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Image Reconstruction from Incomplete Data VI

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Introduction

Image Reconstruction from Incomplete Data VI (IRID-VI) was held 2–3 August 2010. A total of 27 papers were accepted for presentation. In addition two joint sessions with Conference 7798 (Applications of Digital Image Processing XXXIII) were scheduled and an excellent plenary address by Mohammad A. Karim on "Optics in antiquity."

This conference continues those of the same name held at the SPIE Annual Meetings in San Diego in 2000, Seattle in 2002, Denver in 2004, and at SPIE Optics + Photonics in San Diego in 2006 and 2008. Conferences on this foundational topic of imaging when measured data are limited, noisy or corrupted somehow have a long history with SPIE under the auspices of the Mathematical Imaging Program. Early meetings on this subject include Applications of Mathematics in Modern Optics (Vol. 358), chaired by W.H. Carter in 1981 at which 29 papers were presented and Inverse Optics I (Vol. 413), edited by A. J. Devaney in 1982 which had 30 papers. The objective of these meetings and the twenty or so that have followed has been to bring together those working on a variety of imaging and inverse problems from a broad range of disciplines. The underlying mathematical structures to image reconstruction and restoration methods are widely applicable to a number of quite different imaging modalities, and the cross fertilization of ideas between those working in these diverse areas is always very stimulating.

In addition to the half day joint session on computational imaging with Applications of Digital Image Processing XXXIII, this year's conference was divided into sessions on tomography with limited data, algorithms and implementation, high resolution imaging, molecular imaging, and two sessions on imaging and sensing. The opening invited presentation by Abbas Ourmazd, "Tomography with random snapshots of faint non-stationary objects" set the scene very well for the conference. The talk illustrated key challenges that attendees and others in the field of image recovery are facing, namely how to combine noisy data sets together, with the help of constraints to generate useful images of either identical or different objects. A number of other papers presented complimented this theme. In the second invited presentation, Usuki et al. described adding redundancy, or additional information, by using structured illumination for optical microscopy of semiconductor wafers. The role of symmetry received particular attention from a number of presenters and in discussions. As in previous years, a wide range of applications from astronomy to imaging viruses, demonstrated the commonality of many imaging problems when using incomplete data.

During this conference there was an opportunity to have an open discussion about challenges and future directions in the field. This took place in session 3 under the themed title of "Challenges in Image Recovery". The conversation was wide ranging and identified several of the factors which in 2010 are generating

challenges. Despite the advances which have been made in digital processing and methodology, it was recognized that ever more difficult imaging problems meant that the field is still faced with many more challenges. The discussion can be summarized by the following bullets:

- Fewer and fewer measurements:
  - the need to reduce acquisition time (e.g. MRI)
  - sparse data collection as an economic or technical necessity (e.g. radio astronomy)
  - fewer measurements require a more trustworthy model

- High noise environments:
  - low dose (e.g. cryoEM, X-ray CT)
  - more extreme experimental requirements (e.g. exploding molecules)
  - need to move away from Gaussian models

- Multiple object classes:
  - different conformations
  - different configurations
  - different orientations
  - different objects (e.g. before and after a reaction, evolving objects)

- Cheaper & cheaper "optics":
  - availability of adaptive systems
  - smart optics
  - new sensors
  - 'no optics' optics
  - driven by the cost of high quality optics

- Maybe we do not need an image at all (!):
  - parameters, not pictures
  - decisions, not pictures
  - meaning comes from the dataset
  - What is an image? (When is a set of numbers an image?)

- Need to evaluate image quality:
  - probably has to be task specific
  - need to design experiments (e.g. how much data are needed to achieve a specific goal, what types, what quality?)

- Exploiting prior knowledge:
  - Is symmetry the most powerful prior knowledge?
  - How to best identify available priors?
  - How to optimally incorporate priors into the recovery process?

The quality of the presentations was high and interactions between participants were productive. The chairs would like to thank the participants, authors, and the program committee members, for their part in making this meeting so successful. Special thanks also go to the professional and efficient staff at SPIE for their assistance over the last year. We look forward to IRID-VII in 2012.

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