Course and seminars on "Reconstruction methods for sparse-data tomography"

(25-29 June)

Course: Reconstruction methods for sparse-data tomography

Lecturer: Samuli Siltanen, University of Helsinki, Finland

In tomography, one attempts to image the internal structure of a physical body from indirect measurements. A classic example is the medical CAT-scan, where a 3D volume view of a patient is reconstructed from a collection of X-ray radiographs recorded with a fine angular sampling using a rotating source-detector arrangement. In many practical imaging settings, such a comprehensive dataset is not available. The main reason for collecting a sparse X-ray dataset in medical imaging is lowering the radiation dose to the patient. Other reasons include geometric restrictions on the imaging arrangement, requirements for quick data collection, and cost of equipment. Reconstructing tomographic images from sparse datasets using Filtered Back-Projection (FBP) leads to sub-optimal results as that method is designed for densely sampled datasets. However, various limitations of data can be compensated for by using sophisticated mathematical reconstruction methods. Basic theory and computational methods for sparse-data tomography are presented in this course. Construction of matrix-based measurement models are discussed in detail, including analysis of the ill-posedness of the inverse problem using Singular Value Decomposition (SVD), Tikhonov regularization, and Total Variation (TV) regularization are discussed as versatile methods for image reconstruction. Computational examples are shown, based both on simulated and measured data. The course will contain lectures and Matlab demonstrations.

Seminars:

- **Fast iterative model based methods from limited data in 3D X-ray CT**

  Lecturer: Elena Loli Piccolomini, Università di Bologna – Alma Mater Studiorium A.D. 1088, Italy

  The reconstruction of X-Ray Computed Tomography (CT) images from low sampled data is of great interest in different applications, such as medicine or engineering. We follow a regularization approach with a smoothed differentiable Total Variation function. We consider the 3D case where the problem is challenging for its very large size and because a good reconstruction is required in a very short time. We present different algorithms on test problems on simulated and real data.

- **Forward-operator approximation techniques in numerical CT**

  Lecturer: Gaetano Zanghirati, Università degli Studi di Ferrara

  The iterative methods to numerically solve the inverse problems involved in Computed Tomography (CT) require, in simulations as well as in real world situations, to take a step with the CT forward operator. This operator is intended to model the geometry of the acquisition device. If it is used in a naive way, it can heavier (even strongly) the computational effort to compute the reconstruction. As alternatives to the well known classical approach (know as "ray driven") and its modifications, in more recent years different techniques have been proposed. They all are intended to improve the accuracy of the approximation as well as to allow better efficiency in the numerical computations. The seminar will overview some of these techniques, which are widely used in practical applications.