COMPUTATIONAL INVERSE PROBLEMS

Place and time: In M106 on Friday, Jan 5, at 10:30–12:00
Organizers: Tatiana Bubba (University of Helsinki)
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Polynomial collocation for handling an inaccurately known measurement configuration in electrical impedance tomography

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Abstract. The objective of electrical impedance tomography is to reconstruct the internal conductivity of a physical body based on measurements of current and potential at a finite number of electrodes attached to its boundary. Although the conductivity is the quantity of main interest in impedance tomography, a real-world measurement configuration includes other unknown parameters as well: the information on the contact resistances, electrode positions and body shape is almost always incomplete. In this work, the dependence of the electrode measurements on all aforementioned model properties is parametrized via polynomial collocation. The availability of such a parametrization enables efficient simultaneous reconstruction of the conductivity and other unknowns by a Newton-type output least squares algorithm, which is demonstrated by two-dimensional numerical experiments based on both simulated and experimental data.

Joint work with L. Mustonen

Inverse Problems and Uncertainty Quantification

Hanne Kekkonen *(University of Cambridge)*, hnk22@damtp.cam.ac.uk

Abstract. The aim of the talk is to discuss connections between inverse problems and the emerging field of uncertainty quantification. Uncertainty quantification is necessary in inverse problems to assess statistical reliability of the obtained solutions. Ill-posedness of the underlying model generates challenges that are not typically considered in classical statistics literature. In complex parameter spaces, such as those encountered in inverse problems, calculating frequentist confidence regions can be an almost impossible task, whereas Bayesian uncertainty quantification is often computationally cheap. The problem is that the theoretical and objective meaning of such posterior based inferences is largely unclear. On the other hand frequentist uncertainty quantification is well understood and studied in traditional statistics.

Joint work with M. Lassas and S. Siltanen.

An adaptive selection on the regularization parameter: An application for X-ray tomography

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Abstract. Tomographic reconstruction is an ill-posed inverse problem that calls for regularization. One possibility is to require sparsity of the unknown in particular basis or dictionary. It can be achieved by variational regularization, where the

penalty term is the sum of the absolute values of the coefficients from a given transformation. In this work, we apply wavelet and shearlet transform. The primal-dual fixed point (PDFP) algorithm showed that the minimizer of the variational regularization functional can be computed iteratively using a soft-thresholding operation. Choosing the soft-thresholding parameter $\mu > 0$ is analogous to the notoriously difficult problem of picking the optimal regularization parameter in Tikhonov regularization. Here, a novel automatic method is introduced for choosing μ, based on a control algorithm driving the sparsity of the reconstruction to an a priori known ratio of nonzero versus zero wavelet/shearlet coefficients in the unknown.

Direct reconstruction in Electrical Impedance Tomography using the D-bar method

Janne Tamminen *(University of Helsinki)*, `janne.tamminen@helsinki.fi`

Abstract. Electrical Impedance Tomography uses electrical measurements on the boundary of an object to reconstruct the conductivity distribution inside the object. This nonlinear and ill-posed inverse problem can be solved using the *D-bar method* which has its origins in the field of Inverse Scattering. The D-bar method is not iterative nor statistical method and the corresponding forward problem does not need to be solved: instead the boundary measurement are linked to the conductivity via the related Complex Geometrics Optics (CGO) solutions and the (non-physical) scattering transform. In this presentation the D-bar method is used for simulated data and real data from the open-access EIT dataset available at the FIPS webpage.