WIAS–PGMO Workshop
Nonsmooth and Stochastic Optimization with Applications to Energy Management

Weierstrass Institute for Applied Analysis and Stochastics
May 10 – 12, 2016

www.wias-berlin.de/workshops/nostop16/

Weierstraß-Institut für
Angewandte Analysis und Stochastik

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Contents

Welcome

Dear Workshop Participant,

It is our pleasure to host the joint WIAS-PGMO Workshop on Nonsmooth and Stochastic Optimization with Applications to Energy Management (NOSTOP 2016). The intention of this workshop is to bring together ideas from nonsmooth optimization/variational analysis and stochastic optimization motivated by applications to energy management. The workshop – organized and co-sponsored by the Weierstrass Institute Berlin (WIAS) – benefited from the support of the FMJH Program Gaspard Monge in optimization and operation research (PGMO) and from the support to this program from Electricité de France (EDF). Further support by the DFG Sonderforschungsbereich Transregio 154 and by the Einstein Center for Mathematics Berlin is gratefully acknowledged. We wish you an interesting workshop with fruitful scientific discussion and a pleasant stay in Berlin.

Given below is some general information regarding logistics and other arrangements for our workshop.

Entrance to the building will be provided showing your participant's badge. Please wear it. Sorry, but the receptionist is supposed not to let you in without it.

Lunch can be taken in a number of restaurants and snack bars in the neighbourhood of the institute, see an extra sheet for more details.

The Conference Dinner will be held in the restaurant *Amici am Gendarmenmarkt*, Jägerstr. 55, 10117 Berlin, on May 11, 2016, 7.30 p.m.

Smoking in the building is not allowed.

Kind regards,

René Henrion
(Organizer)

Tuesday, 10.05.2016

08:15 – 08:45	Registration
08:45 – 09:00	Opening
Chairman: *R. Henrion*	
09:00	**Werner Römisch (Berlin)**
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09:30	**Boris Mordukhovich (Detroit)**
	Subdifferentiation of integral functionals with applications to stochastic dynamic programming
10:00	**Alejandro Jofre (Santiago)**
	Mechanism design and allocation algorithms for energy markets with externalities
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11:00	**Christian Clason (Essen)**
	Second-order analysis of pointwise subdifferentials and applications to nonsmooth optimization
11:30	**Stephan Dempe (Freiberg)**
	Pessimistic linear bilevel optimization
12:00	**Jiri Outrata (Prague)**
	On the Aubin property of implicit multifunctions
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Chairman: *A. Jofre*	
14:00	**Didier Aussel (Perpignan)**
	On Nash games and quasivariational inequalities defined by nonself constraint maps
14:30	**Miroslav Pištěk (Prague)**
	Nash equilibrium in pay-as-bid electricity market
15:00	**Hernan Leövey (Berlin)**
	Best-CBC lattice rules for simulation in stochastic optimization problems in energy industry
15:30 – 16:00	Coffee Break
Chairman: Chairman: *W. Römisch*	
16:00	**Thomas Surowiec (Berlin)**
	Handling non-smooth risk measures in risk-averse PDE-constrained optimization
16:30	**Matthias Claus (Essen)**
	Stability in mean-risk stochastic bilevel programming

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09:30	**Mohammad Hassan Farshbaf Shaker (Berlin)** Allen–Cahn MPECs
10:00	**Kevin Sturm (Essen)** Shape optimisation with nonsmooth cost functions: From theory to numerics
10:30 – 11:00	Coffee Break
Chairman: *T. Surowiec*	
11:00	**Wim van Ackooij (Clamart)** (Sub-) Gradient formulae for probability functions of random inequality systems under Gaussian and Gaussian-like distribution
11:30	**Lukas Adam (Berlin)** Nonlinear chance constrained problems: Optimality conditions, regularization and solvers
12:00	**Pedro Perez-Aros (Santiago)** On the subdifferential of possibly non-Lipschitzian Gaussian probability functions
12:30 – 14:00	Lunch Break
Chairman: *C. Clason*	
14:00	**Rüdiger Schultz (Essen)** Nomination validation in gas networks using symbolic computation
14:30	**Holger Heitsch (Berlin)** Nonlinear probabilistic constraints in gas transportation problems
15:00	**Tatiana González Grandón (Berlin)** A joint model of robust optimization and probabilistic constraints for stationary gas networks
15:30 – 16:00	Coffee Break
Chairman: *W. van Ackooij*	
16:00	**Seyedehsomayeh Hosseini (Bonn)** Nonsmooth descent methods on Riemannian manifolds
16:30	**Ingo Bremer (Berlin)** Dealing with probabilistic constraints under multivariate normal distribution in a standard SQP solver by using Genz' method
19:30 – 22:30	Dinner

Thursday, 12.05.2016

Chairman: *S. Dempe*	
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	Perturbation of error bounds
09:30	**Marian Fabian (Prague)**
	Fréchet subdifferentiability calculus in Asplund spaces
10:00	**Russell Luke (Göttingen)**
	Lagrange multipliers, (exact) regularization and error bounds for monotone variational inequalities
10:30 – 11:00	Coffee Break
Chairman: *R. Schultz*	
11:00	**Fabio D'Andreagiovanni (Berlin)**
	Multiband robust optimization for optimal energy offering under price uncertainty
11:30	**Axel Bredenstein (Hamburg)**
	A Lagrange relaxation implementation in GAMS for stochastic optimization based bidding in day-ahead electricity auction markets
12:00	**Ron Shefi (Göttingen)**
	A dual method for minimizing a nonsmooth objective over one smooth inequality constraint
12:30 – 12:45	Closing

Lukas Adam (Humboldt University Berlin)

Nonlinear chance constrained problems: Optimality conditions, regularization and solvers

We deal with chance constrained problems (CCP) with differentiable nonlinear random functions and discrete distribution. We allow nonconvex functions both in the constraints and in the objective. We reformulate the problem as a mixed-integer nonlinear program, and relax the integer variables into continuous ones. We approach the relaxed problem as a mathematical problem with complementarity constraints (MPCC) and regularize it by enlarging the set of feasible solutions. For all considered problems, we derive necessary optimality conditions based on Fréchet objects corresponding to strong stationarity. We discuss relations between stationary points and minima. We propose two iterative algorithms for finding a stationary point of the original problem. The first is based on the relaxed reformulation, whilst the second one employs its regularized version. Under validity of a constraint qualification, we show that the stationary points of the regularized problem converge to a stationary point of the relaxed reformulation and under additional condition it is even a stationary point of the original problem. We mention a possible application to gas networks with random demand.

Didier Aussel (University of Perpignan)

On Nash games and quasivariational inequalities defined by nonself constraint maps

A generalized Nash problem is a non-cooperative game in which the constraint set is depending on the variable. But the constraint map may not be a self map and then there is usually no solution. Thus we define the concept of projected solution and, based on a fixed point theorem, we establish some results on existence of projected solution for generalized Nash games in a finite dimensional space where the constraint map is not necessarily self-map. Projected solution of quasi-variational inequalities and quasi-optimization problems will be also considered.

All these developments will be motivated by the bid process in electricity markets.

The talk is based on reference [1].

(joint work with Asrifa Sultana and V. Vetrivel)

References

[1] D. Aussel, A. Sultana, V. Vetrivel, On the Existence of Projected Solutions of Quasi-Variational Inequalities and Generalized Nash Equilibrium Problems, submitted (2015), 14 pp.

Axel Bredenstein (Vattenfall Energy Trading, Hamburg)

A Lagrange relaxation implementation in GAMS for stochastic optimization based bidding in day-ahead electricity auction markets

We consider the problem of building optimal bidding curves in a day-ahead energy market. A producer taking part in a day-ahead auction is offering power of his generation units. He has to take into account constraints of the generation units and faces uncertainty in the price outcome. While bid curves are typically independent for each hour, costs and constraints for power production are not. Scenario-based two-stage stochastic optimization is a powerful framework to address uncertainty in mathematical programming models such as this unit commitment problem.

In this presentation we describe the path from an (unsolvable) closed form deterministic equivalent of the model to a practical implementation of a Lagrangian Relaxation method with primal heuristics. We have implemented the model in the algebraic modelling language GAMS utilizing commercial MIP solvers and taking advantage of the parallel hardware architecture (multi-core).

(joint work with Eckart Boege, Jonathan Griffiths, Sjoerd Verhagen (Vattenfall), Michael Bussieck & Stefan Vigerske (GAMS))

Ingo Bremer (WIAS Berlin)

Dealing with probabilistic constraints under multivariate normal distribution in a standard SQP solver by using Genz' method

From practical applications in the area of wind and water power management we have prediction models with uncertain data which result in optimization problems with probabilistic constraints, so called chance constraints. In case of multivariate normal-distributed values the distribution function has a reasonable numeric approximation by Genz' method which makes it possible to use some standard SQP solvers like SNOPT. The talk shows which problems arise and how to deal with them, especially with the non-smoothness in A. Genz' original code. Numeric results also show the effect of parallelization and automatic differentiation.

Christian Clason (University of Duisburg-Essen)

Second-order analysis of pointwise subdifferentials and applications to nonsmooth optimization

For nonsmooth optimization problems, the first-order conditions involve proper subdifferential inclusions and hence the second-order analysis required for showing metric regularity (which is needed for proving stability of the solution or convergence of algorithms) involves set-valued derivatives, which are difficult to characterize explicitly in the infinite-dimensional setting. However, for nonsmooth functionals are defined pointwise via convex integrands, it is possible to give a pointwise characterization of regular (co)derivatives, which allows verification of metric regularity via the Mordukhovich criterion. This is illustrated with several examples arising in inverse problems for and optimal control of partial differential equations.

Matthias Claus (University of Duisburg-Essen)

Stability in mean-risk stochastic bilevel programming

From a conceptual point of view, two-stage stochastic programs and bilevel problems under stochastic uncertainty are closely related. Assuming that only the follower can observe the realization of the randomness, the optimistic and pessimistic setting give rise to two-stage problems where only optimal solutions of the lower level are feasible for the recourse problem. The talk focuses on mean risk formulations of stochastic bilevel programs where the lower level problem is quadratic. 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.

Fabio D'Andreagiovanni (Zuse Institute Berlin (ZIB))

Multiband robust optimization for optimal energy offering under price uncertainty

We consider the optimization problem of a generating company that operates in a competitive electricity market and wants to select energy offering strategies for its generation units, with the aim of maximizing the profit while considering the uncertainty of market price. We focus on the case of a price-taker company, i.e. the company cannot influence the market price through its generation decisions. Such optimization problem can be modeled as a quadratic mixed integer program. Price uncertainty represents a major issue for price-taker companies: the hourly prices of the market are not known in advance and companies must thus take their offering decisions by making some kind of assumptions about the future unknown prices. Over the years, many methods have been proposed to tackle price-uncertain energy offering problems. Among these methods, Robust Optimization (RO) has recently known a big success and has been widely applied in power system optimization also in the context of energy offering. In this work, we review central references available in literature about the use of RO in energy offering, pointing out their limits, which severely reduce their applicability in practice, exposing to the risk of suboptimal and even infeasible offering. We then propose a new RO method for energy offering that overcomes all the limits of other RO models. We show the effectiveness of our new method on instances provided by our industrial partners and considering real prices from the Italian energy market, getting very high increases in profit. Our method is based on Multiband Robustness, an RO model that has been proposed by Büsing and D'Andreagiovanni in 2012 (e.g., [3, 4]) to generalize and refine the representation of the uncertainty of the classical Gamma-Robustness model by Bertsimas and Sim [2], while maintaining its computational tractability and accessibility. Multiband Robustness is essentially based on adopting a histogram-like cardinality-constrained uncertainty set that results particularly suitable to represent asymmetric empirical distributions that are commonly available in real-world optimization problems subject to data uncertainty [1].

Part of the results of this talk are presented in [5].

Essential references

[1] T. Bauschert, C. Büsing, F. D'Andreagiovanni, A. M. C. A. Koster, M. Kutschka, U. Steglich, Network Planning under Demand Uncertainty with Robust Optimization, IEEE Communications Magazine, 52(2), 178–185, 2014.

[2] D. Bertsimas, M. Sim, The Price of Robustness. Operations Research, 52 (1), 35–53, 2004.

[3] C. Büsing, F. D'Andreagiovanni, New Results about Multi-band Uncertainty in Robust Optimization, Experimental Algorithms – SEA 2012, LNCS 7276, 63-74, Springer, 2012.

[4] C. Büsing, F. D'Andreagiovanni, Robust Optimization under Multiband Uncertainty – Part I : Theory, Preprint available at: http://arxiv.org/abs/1301.2734, 2013.

[5] F. D'Andreagiovanni, G. Felici, F. Lacalandra, Revisiting the use of Robust Optimization for energy offering, Preprint available at: http://arxiv.org/abs/1601.01728, 2016.

Stephan Dempe (TU Bergakademie Freiberg)

Pessimistic linear bilevel optimization

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 (Guangdong University of Finance, Guangzhou, PR China) and S. Franke (TU Bergakademie Freiberg))

Marian Fabian (Mathematical Institute, Prague)

Fréchet subdifferentiability calculus in Asplund spaces

We present a structural statement characterizing Asplund space X via a certain "rich" family $\mathcal{A}$ of carefully chosen separable "rectangles" $V \times Y \subset X \times X^*$. Given any function f on X, we construct a smaller, still rich, family $\mathcal{S} \subset \mathcal{A}$ which serves for separable reduction of the Fréchet subdifferential of f in a very precise way. Thus we immediately get separable reductions for non-emptiness of subdifferential, fuzzy calculus, non-zeroness of cone, and extremal principle — all considered in sense of Fréchet. In the construction of $\mathcal{S}$, no translation of Fréchet subdifferential into the primal space is needed! The lecture is based on a joint paper with Marek Cúth published in Journal of Functional Analysis 270, Issue 4, (2016), 1361–1378.

Mohammad Hassan Farshbaf Shaker (WIAS Berlin)

Allen–Cahn MPECs

In this talk, we discuss the mathematical investigation of the first-order optimality conditions to some Allen-Cahn MPECs.

Tatiana González Grandón (Humboldt University Berlin)

A joint model of robust optimization and probabilistic constraints for stationary gas networks

In this talk, we present an optimization problem for gas transportation in a stationary tree structured network, where we encounter two different characters of uncertainty: first, the amount of gas withdrawn at exit points (load) for which a multivariate statistical distribution can be estimated from historical data; second, the friction coefficients from the pipelines for which no statistical information is available by a lack of measurement. Both variables enter a system of inequalities describing the technical feasibility of demand satisfaction in gas networks. Usually the first type of uncertainty is dealt with by means of so-called probabilistic constraints whereas the second one is considered in the sense of robust optimization (worst case within a given uncertainty set). Our aim is to establish and algorithmically deal with a joint model of probabilistic and robust constraints in some optimization problem where we maximize uncertainty around a nominal friction coefficient, while keeping a high probability for the load to meet the nominated demands.

Holger Heitsch (WIAS Berlin)

Nonlinear probabilistic constraints in gas transportation problems

We deal with optimization problems in gas transport networks under uncertainty. The problems are formulated in terms of stochastic programming models with probabilistic constraints, a major class in stochastic programming. Our approach for solving such models consists in applying nonlinear programming methods. Therefore, approximations for both values and gradients of the underlying probability functions must be provided. We introduce a sampling scheme based on the spheric-radial decomposition of Gaussian random vectors, which allows to compute values and gradients of such functions simultaneously. Theoretical and numerical studies for simple gas networks are provided, which are based on the characterization of feasible nominations in stationary gas networks with random load [1]. We consider relevant example problems like the validation of booked capacity and the optimization of certain network parameters as, for example, the minimal installation costs of upper pressure bounds within the network.

References

[1] C. Gotzes, H. Heitsch, R. Henrion, R. Schultz, Feasibility of nominations in stationary gas networks with random load, WIAS Preprint no. 2158, 2015.

Michael Hintermüller (WIAS Berlin)

Optimal control of variational inequalities of the second kind

The directional dierentiability of the solution mapping for a class of variational inequalities of the second kind inspired by applications in fluid mechanics and moving free boundary problems is investigated. The result is particularly relevant for the model predictive control or optimal control of such variational inequalities in that it can be used to derive stationarity conditions and efficient numerical methods.

Seyedehsomayeh Hosseini (University of Bonn)

Nonsmooth descent methods on Riemannian manifolds

This talk is concerned with subgradient-oriented descent methods in nonsmooth nonconvex optimization problems on Riemannian manifolds. Much attention has been paid over centuries to understanding and solving the problem of minimization of functions. Compared to linear programming and nonlinear unconstrained optimization problems, nonlinear constrained optimization problems are much more difficult. Since the procedure of finding an optimizer is a search based on the local information of the constraints and the objective function, it is very important to develop techniques using geometric properties of the constraints and the objective function. In fact, differential geometry provides a powerful tool to characterize and analyze these geometric properties. Thus, there is clearly a link between the techniques of optimization on manifolds and standard constrained optimization approaches. Furthermore, there are manifolds that are not defined as constrained sets in $\mathbb{R}^n$; an important example is a Grassmann manifold. Hence, to solve optimization problems on these spaces, intrinsic methods are used.

In this talk we will explain subgradient-oriented descent methods in nonsmooth optimization on Riemannian manifolds. We prove convergence in the sense of subsequences for nonsmooth functions whose standard model is strict. Adding the Kurdyka-Lojasiewicz condition, we demonstrate convergence to a singular critical point.

keywords: Riemannian manifolds, Descent directions, Locally Lipschitz functions

Alejandro Jofre (Center for Mathematical Modeling, Santiago)

Mechanism design and allocation algorithms for energy markets with externalities

Motivated by electricity markets we introduce in this paper a general network market model, in which agents are located on the nodes of a graph, a traded good can travel from one place to another through edges considering quadratic losses. An independent operator has to match locally production and demand at the lowest expense. As argued in our previous paper “Cost-minimizing regulations for a wholesale electricity market” this setting is relevant to describe some real electricity markets, pricing behavior and market power coming from the fact that generators can bid above their true value. In a general setting of many distributed generator agents connected by a transmission network, bidding piece-wise linear cost functions, we propose a pricing optimal mechanism model to reduce market power. Our main results are the expression of the optimal mechanism design, two algorithms for the allocation problem and market power estimations. To deduce these nice properties, we intensively use convex analysis and some monotone behaviors of the set-valued maps involved. Furthermore, these algorithms make it possible to numerically compute a Nash equilibrium for the procurement auction, which is important to compare the optimal mechanism and the standard auction setting. Finally, we also show some interesting examples.

(joint work with Benjamin Heymann, Ecole Polytechnique, France)

Hernan Leövey (Humboldt University Berlin)

Best-CBC lattice rules for simulation in stochastic optimization problems in energy industry

Simulation and integration problems in energy industry are often very high dimensional, and Monte Carlo and quasi-Monte Carlo (QMC) techniques are usually employed for sampling over uncertainty parameters. A particular QMC technique that seems very attractive to apply are the so called randomly-shifted lattice rules. The latter have the advantage that they may help to overcome the curse of dimensionality if an embedding of the underlying integrands into conveniently weighted reproducing kernel Hilbert spaces (WRKHS) is feasible. The (fast) component-by-component (CBC) algorithm is an efficient tool for the construction of generating-vectors for QMC lattice rules over WRKHS. Nevertheless, the results of the CBC method may not be unique, and several outputs/generating-vectors can arise as the result of a natural branching process in each optimization stage of the algorithm. Moreover, the different outputs may differ significantly in their objective values, which are given in terms of the corresponding worst-case errors. We investigate a generalization of the CBC method that allows for general successive coordinate search and optimal branching selection. The proposed method delivers the true optimal branching if a decay condition on the weights is satisfied. The method also admits the same type of worst-case error upper bounds as the CBC method and a fast version is available too. A practical combination with classical CBC can be performed so that the final results are never worse that CBC outputs and sometimes significantly better, depending on the weights, with a minor overhead in the runtime.

(joint work with Adrian Ebert, from KU Leuven)

Russell Luke (University of Göttingen)

Lagrange multipliers, (exact) regularization and error bounds for monotone variational inequalities

We examine two central regularization strategies for monotone variational inequalities, the first a direct regularization of the operative monotone mapping, and the second via regularization of the associated dual gap function. A key link in the relationship between the solution sets to these various regularized problems is the idea of exact regularization, which, in turn, is fundamentally associated with the existence of Lagrange multipliers for the regularized variational inequality. A regularization is said to be exact if a solution to the regularized problem is a solution to the unregularized problem for all parameters beyond a certain value. The Lagrange multipliers corresponding to a particular regularization of a variational inequality, on the other hand, are defined via the dual gap function. Our analysis suggests various conceptual, iteratively regularized numerical schemes, for which we provide error bounds, and hence stopping criteria, under the additional assumption that the solution set to the unregularized problem is what we call *weakly sharp* of order greater than one.

(joint work with C. Charitha and Joydeep Dutta)

Boris Mordukhovich (Wayne State University, Detroit)

Subdifferentiation of integral functionals with applications to stochastic dynamic programming

This talk concerns the investigation of nonconvex and nondifferentiable integral functionals on general Banach spaces, which may not be reflexive and/or separable. Considering two major subdifferentials of variational analysis, we derive nonsmooth versions of the Leibniz rule on subdifferentiation under the integral sign, where the integral of the subdifferential set-valued mappings generated by Lipschitzian integrands is understood in the Gelfand sense. Besides examining integration over complete measure spaces and also over those with nonatomic measures, our special attention is drawn to a stronger version of measure nonatomicity, known as saturation, to invoke the recent results of the Lyapunov convexity theorem type for the Gelfand integral of the subdifferential mappings. The main results are applied to the subdifferential study of the optimal value functions and deriving the corresponding necessary optimality conditions in nonconvex problems of stochastic dynamic programming with discrete time on the infinite horizon.

(joint work with Nobusumi Sagara (Japan))

Jiri Outrata (Institute of Information Theory and Automation, Prague)

On the Aubin property of implicit multifunctions

The talk is devoted to new sufficient conditions for the Aubin property of implicit multifunctions. As the basic tool one employs the directional limiting coderivative which, together with the graphical derivative, enables us a fine analysis of the local behavior of the investigated multifunction along relevant directions. The obtained new conditions are applied to a class of parameter dependent variational systems. As an auxiliary tool, a handy formula for the computation of the directional limiting coderivative of the normal-cone map with a polyhedral set is provided. Important statements are illustrated by examples.

(joint work with H. Gfrerer)

Pedro Perez-Aros (University of Chile, Santiago)

On the subdifferential of possibly non-Lipschitzian Gaussian probability functions

We are interested in the study of the (Frechet-, Mordukhovich-, Clarke–Rockafellar-) subdifferential of the probabilistic function

$$\varphi(x) := \mathbb{P}(g(x,\xi) \leq 0),$$

where $(\Omega, \Sigma, \mathbb{P})$ is a probability space, ξ is an m-dimensional gaussian random vector, $g : X \times \mathbb{R}^m \to \mathbb{R}$ is a locally Lipschitz function and convex in the second variable and X is a separable Banach space. Applications for this class of functions can be found in water management, telecommunications, electricity network expansion, mineral blending, chemical engineering, etc, where the constraint $\mathbb{P}(g(x,\xi) \leq 0) \leq p$ expresses that a desicion vector x is feasible if and only if the random inequality $g(x,\xi) \leq 0$ is satisfied with probability at least p. In [1, 2] the authors have provided criteria for the differentiability and Clarke continuity of the probabilistic function φ together with formulas for the gradient and subgradient of φ at a point $\bar{x}$ under the hypothesis that X is finite dimensional, g is the maximum of a finite number of continuously differentiable functions g_j and using some growth condition for the gradient $\nabla_x g(x,z)$ in a neighborhood of $\bar{x}$ or assuming that the set $\{z \in \mathbb{R}^m : g(\bar{x},z) \leq 0\}$ is bounded. The aim of this work is to extend the previous result to infinite dimensional spaces X, using a weaker growth condition and assuming local Lipschitz continuity of g only, even when the probabilistic function φ could be non-Lipschitz. We also provide conditions for local Lipschitz continuity and differentiability of the probabilistic function.

(joint work with Abderrahim Hantoute, René Henrion)

References

[1] Wim van Ackooij, René Henrion, Gradient formulae for nonlinear probabilistic constraints with Gaussian and Gaussian-like distributions, SIAM J. Optim., 24(4):1864–1889 (2014).

[2] Wim van Ackooij, René Henrion, (Sub-)Gradient formulae for probability functions of random inequality systems under Gaussian distribution, WIAS Preprint no. 2230, 2016, submitted.

Miroslav Pištěk (Institute of Information Theory and Automation, Prague)

Nash equilibrium in pay-as-bid electricity market

We model the competition of electricity producers in deregulated pay-as-bid market as equilibrium problem with equilibrium constraints [2, 3, 4]. By $D > 0$ we denote the overall energy demand, $\mathcal{N} = 1,..,N$ is finite set of producers, $q_i \geq 0$ represents the production of the i-th producer. For $i \in \mathcal{N}$ and vector $v \in \mathcal{R}_+^N$ we denote by $v_{-i} \in \mathcal{R}_+^{N-1}$ the vector $v_{-i} = (v_1,..,v_{i-1},v_{i+1},..,v_N)$, and by $a_i, b_i \geq 0$ the coefficients of the (approximation of) i-th producer's bid function $a_i q_i + b_i q_i^2$. The real cost function is given by $A_i q_i + B_i q_i^2$ with $A_i \geq 0$ and $B_i > 0$ capturing the increasing marginal price of electricity production.

Knowing the bid vectors $a, b \in \mathcal{R}_+^N$ provided by producers, the ISO computes the electricity dispatch $q = (q_1, \ldots, q_N) \in \mathcal{R}_+^N$ to minimize the total generation cost for overall demand $D > 0$. This leads to the following optimization problem

$$\text{ISO(a,b,D)} \qquad \min_q \sum_{i\in\mathcal{N}} (a_i q_i + b_i q_i^2)$$
$$\text{s.t.} \begin{cases} q_i \geq 0, \ \forall i \in \mathcal{N} \\ ((a_i, b_i) = (a_j, b_j) \Rightarrow q_i = q_j), \forall i, j \in \mathcal{N} \\ \sum_{i\in\mathcal{N}} q_i = D. \end{cases}$$

We provide an analytic formula for the optimal electricity dispatch $q(a, b, D)$ solving the ISO(a,b,D) problem. Then, each producer $i \in \mathcal{N}$ maximizes his profit $\pi_i(a, b, D) = (a_i - A_i)\, q_i(a, b, D) + (b_i - B_i)\, q_i(a, b, D)^2$ manipulating his own strategic variables $a_i, b_i \geq 0$ with the rest of variables $(a_{-i}, b_{-i}) \in \mathcal{R}_+^{2N-2}$ kept fixed. Thus the i-th producer's problem $P_i(a_{-i}, b_{-i}, D)$ reads

$$P_i(a_{-i}, b_{-i}, D) \qquad \sup_{a_i, b_i \geq 0} \pi_i(a, b, D).$$

For such a market setting we derive a full characterization of Nash equilibria

$$\mathcal{E}(A, B, D) = \left\{ (\tilde{a}, \tilde{b}) \in \mathcal{R}_+^{2N} : \pi_i(\tilde{a}, \tilde{b}, D) = \sup_{a_i, b_i \geq 0} \pi_i(a_i, \tilde{a}_{-i}, b_i, \tilde{b}_{-i}, D), \forall i \in \mathcal{N} \right\}$$

for any (A, B, D), and provide an illustrative example, for more details see [1].

References

[1] D. Aussel, P. Bendotti, M. Pištěk, Nash equilibrium in a pay-as-bid electricity market: Part 1 – existence and characterisation; Part 2 – best response of a producer, *Optimization* (submitted 2015, minor revision).

[2] J.F. Escobar, A. Jofré, Monopolistic competition in electricity networks with resistance losses, *Econom. Theory,* 44(1):101–121, 2010.

[3] R. Henrion, J.V. Outrata, T. Surowiec, Analysis of M-stationary points to an EPEC modeling oligopolistic competition in an electricity spot market, *ESAIM: Control, Optim. and Calculus of Variations,* 18:296–317, 2012.

[4] X. Hu, D. Ralph, Using EPECs to model bilevel games in restructured electricity markets with locational prices, *Oper. Res.,* 55(5):809–827, 2007.

Werner Römisch (Humboldt University Berlin)

Quasi-Monte Carlo methods for mixed-integer two-stage stochastic programs

An explanation of the good performance of randomized Quasi-Monte Carlo methods for mixed-integer two-stage stochastic programs is presented. Starting from the structure of integrands of such stochastic optimization models we explain why low order terms of the ANOVA decomposition of the discontinuous integrands are much smoother if certain conditions are satisfied. We also explain why the conditions hold almost surely in case of normal distributions and why a low effective dimension of the integrand becomes important. The latter is achieved by applying principal component factorization to the covariance matrix and discussed for a mixed $0-1$ electricity portfolio model with uncertain prices and demand.

(joint work with H. Leövey)

Rüdiger Schultz (University of Duisburg-Essen)

Nomination validation in gas networks using symbolic computation

Nomination validation, i.e., the decision of technical feasibility (validity) of a transportation order (nomination) in a gas network is becoming more and more a, nontrivial though, routine task for gas companies. Being, probably, the most basic problem it offers challenging modeling perspectives in this class. The stationary passive gas transportation considered in the talk has potential of becoming a submodel to be iterated with different parameter settings in a variety of more complex decision problems and methods for their solution.

Nomination validation not only offers models of different provenience but also amazes with its spectrum of solution approaches. The talk, partly based on joint work with Matthias Claus, Ralf Gollmer, Claudia Gotzes, Holger Heitsch, and Reneé Henrion, will illuminate the role of symbolic computation in this respect.

Ron Shefi (University of Göttingen)

A dual method for minimizing a nonsmooth objective over one smooth inequality constraint

We consider the class of nondifferentiable convex problems which minimizes a nonsmooth convex objective over a smooth inequality constraint. Exploiting the smoothness of the feasible set and using duality, we introduce a simple first order algorithm proven to globally convergence to an optimal solution with a sublinear rate. The performance of the algorithm is demonstrated by solving large instances of the convex sparse recovery problem.

Kevin Sturm (University of Duisburg-Essen)

Shape optimisation with nonsmooth cost functions: From theory to numerics

In this talk we consider a non-smooth shape optimization problem. The cost function is essentially a maximum functions acting on continuous functions and it is constrained by a quasi-linear partial differential equation. We prove the Eulerian semi-differentiability and give a complete characterization of the derivative. We characterize stationary points and show how to compute steepest descent directions using kernel reproducing Hilbert spaces. Finally some numerical results are presented.

Thomas Surowiec (Humboldt University Berlin)

Handling non-smooth risk measures in risk-averse PDE-constrained optimization

We consider the problem of optimizing over the solution set of a partial differential equation with uncertain parameters (PDEU). In order to obtain a “robust”, i.e. risk-averse, optimal solution/control, we utilize the concept of coherent risk measures as developed in management science. This leads to a risk-averse PDEU-constrained optimization problem. We provide verifiable bounds for the well-definedness of these problems, prove existence of an optimal solution, and derive a general set of optimality conditions by exploiting the properties of coherent risk measures. Finally, we restrict ourselves to the conditional-value-at-risk (CVaR) risk measure. In order to develop efficient numerical methods for this class of problems, we develop two regularization procedures and demonstrate their performance on several examples.

Michel Théra (University of Limoges)

Perturbation of error bounds

In this presentation that summarizes a recent joint work with A. Kruger and M. Lopez, I propose to extend older developments from Kruger, Ngai & Théra, SIAM J. Optim. **20**(6), 3280–3296 (2010) and, more precisely, to characterize, in the Banach space setting, the stability of the local and global error bound property of inequalities determined by proper lower semicontinuous under data perturbations. In order to achieve this goal, we propose new concepts of (arbitrary, convex and linear) perturbations of the given function defining the system under consideration, which turn out to be a useful tool in our analysis. The characterizations of error bounds for families of perturbations can be interpreted as estimates of the ‘radius of error bounds’.

Bibliography

- Kruger, Ngai & Théra, Stability of error bounds for convex constraint systems in Banach spaces, SIAM J. Optim. **20**(6), 3280–3296 (2010).
- Kruger, Lopez & Théra, Perturbation of error bounds, arXiv:1512.04742.

Wim van Ackooij (EDF R&D, Clamart)

(Sub-) Gradient formulae for probability functions of random inequality systems under Gaussian and Gaussian-like distribution

In this talk, we will consider probability functions of parameter- dependent random inequality systems under Gaussian distributions. As a main result, we provide an upper estimate for the Clarke subdifferential of such probability functions without imposing compactness conditions. A constraint qualification ensuring continuous differentiability is formulated. Using these results, several explicit formulae can be derived from the general result in case of linear random inequality systems. In the case of a constant coefficient matrix an upper estimate for even the smaller Mordukhovich subdifferential is proven. Throughout the talk, we will also discuss several concrete examples.

(joint work with R. Henrion)

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