A Fraunhofer Institute for Industrial Mathematics (ITWM) workshop focused on

Outcome Evaluation and Pricing in Superiorization and in Multiobjective Optimization

July 17-19, 2023 Kaiserslautern, Germany

https://www.itwm.fraunhofer.de/outcome-evaluation-pricing2023

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APPROACH

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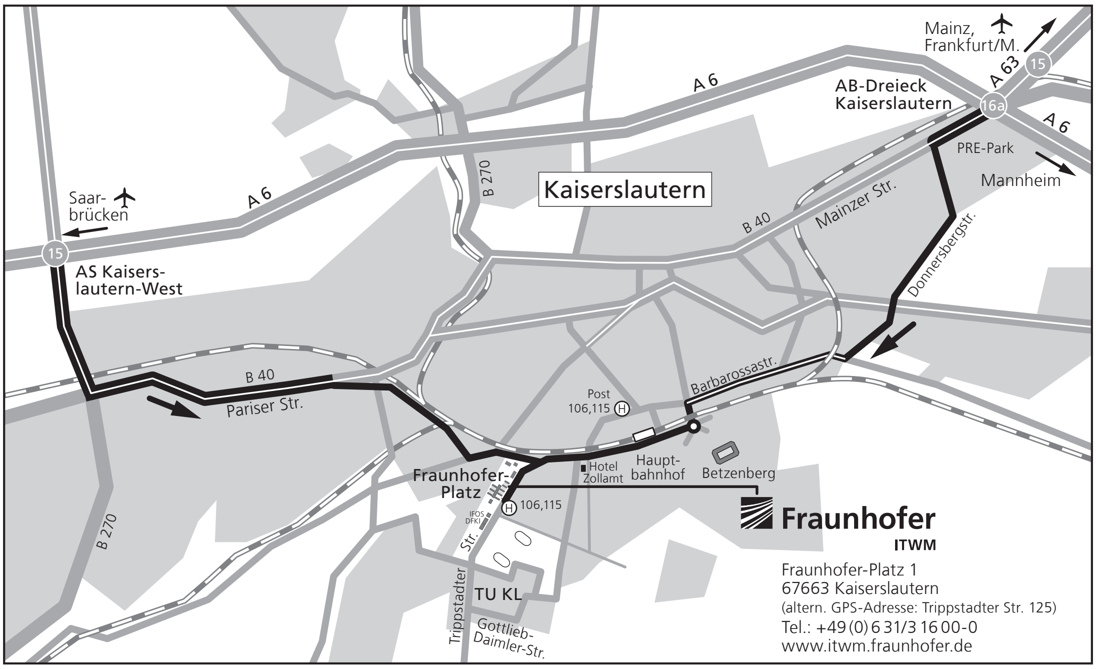
By car: Coming from the West on Autobahn A 6, take the exit Kaiserslautern-West (15), then go towards downtown and follow the signs towards the university. Before you get to the university, you will reach the Fraunhofer-Zentrum a few hundred meters down Trippstadter Straße, on the right side. Coming from the East on Autobahn A 6 or A 63, take the exit "Autobahndreieck Kaiserslautern" (16a or 15) and follow the sign "Stadtmitte", then "Universität". It is best to use the detour behind the train station via Zollamtstraße; at the end of the street, turn onto Trippstadter Straße.

By rail and bus: From Kaiserslautern-Hauptbahnhof (main station), you may take a taxi (approx. 2 km) or the bus from stop "Post" (walking distance from main station: appr. 3 min.) no. 106 to "Mölschbach" resp. no. 115 to "Universität". Get off the bus at "Fraunhofer-Zentrum".

By Intercity bus: Several Intercity buses stop at bus terminal Kaiserslautern in front of the main station.

By air: From Frankfurt Rhein-Main-Airport, either by train (approx. 90 min.) or rental car (approx. 60 min.); from Saarbrücken-Airport by rental car (approx. 60 min.)



Overview

During this workshop high-level internal and external specialists, from various fields, come together to discuss the optimization of the »quality/price« ratio when solving complex real-world problems with feasibility-seeking, constrained optimization and superiorization, which involves many algorithmic decisions on the part of the user. These range from choice of the modeling approach to scaling and tuning permissible parameters.

If complete characterization conditions of the solution that is sought after are available, they can be used to evaluate and price the outcome of any algorithm that is applied. In the more commonly encountered situation when the latter is not applicable, we need tools to evaluate the quality of solutions. At the same time, we would also like to price various possible outcomes so that intelligent decisions can be made about how to run algorithms and optimize quality and price.

Organizers and Scientific Team

- Prof. Dr. Karl-Heinz Küfer, Head of the Division Optimization and Head of Department Optimization in Life Sciences, Fraunhofer ITWM, Kaiserlsautern, Germany
- Dr. Philipp Süss, Deputy Head of Department Optimization – Technical Processes in the division Optimization, Fraunhofer ITWM, Kaiserlsautern, Germany
- Prof. Yair Censor, Department of Mathematics, Faculty of Natural Sciences, University of Haifa, Israel
- Assoc. Prof. Aviv Gibali, Head of Mathematics Department, Braude College of Engineering, Karmiel, Israel

List of speakers

The complete list of participants, in alphabetical order, includes eight speakers invited from outside ITWM and five speakers from ITWM.

- Renato Cavalcante
  https://www.tu.berlin/en/netit/dr-renato-l-g-cavalcante.
- Yair Censor
  https://math.haifa.ac.il/yair/.
- Aviv Gibali
  https://w3.braude.ac.il/lecturer/assoc-prof-aviv-gibali/.
- Elias Helou Neto
  http://www.otm.icmc.usp.br/index.php/pt/pessoas/professores/14-elias.
- Karl-Heinz Küfer
  https://www.itwm.fraunhofer.de/en/departments/optimization/staff/karl-heinz-kuefer.html.
- Ion Necoara
  https://acse.pub.ro/index.php/en/ion-necoara/.
- Juan Peypouquet
  https://www.rug.nl/staff/j.g.peypouquet/.
- Jochen Schmid
  https://www.itwm.fraunhofer.de/de/abteilungen/optimierung/mitarbeiter/jochen-schmid.html.
- Jan Schroeder
  https://www.itwm.fraunhofer.de/en/departments/optimization/staff/jan-schroeder.html.
- Tobias Seidel
  https://www.researchgate.net/profile/Tobias-Seidel-5.
- Mathias Staudigl
  https://sites.google.com/view/mathiasstaudigl.
- Philip Süss
  https://www.itwm.fraunhofer.de/en/departments/optimization/staff/philipp-suess.html.
- Stavros Zenios
  https://www.bruegel.org/people/stavros zenios.

Schedule

Date	Time	Slots	Event
Monday 17.7.2023	9:00-12:00		Arrival, registration and get together
	12:00-13:30		Lunch
	14:00-17:00	14:00-14:15	Karl-Heinz Küfer, *Opening Remarks*
		14:15-15:00	Yair Censor, *Superiorization: The asymmetric roles of feasibility-seeking and objective function reduction*
		15:00-15:45	Elias Helou Neto, *From Superiorization to simple bilevel convex optimization*
		15:45-16:15	Coffee break
		16:15-17:00	Stavros Zenios, *Robust optimization models for explaining some under-diversification puzzles in finance*
	19:00		Dinner
Tuesday 18.7.2023	8:30-9:00		Coffee
	9:00-12:00		All participants, *Round-table discussion on "cost versus outcome"*
	12:15-14:00		Lunch & free discussions
	14:00-17:00	14:00-14:45	Aviv Gibali, *Superiorization as an acceleration technique and beyond*
		15:00-15:45	Jan Schroeder, *Impact of the condition number on the quality and runtime of superiorization methods*
		15:45-16:00	Coffee break
		16:00-16:45	Tobias Seidel, *Challenges of optimization in chemical engineering*

	19:00		Dinner
Wednesday 19.7.2023	8:30-9:00		Coffee
	9:00-12:00	9:00-9:45	Jochen Schmid, *Adaptive discretization algorithms for shape-constrained regression and experimental design*
		10:00-10:45	Renato Cavalcante, *Fixed point algorithms for resource allocation in wireless networks*
		11:00-11:30	Coffee break
		11:30-12:15	Juan Peypouquet, *A speed restart scheme for first order dynamics bearing second order information in time and space*
	12:15-14:00		Lunch & free discussions
	14:00-17:00	14:00-14:45	Ion Necoara, *Efficiency of stochastic coordinate minimization*
		15:00-15:45	Mathias Staudigl, *Distributed random block-coordinate descent methods for ill-posed composite convex optimization problems*
		16:00-16:30	Coffee break
		16:30-17:15	Speaker to be announced, *Topic to be announced*
		17:15-17:30	Karl-Heinz Küfer, *Concluding Comments*
Thursday 20.7.2023	08:00-17:00		Excursion to Laufertsweiler with lunch on site

Abstracts

Renato Luís Garrido Cavalcante

Fraunhofer Heinrich Hertz Institute, Berlin, Germany

Fixed point algorithms for resource allocation in wireless networks

In wireless networks, spectrum is a scarce resource shared by multiple users in the system, so network engineers have to balance the utility function of each user (e.g., achievable rates) and fairness. In this talk, by using an axiomatic framework to define utilities and constraints, we show a simple parametrization of the weak Pareto boundary of the utility region, and we review a fixed point algorithm that solves a (weighted) max-min utility optimization problem and that obtains a particular point on the weak Pareto boundary. We also discuss another class of resource allocation problems that can be solved with fixed point iterations of mappings that are contractive in Thompson's metric space. For this last class of problems, we show that the concept of (nonlinear) eigenvalue is useful not only for establishing the existence of a solution, but also for obtaining information about the convergence rate of the fixed point iterations. While introducing these results, we comment on open problems of high relevance to wireless engineers and on opportunities to consider the superiorization methodology in Thompson or Hilbert-projective metric spaces.

Yair Censor

Department of Mathematics, University of Haifa, Haifa, Israel

Superiorization: The asymmetric roles of feasibility-seeking and objective function reduction

The superiorization methodology is not trying to solve the full-fledged constrained minimization problem composed from the modeling constraints and the chosen objective function. Rather, the task is to find a feasible point which is "superior" (in a well-defined manner) with respect to the objective function, to one returned by a feasibility-seeking only algorithm. The real-world situation in an application field is commonly represented by constraints defined by the modeling process and the data, obtained from measurements or otherwise dictated by the model-user.
At the heart of the superiorization methodology lies the modeler desire to use an objective function, that is exogenous to the constraints, in order to seek a feasible solution that will have lower (not necessarily minimal) objective function value. This aim is less demanding than full-fledged constrained minimization but more demanding than plain feasibility-seeking.
Putting emphasis on the need to satisfy the constraints one recognizes the asymmetric roles of feasibility-seeking and objective function reduction since fulfilling the constraints is the main task while reduction of the exogenous objective function plays only a secondary role.
Since its inception in 2007, the superiorization methodology has evolved and gained ground, as can be seen from the, compiled and continuously updated, bibliography at: http://math.haifa.ac.il/yair/bib-superiorization-censor.html#top. We telegraphically review the superiorization methodology and where it stands today and propose a rigorous formulation of its, yet only partially resolved, guarantee problem.

Aviv Gibali

Department of Mathematics, Braude College of Engineering, Karmiel, Israel

Superiorization as an acceleration technique and beyond

In this talk I'll present some results in which we used superiorization and the bounded perturbation resilience of algorithms to speed up convergence of given algorithm in multi and single objective optimization problems. Moreover, show how this methodology can help for treating non-convex objective functions.
Several open question to the auidenace/experts are also given.

Elias Salomão Helou Neto

University of São Paulo, São Paulo, Brazil

From Superiorization to simple bilevel convex optimization

This talk will present a general algorithm that converges to the solution of a simple convex bilevel optimization problem. One way to interpret the method is by viewing it as a perturbed version of the classical ϵ-subgradient algorithm, similar to what is done in many superiorization methods. The method uses only first-order information and, as such, has computationally cheap iterations, which allows it to be applied to huge problems, such as those arising from tomographic image reconstruction.

Ion Necoara

Institute of Mathematical Statistics and Applied Mathematics of the Romanian Academy & University Politehnica Bucharest

Efficiency of stochastic coordinate minimization

We consider composite optimization problems having the objective function formed as a sum of two terms, one has Lipschitz continuous gradient along random subspaces and may be nonconvex and the second term is simple and differentiable, but possibly nonconvex and nonseparable. Under these general settings we derive and analyze two new coordinate descent methods. The first algorithm, referred to as coordinate proximal gradient method, considers the composite form of the objective function and achieves scalability by constructing at each iteration a local approximation model of the whole nonseparable objective function along a random subspace with user-determined dimension. The other algorithm disregards the composite form of the objective and uses the partial gradient of the full objective, yielding a coordinate gradient descent scheme with novel adaptive stepsize rules. We prove that these new stepsize rules make the coordinate gradient scheme a descent method, provided that additional assumptions hold for the second term in the objective function. We present probabilistic worst-case complexity analysis for our stochastic coordinate (proximal) gradient methods in the convex and nonconvex settings, in particular we prove high-probability bounds on the number of iterations before a given optimality is achieved. Preliminary numerical results also confirm the efficiency of our two algorithms on practical problems such as non-negative matrix factorization.

Juan Peypouquet

Bernoulli Institute for Mathematics, Computer Science and Artificial Intelligence, University of Groningen, The Netherlands

A speed restart scheme for first order dynamics bearing second order information in time and space

We present two techniques that can help stabilize otherwise erratic inertial methods. Combined, they can enhance the performance of accelerated methods, especially for functions with quadratic growth, for which the rate of linear convergence is improved.

Jochen Schmid

Fraunhofer ITWM, Kaiserslautern, Germany

Adaptive discretization algorithms for shape-constrained regression and experimental design

We present adaptive discretization algorithms for shape-constrained regression and for optimal experimental design.
In shape-constrained regression, one tries to learn a model such that, on the one hand, it optimally fits the given data and, on the other hand, it satisfies certain shape constraints known about the true relationship to be modeled. In many cases, such shape-constrained regression problems can be cast as convex semi-infinite optimization problems, for example, in the case of monotonicity or convexity constraints. We present an adaptive discretization algorithm for such problems developed jointly with M. Poursanidis. It terminates after finitely many iterations at a feasible point with an optimality error that is bounded above in terms of the approximate-solution tolerances of the finite subproblems of our algorithm.
In optimal experimental design, one tries to find experiments such that the uncertainty of the model that is fitted to the experimental data becomes minimal. In many cases, such optimal experimental design problems can be cast as constrained convex optimization problems over the probability measures on the design space. We present an adaptive discretization algorithm for such problems developed jointly with P. Seufert, J. Schwientek, T. Seidel, and K.-H. Küfer.
In both applications, it will be interesting to bring to bear ideas from superiorization in order to further improve our algorithms in terms of robustness against modeling and numerical imprecisions.

Jan Schroeder

Fraunhofer ITWM, Kaiserslautern, Germany

Impact of the condition number on the quality and runtime of superiorization methods

Many optimization methods show particularly bad rates of convergence on problems with high condition numbers. While they keep making progress, it becomes less in each iteration, leading to long computation times, especially in high dimensions. Superiorization on the other hand has been observed to obtain better results in earlier iterations in certain cases. This talk will explore the behaviour of superiorization when vary- ing the condition number and dimension, and compare it to optimization solvers in terms of computation time, number of iterations and solution quality.

Tobias Seidel

Fraunhofer ITWM, Kaiserslautern, Germany

Challenges of optimization in chemical engineering

Various applications of process engineering are responsible for a large part of the world's energy consumption. In particular, the separation of mixtures, typically performed by distillation, is energy intensive. Because of this high energy demand, there is also a high potential for energy savings. In addition, energy is not the only criterion. The product quality and the product yield have to be maximized, which makes the problem a multi-objective optimization problem. Unfortunately, optimization problems in chemical engineering, especially those involving distillation processes, are challenging. Simulations can fail and the problem is ill-conditioned. Physical constraints such as the non-negativity of the material flow must be respected, otherwise the solutions are not meaningful. However, there is some flexibility in how to formulate some of the constraints and the objectives of the decision problem. How can this freedom be used to produce good solutions fast?
In this talk we will present recent developments and methods for solving such optimization problems and discuss open questions.

Mathias Staudigl

Department of Business Informatics and Mathematics, University of Mannheim, Germany

Distributed random block-coordinate descent methods for ill-posed composite convex optimisation problems

We develop a novel randomised block coordinate descent primal-dual algorithm for a class of non-smooth ill-posed convex programs. Lying in the midway between the celebrated Chambolle-Pock primal-dual algorithm and Tseng's accelerated proximal gradient method, we establish global convergence of the last iterate as well optimal $O(1/k)$ and $O(1/k^2)$ complexity rates in the convex and strongly convex case, respectively, k being the iteration count. Motivated by distributed and data-driven control of power systems, we test the performance of our method on a second-order cone relaxation of an AC-OPF problem. Distributed control is achieved via the distributed locational marginal prices (DLMPs), which are obtained dual variables in our optimisation framework.

Stavros A. Zenios

University of Cyprus, Cyprus Academy of Sciences, Letters, and Arts, Bruegel, BE.

Robust optimization models for explaining some under-diversification puzzles in finance

We develop a robust portfolio selection model to maximize the mean-to-CVaR portfolio performance ratio for stable distributions under differentiated ambiguities in the means of correlated returns for the home and foreign markets. The model can be formulated as a second-order cone program solvable using interior-point methods, and we show that it satisfies second-order stochastic dominance consistency. We derive analytical derivatives with respect to ambiguity for the two-asset case and show how ambiguity can induce home bias in the portfolio section. Estimating perceived ambiguity from market data using two different methods, we find that the model generates optimal international portfolios with allocations matching the well-known home bias for both developed and emerging markets. A model prediction on the (under)diversification effects of non-differentiated ambiguities is verified on a large dataset of household portfolios.

This is joint work with Somayyeh Lotfi from the University of Cyprus, and a working paper will be available for distribution to participants before the workshop.