PCH60: Computational Inverse Problems - Insight and Algorithms

23-25 August 2017

Technical University of Denmark

DTU Compute
Department of Applied Mathematics and Computer Science

Sponsored by:

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Department of Applied Mathematics and Computer Science

Welcome

Inverse Problems is the science of determining and computing quantities that can only be observed indirectly. Exemplified in tomography, physical signals (e.g. waves, particles, currents) are sent through an object from many different angles, the response of the object to the signal is measured, and an image of the object's interior is reconstructed.

Inverse problems are often inherently ill-posed and thus any reconstruction algorithm must rely on the modelling of prior information often implement in the form of regularization. Insightful modelling and powerful algorithms are cornerstones in the success of inverse problems in applications. Often this field of science in applied mathematics is termed "Computational Inverse Problems".

With this in mind, it is a great pleasure to welcome you to *PCH60: Computational Inverse Problems - Insight and Algorithms.* The occasion of the workshop is Per Christian Hansen's 60th birthday, and we will celebrate Hansen's scientific merits. However, the aim of the workshop is to gather international experts for a great scientific program packed with stimulating talks, novel approaches and mutual discussions on modern and future directions for inverse problems in science and engineering.

We look forward to three exciting days and a program packed with many interesting talks, splendid poster presentations, and lively discussions.

With kind regards,

Martin S. Andersen
Yiqiu Dong
Kim Knudsen
Jakob Sauer Jørgensen
Søren Holdt Jensen
Anne Mette Eltzholtz Larsen

This workshop was made possible thanks to generous support from DTU Compute, Otto Mønsteds Fond, Mosek, and The Danish Council for Independent Research.

Practical Information

Internet Access

Wireless access will be available through the wifi *IDApublic* at the conference center.

Catering

A light breakfast is available at the workshop venue all three days from 8:00. Moreover, lunch is provided also at the venue from 12:00 - 13:00. Wednesday evening from 17:00 we will have a reception with the poster session, and Thursday evening the workshop dinner takes place. All meals are included.

Workshop Website

The workshop website is available at `pch60.compute.dtu.dk`.

Public transportation

The public transportation in Copenhagen is very reliable and takes you almost everywhere. You can get up-to-date travel information and plan your journey on `rejseplanen.dk`. English language can be selected on the site.

Social Activities on Thursday, August 24th, 2017

On Thursday afternoon and evening, the workshop participants are invited to a guided boat tour of the Copenhagen harbour taking us directly to the workshop dinner at Restaurant "No. 2" located at the harbourfront of Copenhagen. The social activities are included in the registration fee.

Please inform the organizers if you do NOT want to participate!

Address:

Restaurant No. 2
Nicolai Eigtvedsgade 32
1402 København K

Wednesday, August 23rd, 2017

08:30	Registration
09:00	Welcome
09:10	**An inverse problem in statistical mechanics** Martin Hanke, Universität Mainz
10:10	**The surprising accuracy of Lanczos tridiagonalization for eigenproblems and solution of equations** Chris Paige, McGill University
10:40	Coffee break
11:00	**Exploring different approaches to improve the inverse problem solutions in electrocardiography** Judit Chamorro-Servent, University of Bordeaux
11:30	**Non linear problems in tomography** Bill Lionhart, University of Manchester
11:45	Lunch
13:00	**Regularization in tomography** Joost Batenburg, CWI Amsterdam
14:00	**Spatially adaptive regularization for total variation minimization** Andreas Langer, University of Stuttgart
14:30	**From ISRA and EM to variable metric inexact linesearch algorithms: application to imaging problems** Marco Prato, Università di Modena e Reggio Emilia
15:00	Coffee break
15:30	**Active-subspace analysis of speckle-based particle measurements** Mirza Karamehmedović, Technical University of Denmark
16:00	**Two-Point Gradient Methods for solving Nonlinear Ill-Posed Problems** Simon Hubmer, Johannes Kepler University Linz
16:30	**Mapping of 3D Grain Structures from Tomographic Data** Erik Lauridsen, Xnovo Technology
17:00	Welcome reception & poster session

Poster Session (17:00–18:30)

Local Mean Multiphase Segmentation With HMMF Models
Jacob Daniel Kirstejn Hansen, University of Copenhagen

Local Mass Pertubations in the Mass-Preserving Image Registration Model
Hari Om Aggrawal, Technical University of Denmark

Iterative Methods for solving an Inverse Problem in Linearized Elasticity
Ekaterina Sherina, Technical University of Denmark

Neumann Boundary Hybrid Data EIT in BV-space
Bjørn Christian Skov Jensen, Technical University of Denmark

Noise in residuals of bidiagonalization-based regularization
Iveta Hhnetynkova, Marie Kubinova, Martin Plesinger, Charles University

Tikhonov-basen regularization methods for ill-posed inverse problems
Alessandro Buccini, Kent State University

Controlled Shearlet Domain Sparsity in X-ray Tomography
Zenith Purisha, University of Helsinki

Directional Total Generalized Variation
Rasmus Dalgas Kongskov, Technical University of Denmark

A Probabilistic Framework for Curve Evolution
Anders Dahl, Technical University of Denmark

Limited-Data X-ray CT for Underwater Pipeline Inspection
Nicolai Brogaard Riis, Technical University of Denmark

New Aspects of the Multi-Frequency Inverse Problem
Adrian Kirkeby, Technical University of Denmark

User-friendly Simultaneous Tomographic Reconstruction and Segmentation with Class Prior
Yiqiu Dong, Technical University of Denmark

Thursday, August 24th, 2017

09:00	**The search for solutions to nonlinear problems - why do algorithms often fail?** Klaus Mosegaard, University of Copenhagen
10:00	**A Unified Framework for the Restoration of Images Corrupted by Additive White Noise** Sgallari Fiorella, University of Bologna
10:30	Coffee break
11:00	**Simultaneous reconstruction and segmentation of CT scans with shadowed data** François Lauze, University of Copenhagen
11:30	**Velocity-space tomography based on neutrons and gammas from fusion reactions at the tokamak JET** Mirko Salewski, Technical University of Denmark
12:00	Lunch
13:00	**Regularization and Compression via Tensor Dictionaries** Misha Kilmer, Tufts University
14:00	**Parallel ILU preconditioning** Thomas Huckle, Technical University of Munich
14:30	Coffee break
15:00	Social activities
18:30	Dinner

Friday, August 25th, 2017

09:00	**SVD Approximations for Large Scale Inverse Problems** James Nagy, Emory University
10:00	**Structure preserving preconditioners for image deblurring** Marco Donatelli, University of Insubria
10:30	Coffee break
11:00	**Iterative Regularization: theory and practice** Silvia Gazzola, University of Bath
11:30	**Adaptive eigenspace method for inverse scattering problems in the frequency domain** Uri Nahum, University of Basal
12:00	Lunch
13:00	**The Arnoldi process for ill-posed problems** Lothar Reichel, Kent State University
14:00	**A computational approach for acousto-electric tomography based on the Levenberg-Marquardt algorithm** Changyou Li, Technical University of Denmark
14:30	Coffee break
15:00	**Computing Segmentation Directly from Projection Data using Parametric Deformable Curve** Vedrana Andersen Dahl, Technical University of Denmark
15:30	**Large Scale Statistical Structure Recovery in Cryogenic Electron Microscopy** Sami S. Brandt, IT University of Denmark
16:00	Closing

Invited Speakers

Joost Batenburg	Centrum Wiskunde & Informatica
Martin Hanke	University of Mainz
Misha E. Kilmer	Tufts University
Klaus Mosegaard	University of Copenhagen
James G. Nagy	Emory University
Lothar Reichel	Kent State University

List of Participants

Joost Batenburg	CWI Amsterdam
James G. Nagy	Emory University
Uri Nahum	University of Basel
Silvia Gazzola	University of Bath
Fiorella Sgallari	Dept. Mathematics, University of Bologna, Italy
Judit Chamorro Servent	Inria-Carmen. IHU-Liryc. University of Bordeaux
Zenith Purisha	University of Helsinki
Alessandro Buccini	Kent State University
Lothar Reichel	Kent State University
Martin Plesinger	Institute of Computer Science, CAS, TU Liberec
Tommy Elfving	Linköping Univ. Sweden
Simon Hubmer	Johannes Kepler University Linz
Martin Hanke	University of Mainz
Jakob Sauer Jørgensen	University of Manchester
Marco Prato	Università di Modena e Reggio Emilia
Christopher Paige	McGill University, Montreal, Canada
Thomas Huckle	Technical University of Munich
Iveta Hnetynkova	Charles University, Faculty of Mathematics and Physics
Marie Kubinova	Charles University, Faculty of Mathematics and Physics
Andreas Langer	University of Stuttgart
Misha E. Kilmer	Tufts University
Marco Donatelli	Università dell'Insubria
Juan M. Peña	Universidad de Zaragoza
Henrik Garde	Department of Mathematical Sciences, Aalborg University
Søren Holdt Jensen	Department of Electronic Systems, Aalborg University
Sami S. Brandt	IT University

Bolaji James Adesokan	DTU Compute
Hari Om Aggrawal	DTU Compute
Martin Andersen	DTU Compute
Anders Dahl	DTU Compute
Vedrana Dahl	DTU Compute
Yiqiu Dong	DTU Compute
Per Christian Hansen	DTU Compute
Bjørn Jensen	DTU Compute
Mirza Karamehmedovic	DTU Compute
Adrian Kirkeby	DTU Compute
Kim Knudsen	DTU Compute
Rasmus Dalgas Kongskov	DTU Compute
Changyou Li	DTU Compute
Kaj Madsen	DTU Compute
Dorte Olesen	DTU Compute
Michael Pedersen	DTU Compute
Nicolai André Brogaard Riis	DTU Compute
Ekaterina Sherina	DTU Compute
Rie Hansen	DTU Electrical Engineering
Michael Mattes	DTU Electrical Engineering
Carsten Gundlach	DTU Physics
Mirko Salewski	DTU Physics
Leise Borg	Department of Computer Science, University of Copenhagen
Jacob Daniel Kirstejn Hansen	Department of Computer Science, University of Copenhagen
Francois Lauze	Department of Computer Science, University of Copenhagen
Klaus Mosegaard	Niels Bohr Institute, University of Copenhagen
Sara Soltani	Fingerprint Cards
Erik Lauridsen	Xnovo Technology ApS

Abstracts

August 23rd, 2017, 09:10-10:10

An inverse problem in statistical mechanics

Martin Hanke
Universität Mainz

Abstract

In a canonical or grand canonical ensemble of classical particles at equilibrium in continuous space we investigate the functional relationship between a given pair potential that determines the interaction of the particles and the molecular distribution functions. For certain admissible perturbations of the pair potential and sufficiently small activity we rigorously establish Frechet differentiability of this mapping in appropriate function spaces, and we provide explicit formulae for the derivative (integral) operator in the thermodynamical limit.

We utilize this information to study iterative methods for the reconstruction of the pair potential of a given system from measured data such as the equilibrium radial distribution function.

August 23rd, 2017, 10:10-10:40

The surprising accuracy of Lanczos tridiagonalization for eigenproblems and solution of equations

Chris Paige
McGill University

Abstract

Cornelius Lanczos's 1952 process for tridiagonalizing a symmetric matrix $A \in \mathbb{R}^{n \times n}$ is the basis for many well known very useful large sparse matrix algorithms. The finite precision process can lose orthogonality immediately the first eigenvector of A has converged to machine precision, and so the Lanczos process was largely discarded, since many believed it did not work. But since about 1971 it has become the basis for some of our most powerful tools for large sparse matrix problems—even though the computational behaviour was poorly understood.

We show that the computational Lanczos process does eventually give all eigenvalues and vectors, or solve equations, with an accuracy similar to that of backward stable methods.

Golub and Kahan's 1965 bidiagonalization of a general matrix B can be used to find the singular value decomposition of B, or solve equations or least squares problems involving B. It can be framed and analyzed as a Lanczos process, and so the present results will probably show it also leads to results which are as accurate as we could hope.

August 23rd, 2017, 11:00-11:30

Exploring different approaches to improve the inverse problem solutions in electrocardiography

Judit Chamorro-Servent
University of Bordeaux

Abstract

Cardiovascular diseases are the leading cause of death in the EU. It causes 11000 death per day in Europe and 5200 death per day in the EU. Non-invasive techniques that identify patients at risk, provide accurate diagnosis, offer a better understanding of the cardiac electrophysiology and guide therapy still fail. These include electrocardiographic imaging (ECGI), an approach in which inverse methods are used to reconstruct heart electrical activity from potentials measured on the body surface. Despite all the success of ECGI, the understanding and treatment of many cardiac diseases is not feasible yet without an improvement of the solution of its inverse problem. A homogeneous meshless scheme based on the method of fundamental solution (MFS) was adapted to ECGI. In the MFS, the potentials are expressed as a linear combination of Laplace fundamental solution over a discrete set of virtual point sources placed outside of the domain of interest. This formulation yields to a linear system, which involves contributions of the Dirichlet and the homogenous Neumann conditions (HNCs) at torso surface (or zero-flux) in an equivalent manner. In this work, we first used the singular value analysis and discrete picard condition (DPC) to optimize our problem (in terms of the respective boundary conditions and virtual sources placement) making it less sensible to the regularization chosen. Then, we reconstruct the potentials, by using a new regularization parameter choice method for the MFS ECGI problem based on DPC. Results demonstrate that: 1. An optimal placement of the sources and *or neglecting the homogeneous Neumann conditions reduces the ill-posedness of the problem, making the solution more robust (less sensible to the regularization chosen). This is especially significant when noise*artifact is present. Furthermore, the computational burden is reduced. 2. The new regularization parameter choice method provided higher correlation coefficients and

lower relative errors than the current one in terms of potentials and activation maps, especially for the spiral data. 3. A spatio-temporal solution seems advisable. To conclude, novel inverse problem methods, some adapted from quite different fields of computer science and mathematics, seems to give a hope to improve the performance of the MFS ECGI inverse solution.

August 23rd, 2017, 11:30-12:00

Non linear problems in tomography

Bill Lionhart
University of Manchester

Abstract

We are used to considering x-ray, gamma ray and neutron attenuation tomography as a linear problems, and for monochromatic attenuation tomography with point sources and point detectors we need only take the logarithm of the data and we have a linear inverse problem. As soon as we have sources and detectors of finite extent the exponential of a linear operator applied to the image is itself averaged and a logarithm no longer linearizes the problem. In rich tomography problems, for example polarimetric neutron tomography of magnetic fields, we have a matrix ODE along rays that cannot be solved with an exponential, even a matrix exponential.

These non-linear problems are relatively mild compared to many other inverse boundary value problems for PDES. For example the Jacobians are still sparse matrices. In this talk we will explore how much of a problem the non-linearity is for reconstruction and practical strategies for solution.

August 23rd, 2017, 13:00-14:00

Regularization in tomography

Joost Batenburg
CWI Amsterdam

Abstract

In this talk I will go over various ways of including regularization techniques for the numerical solution of tomographic problems. We will see that regularization can occur in many forms, both explicitly modelled and deceptively hidden. As an example of the illusionary powers of regularization we will show how it enables us to solve the tomography problem from just one recorded projection.

August 23rd, 2017, 14:00-14:30

Spatially adaptive regularization for total variation minimization

Andreas Langer
University of Stuttgart

Abstract

A good approximation of the original image from an observed image may be obtained by minimizing a functional that consists of a data-fidelity term, a regularization term, and a parameter, which balances data-fidelity and regularization. The proper choice of the parameter is delicate. In fact, large weights not only remove noise but also details in images, while small weights retain noise in homogeneous regions. However, since images consist of multiple objects of different scales, it is expected that a spatially varying weight would give better reconstructions than a scalar parameter. In this vein we present algorithms for computing a distributed weight. We study the convergence behaviour of the proposed algorithms and present numerical experiments for Gaussian noise removal, for impulsive noise removal, and for eliminating simultaneously mixed Gaussian-impulse noise.

August 23rd, 2017, 14:30-15:00

From ISRA and EM to variable metric inexact linesearch algorithms: application to imaging problems

Marco Prato
Università di Modena e Reggio Emilia

Abstract

Many problems in image processing can be reformulated as the minimization of a functional given by a smooth *possibly nonconvex* data fidelity term plus convex *possibly nonsmooth* regularization terms, including indicator functions of convex sets when constraints are available on the desired images. Starting from the iterative space reconstruction algorithm and the expectation maximization method, we show the successive generalizations to the split gradient, scaled gradient projection and variable metric inexact linesearch algorithms, the last one being a recent approach able to address very general formulations of imaging problems in a mathematically sound and practically efficient way.

August 23rd, 2017, 15:30-16:00

Active-subspace analysis of speckle-based particle measurements

Mirza Karamehmedović
Technical University of Denmark

Abstract

We consider laser speckle measurements of concentrations of particle suspensions in a medium when the refractive index n and the size parameter a of the particles are uncertain. Using active-subspace analysis, we quantify the sensitivity of speckle intensity measurements to parameter changes along general directions in the (n, a)-space.

August 23rd, 2017, 16:00-16:30

Two-Point Gradient Methods for solving Nonlinear Ill-Posed Problems

Simon Hubmer
Johannes Kepler University Linz

Abstract

We present and analyse a class of gradient based iterative methods for solving nonlinear ill-posed problems which are inspired by Landweber iteration and Nesterov's acceleration scheme and promise to be good alternatives to second order methods. The usefulness of these methods is demonstrated on two numerical example problems based on a nonlinear Hammerstein operator and the nonlinear inverse problem of single photon emission computed tomography (SPECT).

August 23rd, 2017, 16:30-17:00

Mapping of 3D Grain Structures from Tomographic Data

Erik Lauridsen
Xnovo Technology

Abstract

Laboratory diffraction contrast tomography (LabDCT) opens up new possibilities of non-destructive 3D and time resolved 4D studies of polycrystalline material using a laboratory X-ray source. In addition to absorption contrast and phase contrast tomography, the LabDCT imaging modality spatially resolves crystallographic orientation of individual grains allowing grain shapes and boundaries of metals, alloys or ceramics to be characterized fully in 3D. Examples in both 3D and 4D will demonstrate current capabilities of the LabDCT technique for grain boundary characterization and boundary dynamics.

August 24th, 2017, 09:00-10:00

The search for solutions to nonlinear problems - why do algorithms often fail?

Klaus Mosegaard
University of Copenhagen

Abstract

Some inverse problems in geophysics suffer from a 'brick wall effect', namely that the problem is practically solvable up to a certain number of unknown model parameters, but requires excessive computer resources if only a few more model parameters are added. Such problems seem hard, since an increase in the number of model parameters, due to an extension of the Earth model, apparently results in an (at least) exponential increase in computation time.

Could this effect be a limitation of existing algorithms, or is it a fundamental property of some highly nonlinear inverse problems? If the latter holds true, we must accept in-principle limitations to what can be obtained even from the fastest computers running optimal algorithms.

We shall look into this nature of this problem and see how algorithm developers have sought to ameliorate the performance of current methods. Using information arguments we shall argue that only problem-specific algorithms are able to turn hard inverse problems into polynomial problems.

August 24th, 2017, 10:00-10:30

A Unified Framework for the Restoration of Images Corrupted by Additive White Noise

Sgallari Fiorella
University of Bologna

Abstract

A real captured image may be distorted by many expected or unexpected factors among which blur and random noise are typical and often unavoidable examples. Hence, image deblurring and denoising are fundamental tasks in the field of image processing. Over the years, one of the most studied class of noises is that of additive, independent identically distributed (i.i.d.) noises, which affect all the pixels by independent random corruptions coming from the same distribution. This class includes important noises such as those characterized by Gaussian, uniform, Laplacian and Cauchy distributions, which can be found in many applications, such as e.g. medical and astronomic imaging. For any of these noise distributions, ad hoc variational models have been devised in the past for image restoration.

However, in many practical applications it is difficult to know a priori the noise distribution and, in any case, the noise might be the outcome of several sources thus giving raise to mixed noise models with very specific/complex distributions.

To overcome these inherent difficulties, in this talk we discuss a robust variational model aimed at restoring images corrupted by blur and by the generic wide class of additive white - or uncorrelated - noises, which include i.i.d noises. The solution of the non-trivial optimization problem, due to the non-smooth nonconvex proposed model, is efficiently obtained by means of a numerical algorithm based on the Alternating Directions Method of Multipliers, which in particular reduces the solution to a sequence of convex optimization sub-problems. Numerical results show the potentiality of the proposed model for restoring blurred images corrupted by several kinds of additive white noises.

Joint work with Alessandro Lanza, Serena Morigi and Federica Schiacchitano.

August 24th, 2017, 11:00-11:30

Simultaneous reconstruction and segmentation of CT scans with shadowed data

François Lauze
University of Copenhagen

Abstract

We propose a variational approach for simultaneous reconstruction and multiclass segmentation of X-ray CT images, with limited field of view and missing data. We propose a simple energy minimisation approach, loosely based on a Bayesian rationale. The resulting non convex problem is solved by alternating reconstruction steps using an iterated relaxed proximal gradient, and a proximal approach for the segmentation. Preliminary results on synthetic data demonstrate the potential of the approach for synchrotron imaging applications.

August 24th, 2017, 11:30-12:00

Velocity-space tomography based on neutrons and gammas from fusion reactions at the tokamak JET

Mirko Salewski
Technical University of Denmark

Abstract

JET is the worldwide largest fusion machine and has generated 16 MW of fusion power released in part in the form of neutrons and gamma-rays. Energy spectra of neutrons and gamma-rays have long been used to draw conclusions about the most energetic particles in the fusion plasma. It has this year become possible to measure the 2D velocity distribution of the energetic ions by tomographic inversion relying on three different neutron energy spectrometers and one gamma-ray spectrometer. Here we discuss the method, the challenges and the potential of this new application of velocity-space tomography.

August 24th, 2017, 13:00-14:00

Regularization and Compression via Tensor Dictionaries

Misha Kilmer
Tufts University

Abstract

Over the course of his impressive career to date, Per Christian Hansen's contributions to the algorithms and analysis for the regularization of ill posed problems have been comprehensive in nature. Indeed, my own research has been greatly influenced by his work, and the subjects of our prior joint work have varied considerably. Therefore, I will focus this talk on one small piece of this body of work that is recent and therefore perhaps less well known. Specifically, I will talk about work that has come about as part of a recent project with Per Christian and one of his former students, Sara Soltani, on tensor patch dictionary learning. I will discuss the dictionary learning problem and the use of the dictionaries in applications such as X-ray CT reconstruction [1], image deblurring, and image compression.

[1] Sara Soltani, Misha E. Kilmer, Per Christian Hansen, "A Tensor-Based Dictionary Learning Approach to Tomographic Image Reconstruction," BIT Numer Math, Volume 56, Issue 4, pp 1425–1454, Dec. 2016.

August 24th, 2017, 14:00-14:30

Parallel ILU preconditioning

Thomas Huckle
Technical University of Munich

Abstract

We consider the parallel computation of ILU and MILU preconditioners via Newton iteration. Furthermore, the resulting sparse triangular matrices have to be solved. To this aim we modify the Jacobi method, e.g. including parallel preconditioning. As special case we consider tridiagonal matrices with twisted bidiagonal factorizations.

August 25th, 2017, 09:00-10:00

SVD Approximations for Large Scale Inverse Problems

James Nagy
Emory University

Abstract

Beginning with his 1982 PhD thesis, SVD: Theory and Applications [1], Per Christian Hansen has written numerous important papers that analyze and promote the use of the singular value decomposition for ill-posed inverse problems. In particular, he makes use of the SVD in his most highly cited publications[2, 3, 4, 5], which currently have more than 10000 citations. Moreover, Per Christian has written at least 14 other journal articles (with another 1800+ citations) that have SVD directly in the title. In this talk we provide a brief historical review of some of this early influential work by Per Christian, and use it as motiviation to develop results for a new SVD approximation for large scale inverse problems.

References

[1] P. C. Hansen. SVD – Theory and Applications. PhD Thesis, Danmarks Tekniske Højskole, Numerisk Institut, 1982.

[2] P. C. Hansen. Analysis of discrete ill-posed problems by means of the L-curve. SIAM Review, 34:561–580, 1992.

[3] P. C. Hansen. Regularization tools: A Matlab package for the analysis and solution of discrete ill-posed problems. Numerical Algorithms, 6:1–35, 1994.

[4] P. C. Hansen. Rank-deficient and discrete ill-posed problems. SIAM, Philadelphia, PA, 1997.

[5] P. C. Hansen and D. P. O'Leary. The use of the L-curve in the regularization of discrete ill-posed problems. SIAM J. Sci. Comput., 14:1487–1503, 1993.

August 25th, 2017, 10:00-10:30

Structure preserving preconditioners for image deblurring

Marco Donatelli
University of Insubria

Abstract

Regularizing preconditioners for accelerating the convergence of iterative regularization methods without spoiling the quality of the approximated solution have been extensively investigated in the last twenty years. Several strategies have been proposed for defining proper preconditioners. Usually, in methods for image restoration, the structure of the preconditioner is chosen Block Circulant with Circulant Blocks (BCCB) because it can be efficiently exploited by Fast Fourier Transform (FFT).

Unfortunately, for ill-conditioned problems, it is well known that BCCB preconditioners cannot provide a strong clustering of the eigenvalues. Moreover, in order to get an effective preconditioner, it is crucial to preserve the structure of the coefficient matrix. The structure of such a matrix, in case of image deblurring problem, depends on the boundary conditions imposed on the imaging model. Therefore, we propose a technique to construct a preconditioner which has the same structure of the blurring matrix related to the restoration problem at hand. The construction of our preconditioner requires two FFTs like the BCCB preconditioner. The presented preconditioning strategy represents a generalization and an improvement with respect of both circulant and structured preconditioning available in the literature. The technique is further extended to provide a non-stationary preconditioning in the same spirit of a recent proposal for BCCB matrices. Some numerical results show the importance of preserving the matrix structure from the point of view of both restoration quality and robustness of the regularization parameter.

Joint work with Pietro Dell'Acqua, Claudio Estatico, and Mariarosa Mazza.

August 25th, 2017, 11:00-11:30

Iterative Regularization: theory and practice

Silvia Gazzola
University of Bath

Abstract

This talk will present some new results about iterative regularization methods, which leverage advanced tools in Numerical Linear Algebra. Insight into the theory underlying the new methods, as well as implementation details, will be given.

August 25th, 2017, 11:30-12:00

Adaptive eigenspace method for inverse scattering problems in the frequency domain

Uri Nahum
University of Basal

Abstract

A nonlinear optimization method is proposed for the solution of inverse scattering problems in the frequency domain, when the scattered field is governed by the Helmholtz equation. The time-harmonic inverse medium problem is formulated as a PDE-constrained optimization problem and solved by an inexact truncated Newton-type iteration. Instead of a grid-based discrete representation, the unknown wave speed is projected to a particular finite-dimensional basis of eigenfunctions, which is iteratively adapted during the optimization. Truncating the adaptive eigenspace (AE) basis at a (small and slowly increasing) finite number of eigenfunctions effectively introduces regularization into the inversion and thus avoids the need for standard Tikhonov-type regularization. Both analytical and numerical evidence underpins the accuracy of the AE representation. Numerical experiments demonstrate the efficiency and robustness to missing or noisy data of the resulting adaptive eigenspace inversion method.

August 25th, 2017, 13:00-14:00

The Arnoldi process for ill-posed problems

Lothar Reichel
Kent State University

Abstract

The Arnoldi process is the basis for the GMRES method, which is one of the most popular iterative methods for the solution of large linear systems of algebraic equations that stem from the discretization of a linear well-posed problem. The Arnoldi process and GMRES also can be applied to the solution of ill-posed problems. This talk discusses properties of Tikhonov regularization and iterative methods, that are based on the Arnoldi process, for the solution of linear ill-posed problems. The talk presents joint work with Silvia Noschese and Ronny Ramlau.

August 25th, 2017, 14:00-14:30

A computational approach for acousto-electric tomography based on the Levenberg-Marquardt algorithm

Changyou Li
Technical University of Denmark

Abstract

Acousto-electric tomography (AET) is a hybrid conductivity imaging technique. It is essentially the electrical impedance tomography (EIT) enriched by the modulation effects of focused ultrasound wave on the localized conductivity. It reconstructs conductivity map of physical bodies from measured internal power density and boundary potentials or currents. Most existing computational methods and mathematical analysis of AET were developed by using the ideal continuum model with either Dirichlet or Neumann boundary conditions. This talk will introduce a more practical and accurate computational approach for AET. It will first build the computational reconstruction approach based on Levenberg-Marquardt iteration and complete electrode model (CEM) which is the most accurate forward model for EIT. Numerical experiments shows that this pure CEM-based reconstruction is sensitive to input current pattern and regularization parameters for Levenberg-Marquardt iteration. To overcome this problem, CEM and the ideal continuum model with Dirichlet boundary conditions are mixed in the Levenberg-Marquardt iterations.

August 25th, 2017, 15:00-15:30

Computing Segmentation Directly from Projection Data using Parametric Deformable Curve

Vedrana Andersen Dahl
Technical University of Denmark

Abstract

Processing of projection data usually starts by computing a reconstructed image, often followed by a segmentation step. Combining reconstruction and segmentation leads to methods that compute a segmented reconstruction directly from the projection data. This is useful when the object under study consists of a number of domains with approximately homogeneous absorption coefficients. In the presented work, we use a parametric deformable curve to obtain such segmentation. Unlike similar approaches based on level sets, we never consider a pixel representation of the scanned object. Our current implementation uses a simple closed curve and is capable of separating one object from the background. However, our basic algorithm can be applied to an arbitrary topology and multiple domains of different absorption coefficients. We demonstrate excellent performance under high noise and a small number of projections.

August 25th, 2017, 15:30-16:00

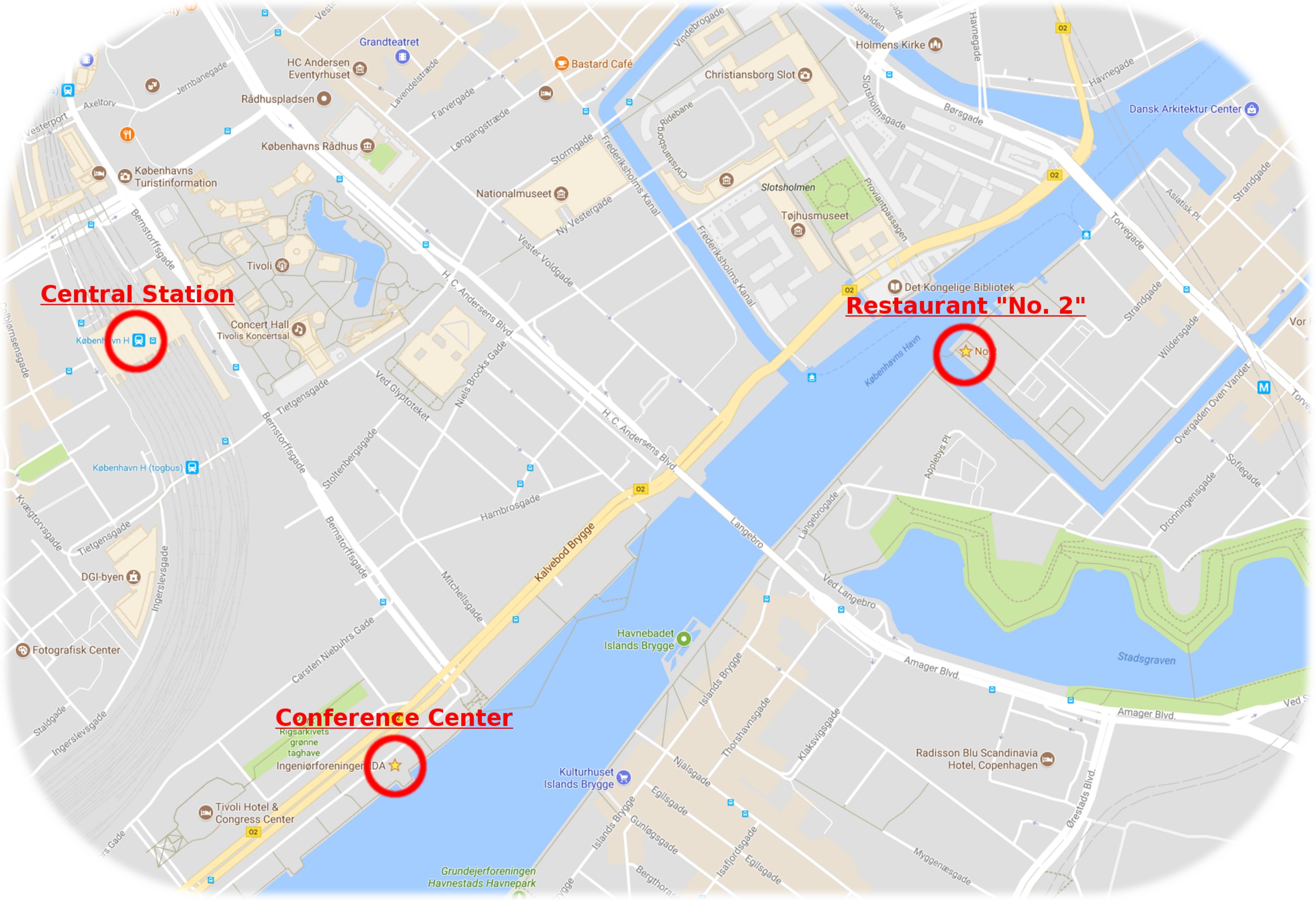
Large Scale Statistical Structure Recovery in Cryogenic Electron Microscopy

Sami S. Brandt
IT University of Denmark

Abstract

Cryogenic electron microscopy intends to reconstruct biological particles on the nanometer scale from transmission images taken by a transmission electron microscope. In contrast to the image reconstruction problems in other fields of tomographic imaging, the reconstruction problem has the particular characteristics of having a huge number of 2D projection images of a bio-particle, with structural variations, while the projection geometry of the projections is unknown and random. This setting makes the statistical inversion problem particularly challenging where the state-of-the-art reconstruction methods require CPU months for processing a single particle. In this talk, we will discuss the reconstruction problem and the state-of-the-art, present our contributions, and sketch an outline for the future.

Notes



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København H (togbus)
Tivoli
Concert Hall
Tivolis Koncertsal
Københavns Rådhus
Rådhuspladsen
HC Andersen Eventyrhuset
Grandteatret
Bastard Café
Københavns Turistinformation
Nationalmuseet
Christiansborg Slot
Holmens Kirke
Slotsholmen
Tøjhusmuseet
Det Kongelige Bibliotek
Dansk Arkitektur Center
Københavns Havn
Stadsgraven
Havnebadet Islands Brygge
Kulturhuset Islands Brygge
Radisson Blu Scandinavia Hotel, Copenhagen
Tivoli Hotel & Congress Center
Ingeniørforeningen IDA
Rigsarkivets grønne taghave
Grundejerforeningen Havnestads Havnepark
DGI-byen
Fotografisk Center
Kalvebod Brygge
H. C. Andersens Blvd.
Bernstorffsgade
Tietgensgade
Stoltenbergsgade
Ved Glyptoteket
Niels Brocks Gade
Hambrosgade
Mitchellsgade
Carsten Niebuhrs Gade
Ingerslevsgade
Kvægtorvsgade
Staldgade
Vester Voldgade
Ny Vestergade
Stormgade
Løngangstræde
Farvergade
Lavendelstræde
Jernbanegade
Axeltorv
Vesterport
Frederiksholms Kanal
Vindebrogade
Ridebane
Christiansborg Ridebane
Slotsholmsgade
Proviantpassagen
Børsgade
Havnegade
Torvegade
Strandgade
Asiatisk Pl.
Wildersgade
Overgaden Oven Vandet
Sofiegade
Dronningensgade
Applebys Pl.
Langebrogade
Langebro
Ved Langebro
Amager Blvd.
Ørestads Blvd.
Islands Brygge
Thorshavnsgade
Klaksvigsgade
Njalsgade
Egilsgade
Gunløgsgade
Isafjordsgade
Bergthorasgade
Myggenæsgade

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