Yearly workshop of the FWO international research network (WOG):
Turning images into value through statistical parameter estimation

Image Reconstruction Workshop

20 September 2019
Conference center Zebrastraat, Ghent

Organizers: Aleksandra Pižurica (local chair), Sandra Van Aert, Arjan Den Dekker and Jan Sijbers

Program

08:45 – 09:20 Registration and coffee

09:20 – 09:30 Welcome word

09:30 – 10:30 **Image reconstruction TUTORIAL - Part 1:** Aleksandra Pižurica and Bart Goossens (UGent)

10:30 – 11:00 coffee break

11:00 – 11:45 **Image reconstruction TUTORIAL - Part 2:** Aleksandra Pižurica and Bart Goossens (UGent)

11:45 – 12:00 coffee break

12:00 – 12:40 **KEYNOTE lecture.** Bogdan Roman (University of Cambridge): *Resolution Phenomena and Structure in Undersampled Physical Imaging*

12:40 – 14:10 Lunch and poster session

14:10 – 14:50 **KEYNOTE lecture**. Christine De Mol (ULB): *Nonnegative Matrix Factorization and Blind Imaging*

14:50 – 15:10 **Invited talk.** Georg Schramm (KU Leuven): *An Introduction to Iterative Time-of-Flight (TOF) PET Reconstruction*

15:10 – 15:30 **Invited talk.** Ahmad Rezaei (KU Leuven): *Joint Reconstruction in TOF-PET*

15:30 – 16:00 coffee break

16:00 – 16:40 **KEYNOTE lecture.** Laurent Jacques (UCLouvain): *Computational Fourier Transform Interferometry for Hyperspectral Imaging*

16:40 – 17:00 **Contributed Talk.** Marina Ljubenovic (UAntwerpen)*: Reconstruction of Terahertz Images: Beam Shape Removal*

17:00 – 17:20 **Group discussion**

17:20 – 18:30 Reception

Keynote lecture:
Dr. Bogdan Roman
Department of Pure Mathematics and Mathematical Statistics, University of Cambridge

Resolution phenomena and structure in undersampled physical imaging

Abstract: Signal recovery from undersampled data is of great interest in many physical imaging systems, in particular medical imaging. This talk will present some intriguing asymptotic phenomena which can lead to improvements when carefully exploited, showcasing some practical results in NMR spectroscopy, Fluorescence Microscopy, Helium Spin-Echo and MRI. We show that standard undersampling reconstruction behaves differently at different resolutions and that this phenomenon can be exploited via sampling principles that are aligned with the asymptotic structures, where it becomes possible to highlight higher length scales of interest in order to enhance image resolution and fidelity.

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Keynote lecture:
Prof. Christine De Mol
Department of Mathematics and ECARES, Université Libre de Bruxelles

Nonnegative Matrix Factorization and Blind Imaging

Abstract: In this talk I will review some problems relating to nonnegative matrix factorization (NMF), i.e. to the factorization of a matrix with nonnegative elements into a product of two such matrices. Exact factorization can be used as a rank-reduction method for high-dimensional data. In the case of noisy data, approximate factorization can be considered instead, and formulated as the minimization of a discrepancy criterion reflecting the statistics of the noise. To stabilize the solution, various regularization penalties can be added to this criterion, according to the available prior knowledge. Applications include hyperspectral imaging, blind deconvolution of (nonnegative) images and some problems in medical imaging. To solve the resulting (biconvex) optimization problem, we will focus on multiplicative update schemes which can be derived through a Majorization-Minimization (MM) approach and we will discuss their convergence properties.

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Keynote lecture:
Prof. Laurent Jacques
Institute of Information and Communication Technologies, Electronics and Applied Mathematics (ICTEAM)**,** Université catholique de Louvain

Computational Fourier Transform Interferometry for Hyperspectral Imaging

Abstract: Fourier Transform Interferometry (FTI) is an appealing Hyperspectral (HS) imaging modality for applications demanding high spectral resolution. In fluorescence microscopy (FM), the effective spectral resolution is, however, limited by the durability (or photobleaching) of biological elements when exposed to the illuminating light.

In this talk, we will first focus on two variants of the FTI imager leveraging the theory of compressive sensing (CS). By following a variable density sampling strategy, we provide two light modulation strategies (acting either temporally or spatiotemporally) minimizing the light exposure imposed on a biological specimen while preserving the spectral resolution. Second, we propose a single-pixel HyperSpectral (HS) imaging scheme collimating the light before interferometry and deploying an adapted space-time coding of the light illumination. This solution is of interest for miniaturized hyperspectral imagers.

This is a joint work with Amirafshar Moshtaghpour (UCLouvain, Belgium) and José Bioucas-Dias (IT, Portugal).

Regular talks

Dr. Georg Schramm and Dr. Ahmad Rezaei (KU Leuven) - combined talk

An Introduction to Iterative Time-of-Flight (TOF) PET Reconstruction and Joint Reconstruction in TOF-PET

Positron Emission Tomography (PET) is an important quantitative molecular imaging technique that is widely used in different clinical fields. In PET, the spatio-temporal distribution of a tracer molecule labeled with a positron-emitting isotope is imaged by detecting photon pairs in coincidence originating from positron annihilations. Over the past two decades, improvements in the timing resolution of PET detectors enabled the measurement of the photon arrival time with sufficient precision which in turn allowed the use of the time-of-flight (TOF) in the image reconstruction process. In this talk, we give an overview about the fundamentals of statistical iterative TOF PET reconstruction. Moreover, we introduce advanced reconstruction concepts such as joint estimation of activity and attenuation that are possible due to the availability of TOF information.

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Dr. Marina Ljubenovic (University of Antwerpen)

Reconstruction of Terahertz Images: Beam Shape Removal

Abstract:
In this talk, I will introduce a terahertz imaging technique, some of its applications, and challenges. Terahertz imaging is a nondestructive technique used in many fields (e.g., security, art conservation, biomedicine, pharmacy) for material analyses, quality control, and monitoring. The technique can be used for imaging of opaque materials and dielectrics. The focus of the talk will be on removing of terahertz beam shape effects that are present since the terahertz beam has a non-zero beam waist. Namely, effects of a beam shape can be formulated as a convolution between an underlying sharp image and a point-spread function assumed to be Gaussian. I will start by showing how this Gaussian beam can be modelled and parametrized. Furthermore, I will show two approaches for image estimation: i) conventional model-based deconvolution approach and ii) approach based on neural networks.