IPwin2021: Book of abstracts

Technical University of Denmark

January 29, 2021

Schedule

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09.00	Marvin Knöller	Maximizing the electromagnetic chriality of thin dielectric tubes
09.20	Aditya Rastogi	Estimation of pharmacokinetic parameters from undersampled DCE-MRI data
09.40	Lukas Høghøj	A brief introduction to topology optimization
		Break (15 min)
10.15	Erik Träff	Methods from topology optimization as seen from the perspective of inverse problems
10.35	Ekaterina Sherina	Challenges in Quantitative Optical Coherence Elastography
10.55	Aksel Rasmussen	Regularized CGO reconstruction for the Calderon problem in 3D
		Break (15 min)
11.30	Henrik Garde	Extreme inclusions in Calderón's problem
11.55	Tommi Brander	Inverse problems with a variable exponent in 1D
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13.20	Giovanni Covi	The higher order fractional Poincarè inequality and its use in Inverse Problems
13:40	Jesse Railo	Higher order fractional Calderón problem
14:00	Keijo Mönkkönen	Partial data problems in scalar and vector field tomography
		Break (10 min)
14:30	Hjørdis Schlüter	Reconstructing anisotropic conductivities on 2D Riemannian manifolds from power density measurements
14:50	Lili Yan	Inverse boundary problems for biharmonic operators in transversally anisotropic geometries
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Abstracts

Maximizing the electromagnetic chriality of thin dielectric tubes

29 Jan
9.00am
Live

Marvin Knöller
Karlsruher Institut für Technologie

Electromagnetic chirality describes the interaction of scattering objects with electromagnetic fields of different helicity. If the scattering behavior of the object with respect to incident waves of one helicity cannot be reproduced with incident fields of the opposite helicity, the scatterer is said to be electromagnetic chiral (em-chiral), otherwise it is called em-achiral. Em-chirality can be quantified by chirality measures that attain the value 0 for an em-achiral object and the value 1 for a maximally em-chiral object. The latter would be invisible to fields of one helicity. In the talk, we discuss a shape optimization problem, where the goal is to construct thin tubular scattering objects consisting of dielectric isotropic materials that exhibit large measures of em-chirality at a given frequency. We present a gradient based optimization method, which is based on an asymptotic perturbation formula for approximating scattered electromagnetic fields due to thin tubular scatterers. We show results of the algorithm and discuss the optimal shapes that are found by the algorithm.

Estimation of pharmacokinetic parameters from undersampled DCE-MRI data

29 Jan
09:20am
Live

Aditya Rastogi
Indian Insitute of Science

Pharmacokinetic model are used for modelling drug delivery/exchange in tissues. These models are based on partial differential equations and may or may not have closed form solution. These models are also used with dynamic contrast enhanced MR images to study the permeability of blood vessels, which is an important parameter in planning and monitoring cancer treatment and for studying blood-brain-barrier. In modern scanners to reduce scan time , dynamic MR images are estimated from undersampled fourier data using compressive sensing techniques. Estimating permeability of blood vessels from undersampled fourier data constituents the inverse problem. My talk focuses on deep learning based and compressive sensing based iterative methods to solve this inverse problem for different pharmacokinetic models.

A brief introduction to topology optimization

29 Jan
9.40am
Live

Lukas Høghøj
DTU Mechanical Engineering

Topology optimization is a gradient based optimization method used to design the layout of structures, which has roots in inverse problem formulations. Contrary to traditional design processes, topology optimization requires almost no knowledge of the final design. In the optimization process, the design domain is decomposed in elements, where a variable indicates the presence or absence of material in the element. The problem is usually solved in the nested iteration approach, where the state field is considered an implicit function of the design variables. The gradients are obtained based on the numerical model of the physics. Topology optimization originated and has most of its applications within structural mechanics, where the objective is to maximize the stiffness and the constraint the weight of the structure. However, the method has also gained in popularity in other areas over the past years.

Methods from topology optimization as seen from the perspective of inverse problems

29 Jan
10.15am
Live

Erik Träff
DTU Mechanical Engineering

Many similarities are present between inverese problems and topology optimization. Both aim to find some material distribution which minimizes an objective function while constrained by a PDE. As the inverse problem comunity, the topology optimization comunity has developed a large set of methods to regularize and constrain the resulting structures in order to ensure discreteness, manufacturability, mesh independency, and more. Indeed, the concept of combining the knowledge of the two fields is nothing new, but can nevertheless still be interesting as new insights are obtained n both fields. The purpose of this talk is to give a brief overview of some of these methods from topology optimization, including the current state-of-the-art, which might have an interest for inverse problems.

Challenges in Quantitative Optical Coherence Elastography

29 Jan
10.35am
Live

Ekaterina Sherina
Faculty of Mathematics, University of Vienna

The ultimate goal of Elastography is to reconstruct material parameters of a specimen by exposing it to external forces. This problem is used in Medicine, in particular for the non-invasive identification of malignant formations inside the human skin or tissue biopsies during surgeries. Different challenges arise on the way from formulating the problem mathematically to implementing a robust solution method on experimental data. In this talk, we discuss crucial points for obtaining reliable material parameter estimates in a two-step approach to Optical Coherence Elastography.

Regularized CGO reconstruction for the Calderon problem in 3D

29 Jan
10.55am
Live

Aksel Rasmussen
DTU Compute

Electrical Impedance Tomography (EIT) gives rise to the Calderón problem of determining the electric conductivity distribution of a body given exterior electrostatic current-and-voltage measurements. Knowing the conductivity of an object is of interest in many fields, notably medical imaging, where applications may vary from stroke detection to early detection of breast cancer. With the use of so-called complex geometrical optics (CGO) solutions, it has been shown that a sufficiently regular conductivity distribution is uniquely determined by the measurements, although the reconstruction map is severely unstable and not theoretically defined for any real-life data. In this talk, we consider the direct non-linear reconstruction in three dimensions and provide an algorithm with regularizing behavior thereby making direct reconstruction practical in three dimensions. We support theoretical results with numerical tests of an implementation of the proposed regularized reconstruction. This is joint work with Kim Knudsen.

Extreme inclusions in Calderón's problem

29 Jan
11.30am
Recorded

Henrik Garde
Department of Mathematics, Aarhus University

Calderón's problem is on determining information about an electrical conductivity coefficient in a body from boundary measurements of current and voltage. Based on a Neumann-to-Dirichlet map on an arbitrarily small part of the domain boundary, I will give an easy criterion that characterizes the support of conductivity perturbations. The perturbations may lead to conductivity values that are perfectly insulating (zero), perfectly conducting (infinite), or other finite values in between.

This is joint work with Valentina Candiani, Jérémi Dardé, and Nuutti Hyvönen.

Inverse problems with a variable exponent in 1D

29 Jan
12.55pm
Live

Tommi Brander

Norwegian University of Science and Technology

We consider a non-linear conductivity equation of variable exponent $p(x)$-Laplace type. To what extent can the exponent $p(x)$ and the linear part of the conductivity $\gamma(x)$ be recovered from the Diricihlet-to-Neumann map in one dimension? It turns out that γ can be recovered to the extent that p is injective, if p is known, while p can be recovered up to a rearrangement if γ is constant. The results for recovering γ are optimal, while there is no reason to believe the same for recovering p. Recovering both at the same time seems challenging at best. Some of the work is joint with David Winterrose and some with Jarkko Siltakoski.

The higher order fractional Poincarè inequality and its use in Inverse Problems

29 Jan
1.20pm
Recorded

Giovanni Covi

University of Heidelberg

Based on a joint work with Keijo Mönkkönen and Jesse Railo, my talk explores some properties of the higher order Laplace operator. The main focus is on the generalized Poincaré inequality, which is useful for the definition and study of higher order fractional Calderón problems. I present a proof of such formula and an example of its use.

Higher order fractional Calderón problem

29 Jan
1.40pm
Live

Jesse Railo

Department of Mathematics, ETH Zurich

We present and discuss our recent studies on the higher order fractional Calderón problem. Our main theorem shows that perturbations of the fractional Schrödinger equation (FSE) by lower order linear PDOs on bounded open domains are uniquely determined from the exterior Dirichlet-to-Neumann data associated with the perturbed FSE. This is proved for two classes of coefficients of PDOs: coefficients which belong to certain spaces of Sobolev multipliers and coefficients which belong to fractional Sobolev spaces with bounded derivatives. This is a quite general statement including many earlier results as its special cases. The recovery of perturbations by any smooth local linear operator also reduces to our case by the Peetre theorem. These results are obtained in the joint works (arXiv:2001.06210, arXiv:2008.10227) with Giovanni Covi (Heidelberg), Keijo Mönkkönen (Jyväskylä), and Gunther Uhlmann (UW / HKUST).

Partial data problems in scalar and vector field tomography

29 Jan
2.00pm
Recorded

Keijo Mönkkönen

Department of Mathematics and Statistics, University of Jyväskylä

I will talk about partial data problems in the X-ray tomography of scalar fields and vector fields. I also discuss the relationship between partial data problems and unique continuation of the normal operator of the X-ray transform.

Reconstructing anisotropic conductivities on 2D Riemannian manifolds from power density measurements

29 Jan
2.30pm
Live

Hjørdis Schlüter

DTU Compute

We present an approach to reconstruct the anisotropic electrical conductivity locally inside a domain on a 2D Riemannian manifold from power density measurements. We show that when the manifold is conformally flat, the conductivity equation satisfied by the electric potential inside that domain is identical to the conductivity equation in the corresponding domain in the plane. This implies that after an appropriate transformation of the power density data and the boundary conditions, the reconstruction problem on the manifold can be reduced to the problem in the plane. As every two-dimensional Riemannian manifold has a local conformal representation in isothermal coordinates, the previous approach can be implemented for sufficiently small domains on the manifold. We illustrate the problem and our proposed reconstruction approach by an illuminating example.

Inverse boundary problems for biharmonic operators in transversally anisotropic geometries

29 Jan
2.50pm
Live

Lili Yan

Department of Mathematics, University of California, Irvine

We study inverse boundary problems for first order perturbations of the biharmonic operator on a conformally transversally anisotropic Riemannian manifold of dimension $n \geq 3$. We show that a continuous first order perturbation can be determined uniquely from the knowledge of the set of the Cauchy data on the boundary of the manifold provided that the geodesic X-ray transform on the transversal manifold is injective.

Sound speed uncertainty in Acousto-Electric Tomography

29 Jan
3.20pm
Live

Bjørn Jensen
University of Helsinki

The goal in acousto-electric tomography (AET) is to reconstruct an image of the unknown electric conductivity in an object from exterior electrostatic currents and voltages that are measured on the boundary of the object while the object is penetrated by propagating ultrasound waves. This problem is a coupled-physics inverse problem. Accurate knowledge of the propagating ultrasound wave is usually assumed and required, but in practice tracking the propagating wave is very hard, or potentially impossible, due inexact knowledge of the object's interior acoustic wave speed. In this talk I will show how we have modelled the uncertainty in the wave speed and propose a reconstruction method and demonstrate that in the presence of an uncertain sound speed, which is not too severe, we can still get useful reconstructions.

The stochastic inverse medium problem for the Helmholtz equation in the plane

29 Jan
3.40pm
Live

Kristoffer Linder-Steinlein
DTU Compute

The presentation introduces stochasticity to the Inhomogeneous Helmholtz equation through the medium. An approximation of the forward operator to the problem with a stochastic medium is derived, and a spectral leakage is found. The derivation of the forward operator is based on the Lippmann-Schwinger equation and Neumann series. The spectral leakage appearing when calculating a spectral decomposition of the forward operator appears to not only introduce changes in the amplitude of the spectrum, but also a dispersion. Finally the spectral leakage is estimated numerically and visualized for certain parameters.

Speaker Index