M2 Computational Inverse Problems

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1. 4D X-ray tomography based on a level set method

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Dynamic sparse X-ray tomography is an appealing research field, motivated by biomedical and nondestructive testing applications as angiography or radiation therapy. In our setting, time is considered as an additional dimension in the problem, and a generalized level set method [Kolehmainen, Lassas, Siltanen, SIAM J Scientific Computation 30 (2008)] is applied in space-time. In this approach, the X-ray attenuation coefficient is modeled by the continuous level set function itself (instead of a constant) inside the domain defined by the level set, and by zero outside. Numerical examples with both simulated and measured data suggest that the method successfully regularizes the inverse problem by enforcing con-tinuity both spatially and temporally.

2. VOLTAGE POTENTIAL INTERPOLATION FOR PARTIAL DATA ELECTRICAL IMPEDANCE TOMOGRAPHY

Andreas Hauptmann, *University of Helsinki*

We present a realistic direct computational approach to recover the CGO solutions and conductivity from partial Neumann-to-Dirichlet (ND) data for electrical impedance tomography. The approach is based on smooth diffusive interpolation of the measured voltage potentials to obtain an approximation to the full data ND-map. For fast and stable computations we propose to apply Born approximation to compute the CGO solutions or the conductivity directly without solving a boundary integral equation. We present computational results on simulated data.

3. 3D thermal tomography with experimental measurement data

Jussi Toivanen, *University of Eastern Finland*

In thermal tomography, a target is non-destructively imaged using surface measurements of heat transfer. In the measurement setup, the target is sequentially heated at different surface heating locations and the induced temperature evolutions are measured at multiple surface measurement locations. Based on these measurements, the thermal properties of the target are estimated as spatially distributed parameters. Initially, the feasibility of thermal tomography was shown with simulations for thermally insulated 2D targets. Next, the computational methods were extended to suit a more practical measurement setup where the target does not need to be thermally insulated. In these 2D simulations, the heat flux between the target and the surrounding air was modeled using a spatially distributed surface heat transfer coefficient which was estimated simultaneously with the spatially distributed thermal conductivity and heat capacity. Later, the computational methods were extended to 3D. Recently, a prototype thermal tomography measurement device was built and the feasibility of using thermal tomography with experimental measurement data was tested using further extended computational methods which are suitable for laboratory measurements.

4. Estimation of conductivity change in Electrical Impedance Tomography in the presence of modeling errors

Dong Liu, *University of Eastern Finland*

Electrical impedance tomography (EIT) is a highly unstable problem with respect to modeling errors arising from inaccuracies in electrode positions, contact impedances and boundary shape. For example, in clinic application of EIT, accurate knowledge of body shape is usually not available, and therefore an approximate model domain has to be used in the computational model. In this talk, we adapt a non-linear approach in difference imaging to tolerate modeling errors caused by inaccurately known body shape. The feasibility of the non-linear approach was evaluated with three potential medical applications: glottal imaging, cardiac imaging and lung imaging in EIT using simulated data, and two test cases using phantom measurements. The performance of the nonlinear approach was compared to the approach based on conventional separate absolute reconstructions and the conventional linear difference reconstruction approach. The results show that the non-linear difference imaging approach combines the advantages of absolute and difference imaging, yielding quantitative reconstructions which are relatively tolerant to modeling errors.