KKT system. Computational results for benchmark problems from portfolio optimization and robust model predictive control demonstrate the performance of our approach.

Joint work with: Jens Hübner

The Optimization of Power Networks via Space Mapping

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In this talk we aim to derive an efficient approach for the optimization of power networks. For the description of electric transmission lines several mathematical models are available. Here, we will focus on the telegraph equations that are based on hyperbolic conservation laws. Applying numerical discretization techniques to the partial differential equations results in a large scale problem. For the nonlinear discretized problem a special optimization method based on space mapping will be developed to compute reliable solutions and to reduce computational costs. Space mapping combines the accuracy of a fine model and the low computing time of a coarser less-accurate model. Furthermore we will conclude the talk with several numerical results.

Joint work with: Simone Göttlich

Optimality Conditions for Nonsmooth Optimization Problems

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For nonsmooth target functions there is so far only a very limited number of results on optimality conditions. Here, we consider nonsmooth optimization problems where the nonsmoothness is caused by univariate piecewise linear elemens like min, max or abs. Then the optimisation problem can be stated in the so-called abs-normal form yielding a piecewise linear model that is of second order. We will exploit this representation to derive constructive necessary and sufficient conditions of first and second order for local optimality.

Joint work with: Andreas Griewank

Consistent uncertainty sets and consistent robust estimators

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In statistics one is interested in the asymptotical properties of point estimators. From this perspective we provide a fresh look at robust estimators obtained as solutions to robust optimization problems. For this purpose we introduce the notion of a consistent uncertainty set. We illustrate that - together with continuity of the solution in the problem parameters - this is the right notion to obtain strong consistency of the robust estimator.

We gratefully acknowledge support by:

DFG Deutsche Forschungsgemeinschaft

through RTG (Graduiertenkolleg)

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