1st Alps-Adriatic Inverse Problems Workshop 2019

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Book of Abstracts

Test

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On a semismooth* Newton method for generalized equations

Author: Helmut Gfrerer[None]

Corresponding Author:

In this talk we introduce a new notion of semismoothness*which pertains both sets as well as multi-functions. In the case
of single-valued maps it is closely related with the standard
notion of semismoothness introduced by Qi and Sun in 1993.
Semismoothness* can be equivalently characterized in terms of
regular, limiting and directional limiting coderivatives.

Then we present a semismooth* Newton method for solving inclusions and
generalized equations (GEs), where the linearization concerns
both the single-valued and the multi-valued part and it is
performed on the basis of the respective coderivatives. Two
conceptual algorithms will be presented and shown to converge
locally superlinearly under relatively weak assumptions.

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Iterative regularization for nonsmooth inverse problems

Author: Christian Clason[None]

Corresponding Author:

We consider inverse problems for nonlinear forward models that are directionally but not Fréchet differentiable; examples include solution mappings for nonsmooth partial differential equations or variational inequalities. In this setting, standard derivative-based regularization methods such as Landweber or Levenberg–Marquardt iteration are inapplicable. We show that using elements of the Bouligand subdifferential for the linearization still leads to a convergent regularization scheme.

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Theoretical and numerical analysis of fundamental models in nonlinear acoustics

Author: Mechthild Thalhammer[None]

Corresponding Author:

In this talk, I will present joint work with Barbara Kaltenbacher on fundamental models in nonlinear acoustics. In a first part, I will introduce a hierarchy of nonlinear damped wave equations that arise in the modelling of sound propagation in thermoviscous fluids. In a second part, I will discuss a rigorous result which implies that two classical models, the Kuznetsov and Westervelt equations, are retained as limiting systems for vanishing thermal conductivity and consistent initial data. In addition, I will present numerical illustrations that complement the theoretical findings.

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A high-order discontinuous Galerkin approach for nonlinear sound waves

Author: Vanja Nikolić[None]

Corresponding Author:

Accurate simulation of nonlinear sound waves offers a road to improving a variety of procedures in industry and medicine,
ranging from non-destructive detection of material damages to non-invasive treatments of medical disorders.
In this talk, we will discuss the spatial discretization of Westervelt's quasi-linear acoustic equation by a high-order discontinuous Galerkin method.
The challenges in the numerical analysis lie in handling the nonlinearity in the model which involves the derivatives in time of the acoustic velocity potential,
and in preventing the model from degenerating. Numerical experiments will illustrate the theoretical convergence results.
This is joint work with Paola F. Antonietti, Ilario Mazzieri (MOX, Politecnico di Milano), Markus Muhr, and Barbara Wohlmuth (TU Munich).

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Control and controllability of PDEs with hysteresis

Author: Pavel Krejcí[None]

Corresponding Author:

For a diffusion equation with a complex hysteresis operator we consider the problem of controllability, that is, finding a control which guarantees that the solution reaches a desired value at a given time. It is solved here by a constructive method based on a two-parameter penalty argument. One small parameter penalizes the distance of the solution at final time from the expected value, the second one represents viscous regularization of the underlying rate independent variational inequalities in the hysteresis term. We prove that a solution to the controllability problem can be obtained by passing to the singular limit in the doubly degenerate control system. This is a joint work with Chiara Gavioli from Modena.

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Augmented GMRES-type versus CGNE methods for the solution of linear ill-posed problems

Author: Andreas Neubauer[None]

Corresponding Author:

In this paper we compare (augmented) GMRES-type methods and (augmented) CGNE methods. The numerical results show that the CGNE method is more robust and is suitable for ill-posed problems with a much higher degree of ill-posedness. GMRES-type methods only yield useful results for very moderate ill-posed problems.

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On Levenberg-Marquardt type methods for ill-posed operator equations

Author: Antonio Leitao[None]

Corresponding Author:

On this talk we report on a joint work with Prof. B.Kaltenbacher on Levenberg-Marquardt type methods for solving nonlinear ill-posed operator equations in Hilbert spaces.
Moreover, we also discuss some recent research results on this iterative method.

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Acceleration of sequential subspace optimization in Banach spaces by orthogonal search directions

Author: Thomas Schuster[None]

Corresponding Author:

A standard solution technique for linear operator equations of first kind is the Landweber scheme which is an iterative method that uses the negative gradient of the current residual as search direction, which is then also called the Landweber direction. Though this method proves to be stable with respect to noisy data, it is known to be numerically slow for problems in Hilbert spaces and this behavior shows to be even worse in some Banach space settings. This is why the idea came up to use several search directions instead of the Landweber direction only which has led to the development of Sequential Subspace Optimization (SESOP) methods. This idea is related to Conjugate Gradient (CG) techniques that are known to be amongst the most effective methods to solve linear equations in Hilbert spaces. SESOP methods in Banach spaces do not share the conjugacy property with CG methods. In this talk we present the concept of generalized (g-)orthogonality in Banach spaces and apply metric projections to orthogonalize the current Landweber direction with respect to the search space of the last iteration. This leads to an accelerated SESOP method which is confirmed by various numerical experiments.
(joined work with Frederik Heber and Frank Schoepfer)

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Optimal convergence rates for sparsity promoting wavelet-regularization in Besov spaces

Author: Thorsten Hohage[None]

Corresponding Author:

We report on joint work with Philip Miller on Tikhonov regularization for linear and nonlinear ill-posed operator equations with wavelet Besov norm penalties. We focus on Besov norms with fine index 1, which yield estimators that are sparse with respect to a wavelet frame. Our framework includes, among others, the Radon transform and some nonlinear inverse problems in differential equations with distributed measurements.
Using variational source conditions we show that such estimators achieve minimax-optimal rates of convergence for finitely smoothing operators in certain Besov balls both for deterministic and for statistical noise models.
Using explicit bounds on the number of nonvanishing coefficients of the estimator, we also derive a converse result for approximation rates.

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Tikhonov regularization with oversmoothing penalty: phenomena, convergence and rates

Author: Bernd Hofmann[None]

Corresponding Author:

The presentation is devoted to Tikhonov regularization under conditional stability estimates for nonlinear ill-posed operator equations in Hilbert scales. Our focus is on the case of oversmoothing penalties, for which the true solution no longer attains a finite value. In this context, we present some new results on convergence and recall assertions on rates. We strongly highlight the local character of conditional stability estimates for nonlinear problems and demonstrate that pitfalls may occur. Then convergence can completely fail and the stabilizing effect of conditional stability may be lost. Numerical case studies for some nonlinear examples illustrate such effects.

This talk presents joint work with Peter Mathé (Berlin), Robert Plato (Siegen), Daniel Gerth and Christopher Hofmann (Chemnitz). Research is supported by the Deutsche Forschungsgemeinschaft (DFG) under grant HO 1454/12-1.

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A multiplicative iterative method for ill-posed problems

Author: Elena Resmerita[None]

Corresponding Author:

We present a multiplicative entropic type method for ill-posed equations, which has a closed form and preserves nonnegativity of the iterates. Interestingly, this has been investigated in finite dimensional optimization under different names/versions, while related methods have been considered in inverse problems as well. We discuss convergence and error estimates, and test the method on several examples, in comparison with two other iterative methods.

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The tangential cone condition for some coefficient identification model problems in parabolic PDEs.

Author: Tram Ngoc Nguyen[None]

Corresponding Author:

The tangential condition was introduced in [Hanke, Neubauer, and Scherzer, 1995] as a sufficient condition for convergence of the Landweber iteration for solving ill-posed problems. This condition ensures nonlinearity of the forward operator fits together with the data misfit. In this talk, we present a series of time dependent benchmark inverse problems for which we can verify this condition. We establish the tangential condition in two different modeling settings: an all-at-once and a reduced version.

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A Random Wanderers guide to the Diffusion Equation Universe

Author: Bill Rundell[None]

Corresponding Author:

The classical reaction-diffusion equation can be stated as the rate of change of the state variable u equals the sum of a diffusion operator and a (often nonlinear) reaction term: $u_t = -L\,u + f(u)$, where typically $-L$ is an elliptic operator. The equation, while known in form, can have specific parameters undetermined; for example coefficients in L or the function f itself.
We look at various models for recovery of these but we also do so in a context beyond Brownian motion diffusion and its parabolic pde format. These so-called anomalous diffusion models give rise to nonlocal differential operators of fractional type and add further difficulties to an already complex problem.
The work is joint with Barbara Kaltenbacher.

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Data driven regularization by projection

Author: Otmar Scherzer[None]

Corresponding Author:

Regularization methods for inverse problems can be based on mathematical forward methods which represent the Physics and Chemistry
as precise as possible. With the rise of the area of big data, methods that combine forward modelling with data driven techniques have been
being developed. In this talk we demonstrate that regularisation by projection can be formulated in a purely data driven setting
when the linear forward operator is given only through training data. We study convergence and stability of the regularised solutions.
We discuss counter examples on convergence of the method of regularization by projection by Seidman in this context.

This is joint work with Andrea Aspri (RICAM, Linz), Yury Korolev (Cambridge).

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Inverse Scheme for Acoustic Source Localization based on Adjoint Method

Author: Manfred Kaltenbacher[None]

Corresponding Author:

We propose an inverse scheme for acoustic source localization based on solving the corresponding partial differential equation in the frequency domain (Helmholtz equation) by applying the Finite Element (FE) method. This allows us to fully take into account the actual boundary conditions as given in the measurement setup. To recover the source locations, an inverse scheme based on a sparsity promoting Tikhonov functional to match measured (microphone signals) and simulated pressure is proposed. Since the differential operators for the state equation and the adjoint equation are the same, the FE system matrix for both partial differential equations is the same, which results in a computational highly efficient solution process. Furthermore, the computational time does not depend on the number of microphones nor on the assumed number of possible sources. Finally, the inverse scheme results in a source map both for amplitude and phase and in addition the reconstructed acoustic field is provided. The properties of this inverse scheme and its applicability to source localization in the low frequency range will be demonstrated.

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Mathematical modelling and statistical inference for large-scale models of cancer signalling

Corresponding Author:

The sequencing of cancer biopsies revealed that cancer is multi-factorial diseases, which strongly vary between patients. This inter-patient variability poses a challenge for clinicians. A priori it is not clear which drug will be most beneficial for a specific patient. Here, we approach the problem of drug response prediction using mechanistic mathematical models. We develop a mathematical model describing several cancer associated signaling pathways. This model can be individualized using sequencing data. For statistical inference we develop a scalable approach facilitating the study of models with thousands of parameters. We the approach to analyse drug response data from the Cancer Cell Line Encyclopaedia for 7 drugs and 120 cell lines originating from five different tissues. These results demonstrate the potential of large-scale mechanistic modeling for drug selection in personalized therapy.

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A Collection of Inverse Problems in Engineering Applications

Author: Tom Lahmer[None]

Corresponding Author:

The talk presents a series of examples, where engineers are actually faced with inverse problems of different types. Solution strategies and results are given for several examples including poroelasticity and piezoelectricity. The inverse problems are mainly of parameter and source identification type.

A new series of inverse problems comes up by the rapid developments in additive printing techniques. Here, the talk will name some of the newly arising challenges during the characterization of materials which are built by additive printing techniques.

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All-at-once formulations of inverse problems within the Bayesian approach

Author: Anna Schlintl[None]

Corresponding Author:

The all-at-once-formulation for deterministic inverse problems has recently been considered. Our goal is to put this approach in a Bayesian framework. The advantages of our approach are the additional choice of a prior also for the state variable and the possibility to take into account perturbations in the model. By means of the inverse source problem and the backward heat equation we test the all-at-once formulation in appropriate function spaces, derive adjoint operators, investigate in different priors for the state and do numerical tests.

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Minimization based formulations of the EIT problem with the CEM

Author: Kha Van Huynh[None]

Corresponding Author:

One of the recent approaches to solving inverse problems is to use the all-at-once formulation where both the state and the parameter are considered as unknowns. The advantage of this method is to avoid using the parameter-to-state map, which is usually difficult to determine in real problems and sometimes leads to strictly restrictive conditions. In this talk, we regularize the electrical impedance tomography (EIT) problem with the complete electrode model (CEM) in the plane. The regularization method is to formulate our problem as a minimization problem, which is a generalization of the all-at-once formulation. The new one is to use CEM, a widely used practical model.

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Modelling approaches to assess the reliability of semiconductor devices

Author: Olivia Pfeiler[None]

Corresponding Author:

One research area of KAI – Kompetenzzentrum Automobil- und Industrieelektronik is the reliability of semiconductor devices. Often, the reliability is assessed by extensive testing. To save test resources, we develop lifetime models describing the degradation of the devices under application conditions. To achieve good results we research three approaches: statistical lifetime models, FEM simulation models and stochastic state-space models.

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Stochastic state space modeling of thermo-mechanical fatigue

Author: Barbara Pedretscher[None]

Corresponding Author:

Modeling fatigue induced degradation of a metal film requires a consistent mathematical description of the physically relevant damage driving forces. In this work, a state space model, based on Itó stochastic processes to account for intrinsic stochastic effects, is followed. Parameter identification and uncertainty quantification are based on the system's corresponding Fokker-Planck equation, where an adjoint approach as well as profile likelihoods are implemented and compared to MCMC results.

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Process Simulation at Linde Engineering

Author: Stephania Hokenmaier[None]

Corresponding Author:

Building on its vast and unique experience, Linde has been developing and optimizing gas processing, separation and liquefaction technologies for 140 years. Through trusted, lasting business relationships, it collaborates closely with customers the world over to develop tailored solutions that

maximize plant lifecycle productivity, efficiency and service life.
With the help of process simulation tools entire chemical plants or parts of them are modelled, simulated and also optimized. At Linde Engineering commercial and in-house developed process simulation programs are applied. In this talk the idea, methods and application of process simulation will be explained.

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Modelling and Machine Learning for industrial sensing applications

Author: Romana Boiger[None]

Corresponding Author:

The Materials Center Leoben (MCL) is an internationally active research institution specialized in materials, production and processing engineering and innovative material applications. Besides a comprehensive range of services, the MCL carries out cooperative research and development projects in close collaboration with industry. The latter is the focus of my team, the embedded computing group: we support research projects along the whole product value chain from material design, to material processing and finally their use in innovative products. In this talk, I show two recent examples of my work. This includes a gas sensor device for indoor air quality control and algorithms for visual anomaly detection in semiconductor industry. The mathematics therein involve data analysis, mathematical modelling of dynamical systems, optimization, inverse problems, numerical methods and machine learning using real data from industrial sensors.

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Brief introduction into the work as an actuary

Author: Jonas Offtermatt[None]

Corresponding Author:

In this talk a short introduction into to work of a mathematician at an insurance company will be given. Starting with the one and only necessary equation for insurance mathematics, over working as data analyst, or in marketing, we will end with the work of a mathematician in IT-department.

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A pattern identification problem in energy time series

Author: Peter Steinhorst[None]

Corresponding Author:

Prognoses of energy yield and load profiles are an useful tool for optimization in dimensioning and operation management of renewable energy-storage-systems. Within part of a research project, time series with electric power data of a photovoltaics unit, some machines and overall consumption have been measured with high time resolution at an industrial company.
Caused by breakdowns in measurement and data converting tools, the resulting data contains gaps. Missing data segments in the machine time series shall be filled using production plans of the corresponding machine. For this purpose, a pattern of power consumption over time has to be identified for each type of piece part treated by this machine.

One occuring problem thereby is the choice of suitable measures, because in the machine process flows are some fluctuations from piece to piece.

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Closing Event