EDITORIAL

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Editorial

Advanced x-ray tomography: experiment, modeling, and algorithms

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Being able to visualize and analyze the 3D interior of an object in a nondestructive way is a fundamental capability for obtaining insights in medicine, materials science, geology, and many other research fields. Also in industry, nondestructive ways of 3D imaging are the key to on-the-fly quality control. X-ray tomography is a powerful technique for carrying out such 3D investigations at resolutions ranging from the millimeter down to the submicron level. It relies on a series of x-ray images acquired from a range of angles around the object. After the acquisition, a 3D image is computed from the measured data by a reconstruction algorithm, possibly combined with various pre- and postprocessing steps. Finally, the resulting data needs to be analyzed and visualized in an application specific manner to obtain answers to a variety of questions about the scanned object. As a data-driven research tool, tomography can provide not just qualitative images but also quantitative results on the internal state of the object.

To push the boundaries of current tomography capabilities, state-of-the-art x-ray imaging devices must be combined with novel, advanced computational methods for processing the resulting data. Traditionally, optimization of the imaging experiments and working on the computational (reconstruction/modelling) part have been separated into different academic communities with little interaction between them, thereby losing opportunities to improve on the state-of-the-art by a combination of advanced experiments and computation. Also, the publication venues and conferences typically focus on either one of the two aspects.

To stimulate the interaction and create a cross-disciplinary research community for advanced x-ray tomography that combines experiments, computational models, and algorithms, the EXTREMA COST Action (MP1207) was initiated in 2013, forming an EU-funded research network with participants from over 20 countries. This special issue of *Measurement Science and Technology* is specifically aimed at collecting research results that combine x-ray imaging experiments with sophisticated modelling and/or computational approaches. It collects results obtained from EXTREMA collaborations as well as research that spans beyond the boundaries of the research network.

The issue collects 18 articles on various aspects of advanced x-ray tomography. In [1], a review is given on the development of low-dose phase contrast tomography in the synchrotron, which can be seen as illustrative for the extensive development effort that goes into new tomographic techniques. The remaining articles contain a broad range of novel research results related to various aspects of the tomographic imaging pipeline.

Understanding the details of the experimental imaging system is crucial to optimizing the results of the complete imaging pipeline. The articles [2–6] deal with *simulation*, *calibration*, and *metrology* in the context of x-ray tomography. Based on a model of the imaging system, the key computational challenge in tomography is to carry out image *reconstruction*. Although the standard reconstruction techniques have been developed decades ago, advances in reconstruction algorithms can yield superior image quality in cases of limited data or data artefacts introduced during acquisition. In [7–9], new algorithmic approaches to tomographic reconstruction are presented.

Both the acquisition and the reconstruction steps may introduce *artifacts* in the reconstructed image: structured image distortions that often have a characteristic visual structure. The articles [10–13] propose different strategies for reducing such artifacts through alternative ways of acquiring and processing the data.

Besides image quality, another crucial performance metric of the tomography pipeline is the time required for a scan and the computational requirements of its data processing. The

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articles [14–16] focus on various aspects of *high-throughput* tomography systems, related to running time and data storage requirements.

During the running period of the EXTREMA COST Action (2013–2017), sharing of public tomography data across the community for validation and benchmarking was found to be of primary importance for furthering the advanced tomography community. The papers [17, 18] present the results of two projects aimed at promoting such *open data* research.

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