IP1

Nonconformist Image Processing with the Graph Laplacian Operator

The key building blocks of modern image processing are two-fold: a measure of affinity between pixels; and an operator that turns these affinities into filters that can accomplish a variety of useful tasks. Examples of the affinity measure are many, including bilateral, NLM, etc. And the standard operator used to construct the filters is the (normalized) weighted average of the affinities. But if we consider the pixels in an image as nodes in a weighted graph, the Laplacian operator on this graph gives us a strikingly versatile tool for building a very general class of filters with a much larger range of applications. A little-appreciated property of the (continuous) Laplacian operator is that it measures the nonconformity of a function to its surroundings. This remarkable property and its discrete approximations enable (1) progressive image decomposition from fine to coarse scale, yielding a principled framework for image smoothing, sharpening and local tone manipulation; and (2) a clear framework for building image-adapted priors to solve more general inverse problems such as deblurring. We have used this framework to develop many components of a practical imaging pipeline for mobile and other applications.

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IP2

High Resolution Tactile Sensing for Robotics, Metrology, and Medicine

The interaction of light and matter at a surface is complex. A GelSight sensor overrides the native optics and isolates 3D shape. A clear elastomer slab with a reflective membrane is pressed against the surface. An embedded camera views the membrane; computer vision extracts shape. While conceived as a robot touch sensor, GelSights micronscale resolution has spawned commercial applications in 3D surface metrology (profilometry). In robotics, its high resolution, combined with its ability to capture shape, texture, shear, and slip, provides unique tactile capabilities. We are also exploring medical measurements, ranging from blood pressure to tissue pathology.

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IP3

Image Processing, Internet-of-Things, and Inverse Problems: Blind Deconvolution Meets Blind Demixing

Assume we need to correctly blindly deconvolve and separate (demix) multiple signals at the same time from one single received signal. This challenging problem appears in numerous applications, and is also expected to arise in the future Internet-of-Things. We will prove that under reasonable assumptions, it is indeed possible to solve this ill-posed inverse problem and recover multiple transmitted functions f_i and the associated impulse responses g_i robustly and efficiently from just one single received signal via semidefinite programming. We will tip our toes into the mathematical techniques behind our theory and discuss efficient numerical algorithms as well as applications.

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IP4

Semantic Scene Parsing by Entropy Pursuit

The grand challenge of computer vision is to build a machine which produces a rich semantic description of an underlying scene based on image data. Mathematical frameworks are advanced from time to time, but none clearly points the way to closing the performance gap with natural vision. Entropy pursuit is a sequential Bayesian approach to object detection and localization. The role of the prior model is to apply contextual constraints in order to determine, and coherently integrate, the evidence acquired at each step. The evidence is provided by a large family of powerful but expensive high-level classifiers (e.g., CNNs). The order of execution is determined online, and is driven by removing as much uncertainty as possible about the overall scene interpretation given the evidence to date. The goal is to match, or even exceed, the performance obtained with all the classifiers by implementing only a small fraction.

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IP5

Recent Advances in Seismic Technology: From Imaging to Inversion

The primary goal of seismic imaging is to transform seismic time reflection data recorded at the earths surface into a reflectivity or impedance image of the subsurface in order to locate hydrocarbon reserves. Historically this has been accomplished in seismic processing through imaging algorithms that are based on the adjoint of acoustic forward Born or Kirchhoff scattering. More recently, however, advances in algorithm development have led to the initial use of nonlinear inversion as an alternative to standard imaging algorithms. In this talk I will briefly review the historical development of seismic imaging, and then discuss the status of nonlinear inversion in the seismic industry, including the use of Full-Waveform Inversion for impedance model estimation, and more recent tomographic extensions that attempt to promote inversion technology into a full-bandwidth model-recovery solution. The various concepts I present will be illustrated with seismic imaging and inversion examples from a number of geologic settings around the world.

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IP6

Event-Based Silicon Retina Technology

This talk will be about the development of asynchronous silicon retina vision sensors that offer a spike-event output like biological retinas. These neuromorphic sensors offer advantages for real-world vision problems in terms of latency, dynamic range, temporal resolution, and post-processing cost. These event-based sensors offer opportunities for theoretical and practical developments of new classes of algorithms aimed at many dynamic vision applications. The presentation will include a demonstration of a recent-vintage sensor. URL: http://sensors.ini.uzh.ch

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SP1

SIAG/Imaging Science Early Career Prize Lecture - Revisiting Classical Problems of Image Processing: Looking for New Ways to Address Longstanding Problems

Digital images are generated by using physical acquisition devices, such as digital cameras, but also by simulating light propagation through environmental models. In both cases, physical or computational limitations in the image formation process introduce artifacts such as image blur or noise. Thus, developing image processing techniques becomes indispensable to help overcome these barriers. In this talk, I present several image processing applications in which a change of perspective leads to new insight and simpler, yet powerful, algorithms. Examples are: intrinsic camera PSF estimation, burst and video deblurring, Monte Carlo rendering denoising.

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SP2

SIAG/Imaging Science Best Paper Prize Lecture - Scale Invariant Geometry for Nonrigid Shapes

Animals of the same species frequently exhibit local variations in scale. Taking this into account we would like to develop models and computational tools that answer questions as: How should we measure the discrepancy between a small dog with large ears and a large one with small ears? Are there geometric structures common to both an elephant and a giraffe? What is the morphometric similarity between a blue whale and a dolphin? There have been two schools of thoughts that quantified similarities between surfaces which are insensitive to deformations in size. Namely, scale invariant local descriptors, and global normalization methods. Here, we propose a new tool for shape exploration. We introduce a scale invariant metric for surfaces that allows us to analyze nonrigid shapes, generate locally invariant features, produce scale invariant geodesics, embed one surface into another despite changes in local and global size, and assist in the computational study of intrinsic symmetries where the size of a feature is insignificant.

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CP1

Algorithm to Build A Parametrized Model for the Antenna Aperture Illumination for Radio Astronomical Imaging Application

The imaging performance of modern array radio telescopes is limited by the instantaneous knowledge of the time, frequency and polarization properties of the antenna aperture illumination pattern (AIP). While imaging algorithms exist that can correct for these effects, they require an accurate instantaneous model for the antenna AIP. We describe algorithm for a low-order parametrized model for the AIP and demonstrate that it captures the dominant time, frequency and polarization dependence of the true AIP. Modern interferometric radio telescopes consist of 100s of independent antennas with wide-band receivers (bandwidth 8GHz or more) which are together capable of imaging the sky at imaging dynamic range well exceeding a part in a million. At such high sensitivities the antenna far-field pattern varies with time, frequency, polarization. Correcting for all these variables of the AIP during imaging has so far been considered a hard problem, limiting the imaging performance of modern radio telescopes. The method described here is an important step forward in solving this major problem facing all current and future radio telescopes for deep-imaging observations. We use a computationally efficient ray-tracing code to predict the AIP parametrized for the physical and electromagnetic characteristics of the antenna. We show that our method is optimal in building an AIP model that minimizes the degrees-of-freedom and demonstrate that without such accurate models, modern radio telescopes cannot achieve their advertised imaging performance.

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CP1

Wide-field full-Stokes Radio Interferometric Imaging: The role of the antenna response function

All modern radio interferometry now use wide bandwidth receives capable of enabling high sensitivity imaging. However such receivers and high sensitivities brings with it a number of instrumental and atmospheric effects that inhibit high fidelity, high dynamic range continuum imaging. The dominant instrumental direction dependent effect is that of the antenna far field voltage pattern. Apart from time and frequency dependence, the antenna aperture illumination pattern (AIP – Fourier transform of the far-field voltage pattern) also introduces significant instrumental polarization in directions away from the center in the field-of-view. To correct for the errors due to all these effects, I present a generalized imaging algorithm that enables deep wide-band imaging of the radio sky in all Stokes. The radio sky is inherently linearly polarized at only a few percent level. The full-polarization antenna response to the signal in any one direction is given by the Jones matrix. The diagonal terms of the Jones matrix encode the antenna gain for the two incoming pure polarization products (linear or circular), while the off diagonal terms contains magnitude

of the leakage of one polarization into other due to instrumental imperfections. In practice these off-diagonal terms are much stronger than the signal making precise measurement of sky impossible. The existing A-Projection algorithm accounts for only the diagonal terms. In this talk I will demonstrate the limitations that arise from ignoring the off diagonal terms and the need for the generalized A-Projection algorithm. I will then describe the Full-Jones A-Projection algorithm, and show that it will be required for all current and future telescopes to achieve their advertised high fidelity, high dynamic range imaging capability.

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CP1

Effect of Micro-CT Scans Resolution and Scale on the Prediction of Transport Properties of Digital Rocks

We studied the effects of image resolution on the prediction of transport properties of digital rock samples. Having 3D micro-CT scans of Benthein sandstone acquired with different resolutions we estimated statistical properties of segmented images and performed statistical image reconstruction. After that transport properties and topological structure of the original digital rocks and those reconstructed on the base of truncated Gaussian simulation were computed showing that transport properties stabilizes when resolution goes below 3 micrometers.

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CP1

Compressive Mid-Infrared Spectroscopic Tomography: Label Free and Chemically Specific 3D Imaging.

We develop a mid-infrared optical imaging modality that combines scattering microscopy and imaging spectroscopy to determine spatial morphology and chemical composition in three spatial dimensions from interferometric data. The forward imaging model incorporates the constraint that the sample comprises few chemical species with known spectra. Images are formed using an iterative reconstruction algorithm with sparsity-driven regularization. Simulations illustrate imaging of layered media and sub-wavelength point scatterers in the presence of noise.

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CP1

Sparse View Compton Scatter Tomography with Energy Resolved Data

The use of energy selective detectors for Compton Scatter Tomography holds the hope of enhancing the performance especially for problems with limited- view in presence of highly attenuating materials. We present a broken-ray forward model mapping mass density and photoelectrical coefficients into observed scattered photons, an iterative reconstruction method for image formation and initial results for recovering spatial maps of these physical properties to characterize material in baggage screening application with limited view, energy-resolved data.

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CP2

Matrix Decompositions Using Sub-Gaussian Random Matrices

Matrix decompositions, and especially SVD, are very im-

portant tools in data analysis. When big data is processed, the computation of matrix decompositions becomes expensive and impractical. In recent years, several algorithms, which approximate matrix decomposition, have been developed. These algorithms are based on metric conservation features for linear spaces of random projections. We present a randomized method based on sparse matrix distribution that achieves a fast approximation with bounded error for low rank matrix decomposition.

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CP2

Iterated Tikhonov with General Penalty Term

In many applications, such as astronomy and medicine, arises the problem of image deblurring, this inverse problem is ill-conditioned and the inevitable presence of noise make a very difficult task obtaining a good reconstruction of the true image. The discrete formulation of this problem comes as a linear system

$$Ax = b,$$

where A is a very large and severely ill conditioned matrix and b is corrupted by noise. In order to compute a fair approximation of the original image the problem has to be regularized. One of the most used regularization method is Tikhonov regularization

$$x_\alpha = \arg\min_x \|Ax - b\|^2 + \alpha \|Lx\|^2, \quad \alpha > 0.$$

The formulation above is called *general from*, since it includes also the presence of a regularization operator L which weights the penalty term. This operator enhance some features of the solution while penalizing others. In the case $L = I$, in order to improve the quality of the reconstruction, a refinement technique has been introduced. At each step the reconstruction error is approximated using the Tikhonov minimization on the error equation and is used as a correction term, so this algorithm is denoted as Iterated Tikhonov. However, to the best of our knowledge, the general theory about this iterative method has been developed only in the *standard form*, i.e., when $L = I$. In this talk we want to cover the theory behind the general iterated Tikhonov, when one consider the iteration related to Tikhonov minimization in general form. We will form the method, describe its characteristics and, in particular, we prove that the proposed iteration converges and that is a regularization method. Moreover we will introduce the non-stationary iterations which will show to be more robust in respect to the choice of the regularization parameter α. Finally, we will show the effectiveness of this method on image deblurring test data.

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CP2

Parallel Douglas Rachford Algorithm for Restoring Images with Values in Symmetric Hadamard Manifolds

The talk addresses a generalization of the Douglas-Rachford algorithm to symmetric Hadamard manifolds. It can be used to minimize an anisotropic TV functional for images having values on these manifolds. We derive an parallel DR algorithm, that can be evaluated fast. Convergence of the algorithm to a fixed point is proofed for spaces with constant curvature. Several numerical examples show its beneficial performance when compared with the cyclic proximal point algorithm or half-quadratic minimization.

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CP2

A New Variable Metric Line-Search Proximal-Gradient Method for Image Reconstruction

We present a variable metric line–search based proximal–gradient method for the minimization of the sum of a smooth, possibly nonconvex function plus a convex, possibly nonsmooth term. The strong convergence of the method can be proved if the objective function satisfies the Kurdyka–Łojasiewicz property at each point of its domain. Numerical experience on some nonconvex image reconstruction problems shows the proposed approach is competitive with other state-of-the-art methods.

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CP2

Modulus Iterative Methods for Nonnegative Constrained Least Squares Problems Arising from Image Restoration

For the solution of large sparse nonnegative constrained least squares (NNLS) problems with Tikhonov regularization arising from image restoration, a new iterative method is proposed which uses the CGLS method for the inner iterations and the modulus iterative method for the outer iterations to solve the linear complementarity problem resulted from the Karush-Kuhn-Tucker condition of the NNLS problem. Theoretical convergence analysis including the optimal choice of the parameter matrix is presented for the proposed method. In addition, the method can be further enhanced by incorporating the active set strategy, which contains two stages where the first stage consists of modulus iterations to identify the active set, while the second stage solves the reduced unconstrained least squares problems only on the inactive variables. Numerical experiments show the efficiency of the proposed methods compared to projection gradient-type methods with less matrix vector multiplications and CPU time.

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CP3

Image Deblurring With An Imprecise Blur Kernel Using a Group-Based Low-Rank Image Prior

We present a regularization model for the image deblurring problem with an imprecise blur kernel degraded by random errors. In the model, the restored image and blur are characterized by a group-based low-rank prior enforcing simultaneously the nonlocal self-similarity, local sparsity, and mean-preserving properties. An alternating minimization algorithm is developed to solve the proposed model. Experimental results demonstrate the effectiveness of our model and the efficiency of our numerical scheme.

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CP3

A Fast Algorithm for Structured Low-Rank Matrix Recovery with Applications to Mri Reconstruction

A powerful new class of MRI reconstruction techniques require solving a large-scale structured low-rank matrix recovery problem. We present a novel, fast algorithm for this class of problem that adapts an iteratively reweighted least squares approach to incorporate multi-fold Toeplitz/Hankel structures. The iterates can be solved efficiently in the original problem domain with few FFTs. We demonstrate the algorithm on undersampled MRI reconstruction, which shows significant improvement over standard compressed sensing techniques.

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CP3

Enhanced Sparse Low-Rank Matrix Estimation

We propose to estimate sparse low-rank matrices by minimizing a convex objective function consisting of a data-fidelity term and two non-convex regularizers. The regularizers induce sparsity of the singular values and the elements of the matrix, more effectively than the nuclear and the ℓ_1 norm, respectively. We derive conditions on the regularizers to ensure strict convexity of the objective function. An ADMM based algorithm is derived and is applied to image denoising.

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CP3

Image Regularization with Structure Tensors - Edge Detection, Filtering, Denoising

Edge detection, filtering, and denoising are fundamental topics in digital image and video processing area. Edge preserving regularization and diffusion based methods although extensively studied and widely used for image restoration, still have limitations in adapting to local structures. We consider a class of filters based on multiscale structure tensor based features. The spatially varying exponent model we develop leads to a novel restoration method which retains and enhances edge structures across scales without generating artifacts. Promising extensions to handle jpeg decompression, edge detection, and multichannel imagery are considered. Related project page contains more details: http://cell.missouri.edu/pages/MTTV.

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CP3

Signal Classification Using Sparse Representation on Enhanced Training Dictionary

We propose a method to classify high-dimensional signals based on how sparsely a test signal can be represented over a dictionary containing selected training samples and basis vectors of the approximated tangent planes at those training samples, which are computed using local PCA. Our experiments on various datasets including the standard face databases demonstrate that this method can achieve higher classification accuracy than other sparse representation-based methods when the class manifolds are nonlinear and sparsely-sampled.

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CP3

Low-Rank Approximation Pursuit for Matrix and Tensor Completion

we introduce an efficient greedy algorithm for matrix completion, which is literally a generalization of orthogonal rank-one matrix pursuit method (OR1MP) in the sense that multiple s candidates are identified per iteration by low-rank matrix approximation. Owing to the selection of multiple s candidates, our approach is finished with much smaller number of iterations when compared to the OR1MP. In addition, we extend the OR1MP algorithm to deal with tensor completion.

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CP4

Sparse Approximation of Images by Adaptive Thinning

Anisotropic triangulations provide efficient methods for sparse image representations. We propose a locally adaptive algorithm for sparse image approximation, adaptive thinning, which relies on linear splines on anisotropic triangulations. We discuss both theoretical and practical aspects concerning image approximation by adaptive thinning. This includes asymptotically optimal N-term approximations on relevant classes of target functions, such as horizon functions across α Hölder smooth boundaries and regular functions of $W^{\alpha,p}$ regularity, for $\alpha > 2/p - 1$.

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CP4

Joint Deconvolution and Blind Source Separation of Hyperspectral Data Using Sparsity

The hyperspectral restoration is very challenging when taking into account not only the spectral mixing, but also blurring effects. We propose a new Blind Source Separation method which addresses this problem by alternating two minimizers, one solving a hyperspectral deconvolution problem using sparsity, and leading to a generalization of the FORWARD algorithm, and the second estimating the mixing matrix by a least square inversion. A range of examples illustrates the results.

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CP4

Sparse Source Reconstruction for Nanomagnetic Relaxometry

Source reconstruction for nanomagnetic relaxometry requires solving the magnetic inverse problem. By discretizing the field of view, we can compute a lead field matrix that relates the contribution of each pixel to the signal received by the detectors. We then approximate a minimum l_0-norm solution by iterating over the minimization problem:

$$\min_x ||\frac{x_i}{w_i}||_1 \text{ s.t. } ||Ax - b||_2 \leq \epsilon$$

Our approach for verification and validation of our algorithmic implementation in phantom studies will be presented.

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CP4

Convolutional Laplacian Sparse Coding

We propose to extend the the standard convolutional sparse representation by combining it with a non-local graph Laplacian term. This additional term is chosen to address some of the deficiencies of the ℓ^1 norm in regularizing these representations, and is shown to have an advantage in both dictionary learning and an example image reconstruction problem.

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CP4

Gap Safe Rules for Speeding-Up Sparse Regularization

High dimensional regression / inverse problems might benefit from sparsity promoting regularizations. Screening rules leverage the sparsity of the solution by ignoring some variables in the optimization, hence speeding up solvers. When the procedure is proven not to discard features wrongly, the rules are said to be "safe". We derive new safe rules for generalized linear models regularized with L1 or L1/L2 norms. The rules are based on duality gap computations allowing to safely discard more variables, in particular for low regularization parameters. Our GAP Safe rule can cope with any iterative solver and we illustrate its performance on Lasso, multi-task Lasso, binary and multinomial logistic regression, demonstrating significant speed ups on all tested datasets with respect to previous safe rules. This is a joint work with E. Ndiaye, O. Fercoq and A. Gramfort

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CP5

Removal of Curtaining Effects by a Variational Model with Directional Forward Differences

Focused ion beam tomography provides high resolution volumetric images on a micro scale. However, due to the physical acquisition process the resulting images are often corrupted by a so-called curtaining effect. In this talk, a new convex variational model for removing such effects is proposed. More precisely, an infimal convolution model is applied to split the corrupted 3D image into the clean image and two types of corruptions, namely a striped and a laminar part.

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CP5

NonLocal via Local–NonLinear via Linear: A New Part-Coding Distance Field via Screened Poisson Equation

We propose a repeated use of Screened Poisson PDE to compute a part coding field for perceptual tasks such as shape decomposition. Despite efficient local and linear computations, the field exhibits highly nonlinear and nonlocal behavior. Our scheme is applicable to shapes in arbitrary dimensions, even to those implied by fragmented partial contours. The local behavior is independent of the image context in which the shape resides.

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CP5

Boundary Formulation of Finite Differences: Analysis and Applications

Estimation of numerical derivatives on the boundary values remains an unresolved dilemma in many inverse problems. Many formulations such as cyclic or Neumann conditions violate the derivative continuity and cause discrepancies. This presentation provides a numerical solution to calculate derivatives on the boundaries with high order polynomial accuracy in a unified convolution matrix. The numerical stability of this matrix is analyzed via the distribution of the eigenvalues and perturbation analysis and compared to the existing formulations in the literature.

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CP5

Solving Variational Problems and Partial Differential Equations That Map Between Manifolds Via

the Closest Point Method

Maps from a manifold $\mathcal{M}$ to a manifold $\mathcal{N}$ appear in image processing, medical imaging, and many other areas. This talk introduces a numerical framework for variational problems and PDEs that map between manifolds. The problem of solving a constrained PDE between $\mathcal{M}$ and $\mathcal{N}$ is reduced into two simpler problems: solving a PDE on $\mathcal{M}$ and projecting onto $\mathcal{N}$. Numerical examples of denoising texture maps, diffusing random maps, and enhancing colour images are presented.

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CP5

Regularization Strategy for Inverse Problem for 1+1 Dimensional Wave Equation

An inverse boundary value problem for a 1+1 dimensional wave equation with wave speed $c(x)$ is considered. We give a regularisation strategy for inverting the map $\mathcal{A} : c \mapsto \Lambda$, where Λ is the hyperbolic Neumann-to-Dirichlet map corresponding to the wave speed c. We consider the case when we are given a perturbation of the Neumann-to-Dirichlet map $\tilde{\Lambda} = \Lambda + \mathcal{E}$, and reconstruct an approximate wave speed $\tilde{c}$. Our regularization strategy is based on a new formula to compute c from Λ. Moreover we have done numerical implementation and executed it with a simulated data.

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CP5

Exploiting Sparsity in PDEs with Discontinuous Solutions

Exploiting sparsity plays a central role in many recent developments in imaging and other related fields. We use ℓ_1 regularization techniques to promote sparsity in the edges of PDEs with discontinuous solutions. This has led us to the development of numerical algorithms that do not have the restrictive stability conditions on time stepping that normally occur. With these methods we increase the accuracy of methods that do not account for sparsity in the solution.

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CP6

Extracting Plane Symmetry Group Information from Tiles with Color Permutations

Repeating a base motif creates a tile with different symmetries. A tile has color symmetry, if applying certain symmetry on a tile maps all regions of one color to the regions of another color. In this work, we propose a novel approach to extract the unit cells and fundamental domains of tiles with various color symmetries, both considering and ignoring color permutations. We use multiple ideas from variational and PDE based image processing methods.

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CP6

New Techniques for Inversion of Full-Waveform Induced Polarization Data

Induced polarization (IP) is a geophysical method that measures electrical polarization of the subsurface. Standard methods for inversion of IP data use simplified models that neglect much of the information collected in modern surveys, limiting imaging resolution. We are developing high performance multigrid based methods for modelling full IP decay curves from large sources along with a corresponding inversion algorithm that combines voxel-based Tikhonov regularized inversion with a parametric-level set approach.

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CP6

Bidirectional Texture Function Bernoulli-Mixture Compound Texture Model

This paper introduces a method for modeling textures using a parametric BTF compound Markov random field model. The purpose of our approach is to reproduce, compress, and enlarge a given measured texture image so that ideally both natural and synthetic texture will be visually indiscernible. The model can also be applied to BTF material editing. The control field is generated by the Bernoulli mixture model and the local textures are modeled using the 3DCAR.

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CP6

Information Theoretic Approach for Accelerated Magnetic Resonance Thermometry in the Presence of Uncertainties

A model-based information theoretic approach is presented to perform the task of Magnetic Resonance (MR) thermal image reconstruction from a limited number of observed samples on k-space. The key idea of the proposed approach is to optimally detect samples of k-space that are information rich with respect to a model of the thermal data acquisition. These highly informative k-space samples are then used to refine the mathematical model and efficiently reconstruct the image.

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CP6

BLA: A Weak Form Attenuation Compensation Model for Ultrasonic Imagery

The quality of medical sonography is hindered by the shadowing or enhancement artifacts due to acoustic wave propagation and attenuation across tissue layers. We present a Backscatter-Levelset-Attenuation (BLA) joint estimation model in the context of regional ultrasound attenuation compensation and structural segmentation. The BLA model eliminates the need of solving PDEs over irregular domains, and is formulated using level sets. We provide numerical algorithms along with discretization schemes. The main advantage of the BLA method is its remarkable computational efficiency. We demonstrate the results using simulated, phantom and in vivo ultrasound images.

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CP7

A Fractional Order Variational Model for Optical Flow Estimation Based on Sparsity Algorithm

In this paper, a fractional order variational model is proposed for estimating the optical flow. The proposed fractional order model is introduced by generalizing an integer order variational model formed with a global model of Horn and Schunck and the classical model of Nagel and Enkelmann. In particular, the proposed model generalizes the existing variational models from integer to fractional order, and therefore a more suitable in estimating the optical flow. However, it is difficult to solve this generalized model due to the complex fractional order partial differential equations. The Grünwald-Letnikov derivative is used to discretize the fractional order derivative. The corresponding sparse linear system of equations is solved by using a sparsity algorithm in order to improve the convergence rate of the solution. The experimental results on different datasets verify the validity of the proposed model.

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CP7

Optical Flow on Evolving Sphere-Like Surfaces

We consider optical flow on evolving surfaces which can be parametrised from the 2-sphere. Our main motivation is to estimate cell motion in time-lapse volumetric microscopy images depicting fluorescently labelled cells of a live zebrafish embryo. We exploit the fact that the recorded cells float on the surface of the embryo and allow for the extraction of an image sequence together with a sphere-like surface. We solve the resulting variational problem by means of a Galerkin method based on vector spherical harmonics and present numerical results.

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CP7

Classification of Hyperspectral Data Using the Besov Norm

Sparse representations have been extensively studied in image processing, however not much has been done with sparse-based classification problems. In this study, we discuss the use of wavelets in hyperspectral imaging. The analysis-based approach accounts for more aspects of the data than the coordinate-wise euclidean distance approach. We estimate the local properties of the hyperspectral stack using the Besov norm for a given choice of wavelet. Thereby, allowing for multiscale and multidirectional features.

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CP7

New Uncertainty Principles for Image Feature Ex-

traction

The motivation for this talk is window design for image feature extraction by a filter bank. There is a conventional framework for analyzing localization aspects of window functions. We claim that the conventional framework is flawed, and develop a new adequate theory. Our approach leads to new uncertainty principles and new optimal window functions. Filter banks based on our new optimal window functions have a certain notion of sparsity.

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CP7

Hyperspectral Video Analysis Using Graph Clustering Methods

Perhaps the most challenging imaging modality to analyze in terms of the vast size of the data are videos taken from hyperspectral cameras. We consider an example involving standoff detection of a gas plume involving Long Wave Infrared spectral data with 128 bands. Rather than using PCA or a similar dimension reduction method we treat this as a "big data" classification problem and simultaneously process all pixels in the entire video using novel new graph clustering techniques. Computation of the entire similarity graph is prohibitive for such data so we use the Nystrom extension to randomly sample the graph and compute a modest number of eigenfunctions of the graph Laplacian. A very small part of the spectrum allows for spectral clustering of the data. However with a larger but still modest number of eigenfunctions we can solve a graph-cut based semi supervised or unsupervised machine learning problem to sort the pixels into classes. We discuss challenges of running such code on both desktops and supercompers.

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CP7

Image Segmentation with a Shape Prior

We study variational models for segmentation incorporating a shape prior, and our method involves computing the global minimiser of a functional with fixed fitting terms. We define this prior implicitly in such a way that the image intensity information is incorporated into the minimisation of the affine parameters of the registration step, improving the model's reliability. We discuss how this approach compares to similar methods, and present numerical results to demonstrate its performance.

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CP8

Error Estimates and Convergence Rates for Filtered Back Projection

The filtered back projection (FBP) formula allows us to reconstruct bivariate functions from given Radon samples. However, the FBP formula is numerically unstable and low-pass filters of finite bandwidth are employed to make the reconstruction less sensitive to noise. In this talk we analyse the intrinsic reconstruction error incurred by the low-pass filter. We prove L^2-error estimates on Sobolev spaces of fractional order along with asymptotic convergence rates, where the bandwidth goes to infinity.

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CP8

Density Compensation Factor Design for Non-Uniform Fast Fourier Transforms

In applications such as magnetic resonance imaging (MRI), radar imaging, and radio astronomy, data may be collected as a sequence of non-uniform Fourier samples. One common approach used to reconstruct images from non-uniform Fourier data involves regridding the non-uniform Fourier data to uniform points, and then applying the FFT, a process often referred to as the non-uniform FFT (NFFT). In the regridding process, parameters often termed the density compensation factors (DCFs) are used essentially as quadrature weights to construct the inverse Fourier transform. The DCFs are typically chosen using heuristic arguments, and, depending on the sampling pattern, may not lead to a convergent approximation. In this talk we illustrate the importance of choosing DCFs appropriately. We develop an algorithm to design DCFs based on the given sampling scheme and demonstrate numerical convergence. We further apply our algorithm to recover features (such as edges) of the underlying image, which is especially useful in target identification or tissue classification.

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CP8

The Factorization Method for Imaging Defects in Anisotropic Materials

In this presentation we consider the inverse acoustic or electromagnetic scattering problem of reconstructing possibly multiple defective penetrable regions in a known anisotropic material of compact support. We develop the factorization method for a non-absorbing anisotropic background media containing penetrable defects. In particular, under appropriate assumptions on the anisotropic material properties of the media we develop a rigorous characterization for the support of the defective regions form the given fair field measurements. Finally we present some numerical examples in the two dimensional case to demonstrate the feasibility of our reconstruction method including examples for the case when the defects are voids (i.e. subregions with refractive index the same as the background outside the inhomogeneous hosting media).

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CP8

Ghosting in Principal Component Pursuit: An Incremental Approach

In video background modeling, ghosting occurs when an object that belongs to the background is detected in the foreground. In the context of PCP, this usually occurs when a moving object occludes a highly distinguishable background's object. Based on a previously developed incremental PCP method, we propose a method to identify and eliminate the ghosting effect. It is based on incremental rank-1 SVD updates and on the analysis of the current background estimate.

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CP8

Stochastic Image Interpolation with Positional Errors

We consider the interpolation of sparsely sampled image information when the location of the collecting sensor is uncertain. A Gaussian Process model is employed jointly determining the image data and the sensor locations under various statistical models for the stochastic locations. Analytical tools are developed for quantifying the maximal variance in location uncertainly that can be tolerated to ensure a level of interpolation fidelity. Application to the interpolation of CubeSat radiometer data is considered.

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CP8

Nonlinear Parametric Inversion Using Randomization

In PDE-based inverse problems with many measurements, we have to solve many large-scale discretized PDEs for each evaluation of the misfit or objective function. In the nonlinear case, each time the Jacobian is evaluated an additional set of systems must be solved. This leads to a tremendous computational cost. Our approach leads to solutions of the same quality as obtained using all sources and detectors but at a greatly reduced computational cost.

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CP9

Linear Inverse Mri Approximation from Nonlinear Mri

Magnetic resonance imaging (MRI) produces a complex-valued multivoxel image. Its magnitude is nonlinearly related to the magnetic susceptibility (χ) source; whereas its phase is linearly related to the χ source in the small phase angle regime, which enables χ reconstruction by solving a linear inverse MRI problem. The involved ill-posed dipole inversion is solved by a total-variation-regularized split Bregman (TVB) algorithm. In large phase angle scenarios, the inverse MRI solution becomes nonlinear.

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CP9

The Partial Volume Problem in Magnetic Resonance Fingerprinting from a Bayesian Perspective

Magnetic resonance fingerprinting (Ma et al, Nature 2013) produces quantitative maps of parameters such as T1 and T2 relaxation times. However, pixels containing signal from multiple tissue types may be incorrectly mapped. The mixed signal is $y = Ax + \xi$ where A is a dictionary containing simulated signal evolutions and x determines the contribution of each entry. We solve the system in the Bayesian framework, using the prior density to encourage sparsity of x.

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CP9

MIND Demons: Symmetric Diffeomorphic Deformable Registration of MR and CT Images

A symmetric diffeomorphic 3D image registration algorithm –"MIND Demons'– was developed to estimate nonrigid image transformations incorporating modality-independent-neighborhood descriptors (MIND) and a Huber metric for non-linear MR-CT image intensity non-correspondence. The algorithm optimizes viscoelastic diffeomorphisms under geodesic, smoothness, and invertibility constraints by alternating fast Gauss-Newton optimization and Tikhonov regularization in a multiresolution scheme. Applications to spine surgery demonstrated improved registration accuracy (1-2 mm) and subvoxel inverse-consistency (0.008 mm) compared to mutual-information-based Demons and B-spline methods.

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CP9

Background Signal Suppression for Magnet Resonance (mr) Phase Images

MR images have a magnitude and a phase, but in almost all clinical applications only the magnitude images are used, because the phase images have a smooth but strong background signal that masks useful information. The phase contains information such as the temperature during thermal ablation, and the iron content of brain tissue. We present a novel method to suppress the background that is based on higher order edge detection and sparse image representation.

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CP9

Non-Linear Optical Flow for Lung Ct Registration

The registration of lung CT images plays an important role in effective treatment planning and tracking of medical conditions effecting the lungs, for example tumours, as such fast and accurate registration algorithms are required. In this talk I will describe and compare several non-linear optical flow methods in order to ascertain how well they register sets of lung CT data. I will also discuss results of new models and solution approaches from combining segmentation and registration.

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CP10

Non-Stationary Blind Super-Resolution

Super-resolution is generally referred to as the task of identifying unknown parameters from coarse information. Motivated by applications such as single molecule imaging, radar imaging, etc, we consider the problem of parameter estimation of complex exponentials from their modulations with unknown waveforms, allowing for non-stationary blind super-resolution. This problem, however, is extremely ill-posed since both the parameters associated with the complex exponentials and modulating waveforms are unknown. To alleviate this, we assume that the unknown waveforms live in a common low-dimensional random subspace. Using a lifting trick, we recast this bilinear inverse problem as a parametrized low-rank matrix recovery problem from random sensing measurements. An atomic norm minimization problem is then formulated, which is equivalent to a computationally efficient semidefinite program. We show that, up to the scaling ambiguities, exact recovery of both of the parameters of complex exponentials and the samples of the unknown waveforms is possible when the number of measurements is proportional to the number of degrees of freedom in the problem. Numerical simulations are conducted to support our theoretical findings, which show that non-stationary blind super-resolution using convex programming is possible.

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CP10

A Vectorial Total Generalized Variational Model for Multichannel Sar Image Speckle Suppression

It is a challenging task for multichannel SAR image speckle suppression, especially for those with important details and features. We proposed a novel vectorial total variational model which integrates total generalized variation. This novel model regularizes different image regions at different levels and suppresses speckle with better edges and fine details than the existing regularization models. Some numerical simulations are presented to show that the regularizer preserves various image features much better than the VTV.

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CP10

A Locally Adaptive Wiener Filter in Graph Fourier Domain for Improved Image Denoising

We propose a Wiener filtering scheme in graph Fourier domain for improving image denoising performance achieved by spectral graph based denoising methods. It employs graph Fourier coefficients of the noisy image that are already processed for denoising, to estimate a Wiener filter that further improves the achieved denoising performance; and can be applied patchwise adaptively, or to the entire image. We report higher peak signal-to-noise ratio figures than BM3D method for some images.

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CP10

On Diffeomorfic Image Registration Models and Their Effective Solution Algorithms

Image registration is a process of finding correspondences between two different dates. But in large deformation registration problems, it is very difficult to obtain a solution with no folding. J.Modersitzki (2004,2007) and L.M.Lui(2014) have used Jacobian determinant and Beltrami coefficient to avoid the twist. We propose a novel model combining Jacobian determinant and Beltrami coefficient to get a diffeomorfic transformation. Numerical results demonstrate that our model can have a good effect on the large deformation.

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CP10

CITRUS: Cueing Image Target Regions by Unmixing Spectra

Target detection in remotely sensed hyperspectral imagery traditionally seeks the specific pixels that contain a given material of interest. In this study, we give up some precision in spatial target location in exchange for a lower false alarm rate. Instead of pixels, we seek regions (or tiles) that contain target material. The detection map highlights the tiles with high per-tile detection scores, and serves as a visual cueing tool for an analyst.

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CP11

A Max-Cut Approach to the Heterogeneity Problem in Cryo-Electron Microscopy

The problem in single particle reconstruction is to estimate the structure of a molecule given a set of projection images. When the set contains images of two or more types of molecules, one needs to classify the images. In many cases this problem is unsolved. We present an algorithm for reconstruction of all the structures in a heterogeneous problem. We prove theoretical bounds on the performance of the algorithm, and show results on real data.

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CP11

Single Particle Tracking of Blinking Particles

Live cell imaging experiments frequently generate large volumes of time-lapse image data. The desired information often corresponds to the trajectories of individual, fluorescently-labeled particles, making single particle tracking (SPT) a critical component of the image analysis pipeline. Complicating the analysis, often the fluorescent labels employed either blink or can only be detected intermittently due to their low signal-to-noise. An n-dimensional, graph theory based SPT algorithm has been developed, explicitly designed for tracking intermittent observations.

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CP11

Multiscale Imaging of Carbonate Rocks and 3D Stochastic Reconstruction for Digital Rock Physics

Nano-porous geomaterials are important for subsurface emerging problems. We apply integrated multiscale imaging of carbonate rock from nanometer to centimeter scales to characterize 3D structures and mineral distributions for petrophysical and mechanical properties from the nanometer to centimeter scales. With primary pore textures honored, 3D digital pore networks can be reconstructed using several stochastic approaches. Lattice Boltzmann method is used to obtain tortuosity and permeability at several different scales.

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CP11

The Role of Visual Saliency in Seismic Interpretation with An Application to Salt Dome Delineation

We propose a new saliency-based seismic attribute for computer-assisted interpretation of large seismic volumes. We further propose a framework to delineate salt dome structures using saliency and visual attention theory. The experimental results on the real seismic dataset acquired from the North Sea, F3 block show the effectiveness of the proposed framework using both subjective and objective evaluation measures. The proposed framework has a very promising future in effective seismic interpretation. In this work, we demonstrate that viewing the large seismic volumes as a scene with underlying hypotheses and structures is a very promising direction.

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CP11

Stochastic Methods on Geophysical Inverse Problems

Stochastic optimization methods, like stochastic gradient descent and stochastic average gradient, show fast initial convergence on the first iteration rounds and use only a subset of the data at a time. We study the use of these methods when solving computationally demanding geophysical inverse problems. These problems are ill-posed, with unknown noise and large data sets. Our goal is to use the stochastic aspect to find an appropriate halting time to avoid over-fitting the data.

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MS1

Second Order TV-Type Regularization Methods for Manifold-Valued Images

In many real world situations, measured data is noisy and nonlinear, i.e., the data is given as values in a certain manifold. Examples are Interferometric Synthetic Aperture Radar (InSAR) images or the hue channel of HSV, where the entries are phase-valued, directions in $\mathbb{R}^n$, which are data given on $\mathbb{S}^{n-1}$, and diffusion tensor magnetic resonance imaging (DT-MRI), where the obtained pixel of the image are symmetric positive definite matrices. In this talk we extend the recently introduced total variation model on manifolds by a second order TV type model. We first introduce second order differences on manifolds in a sound way using the induced metric on Riemannian manifolds. By avoiding a definition involving tangent bundles, this definition allows for a minimization employing the inexact cyclic proximal point algorithm, where the proximal maps can be computed using Jacobian fields. The algorithm is then applied to several examples on the aforementioned manifolds to illustrate the efficiency of the algorithm. This is joint work with M. Back, J. Persch, G. Steidl, and A. Weinmann.

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MS1

A Primal-Dual Extragradient Method for Nonlin-

ear Forward Models in Function Spaces

Abstract not available.

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MS1

Variable Metric Line-Search Methods for Nonsmooth Convex and Non-Convex Optimization, with Applications in Imaging

Iterative algorithms for the numerical solution of nonsmooth optimization problems involving an objective function that is a combination of a data misfit term and regularizing penalty are discussed. The proposed algorithms are based on variable metrics, descent directions and the Armijo line-search rule. Convergence results are given in the convex and non-convex case, and are also examined in case the proximal operator of the non-smooth part of the objective function can only be calculated approximately. Based on joint work with S. Bonettini, F. Porta, M. Prato and S. Rebegoldi.

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MS1

Coordinate Update Methods in Image Processing and Machine Learning

This talk focuses on a class of algorithms, called *coordinate update algorithms*, which are useful at solving large-sized problems involving linear and nonlinear mappings, and smooth and nonsmooth functions. They decompose a problem to simple subproblems, where each subproblem updates one, or a small block of, variables each time. The coordinate update method sits a high-level of abstraction and include many special cases such as Jacobi, Gauss Seidel, and coordinate descent methods. They have found applications throughout signal/imaging processing, differential equations, and machine learning. We abstract many problems to the fixed-point problem $x = Tx$. This talk discusses the favorable structures of the operator T that enable highly efficient coordinate update iteration: $x_i^{k+1} = (Tx^k)_i$. It can be carried out in sequential, parallel, or async-parallel fashions. We introduce new scalable coordinate-update algorithms to many problems involving coupling constraints $Ax = b$, composite nonsmooth functions $f(Ax)$, and large-scale data. We present numerical examples with hundreds of gigabytes of data.

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MS2

Convex Relaxation Methods for Computer Vision

Numerous problems in computer vision and image analysis can be solved by optimization methods. Yet, many classical approaches correspond to non-convex energies which leads to suboptimal solutions and often strong dependency on appropriate initialization. In my presentation, I will show how problems like stereo or multiple view reconstruction, segmentation and 3D shape matching can be tackled by means of convex relaxation methods which allow to efficiently compute globally optimal or near-optimal solutions. The arising large-scale convex problems can be solved by means of efficient and provably convergent primal-dual algorithms. They are easily parallelized on GPUs providing high-quality solutions in acceptable runtimes.

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MS2

Partial Optimality in Discrete Problems Based on Their Polyhedral Relaxations

We propose a sufficient condition for optimality of a part of a relaxed solution to the original discrete optimization problem. It generalizes previous results on persistency in vertex packing, pseudo-Boolean optimization, 0-1 polynomial programming as well as a number of methods for partial optimality in multilabel energy minimization (general graphical models). We show that the maximum subset of variables satisfying the condition can be determined in polynomial time and propose an efficient implementation for pairwise models.

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MS2

A Semidefinite Relaxation for Computing Distances Between Metric Spaces

In this talk we explore a semidefinite relaxation for a metric between point clouds. We derive an algorithm based on alternating direction augmented Lagrangian that can

efficiently compute the distance between point clouds with hundreds of points.

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MS2

(Discrete-Continuous Optimization)^2 for Computer Vision

In this talk we discuss two convex relaxations for image processing that contain discrete and continuous aspects. The first relaxation addresses discrete labeling problems (i.e. multi-class segmentation) on continuous domains and their relation to local polytope relaxations well known in machine learning. The second convex relaxation addresses continuous labeling problems on discrete graph structures, which allows to model jointly combinatorial and continuous problems.

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MS3

Recent Advances in Transform Learning for Blind Compressed Sensing in Imaging

Sparse signal modeling using synthesis or analysis dictionary learning involves approximations of NP-hard sparse coding, and expensive learning steps. Recently, sparsifying transform learning (STL) received interest for its cheap and exact closed-form solutions to iteration steps. We present several extensions to this framework: (i) online STL, for big data and video denoising; (ii) a union of transforms model with greater representation power; and (iii) filter bank STL acting on entire images rather than on patches.

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MS3

Flexible Multi-layer Sparse Approximations of Matrices and Applications

Non-adaptive analytic dictionaries such as the Fourier or wavelet matrices benefit from fast algorithms. On the other hand, adaptive learned dictionaries traditionally suffer from their high computational complexity. We propose a dictionary structure that is both adaptive and computationally efficient. We investigate the applicability of this dictionary structure to both reconstructive and predictive dictionary learning, and explore its generalization properties.

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MS3

On Fast Transform Optimization

We study a strategy to optimize sparse convolution kernels leaving on the edges of a tree. They define a fast transform and target atoms prescribed by the user. The so-constructed (deep) optimization problem is smooth but might be strongly non-convex. Experiments shows that fast transforms can be optimized and opens many perspectives.

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MS3

Trainlets: Dictionary Learning in High-Dimension

Dictionary Learning has traditionally been restricted to small dimensions due to computational constraints. We present a method based on a new cropped wavelets decomposition, enabling a multi-scale decomposition without considerable border effects, and employ it within a double sparsity model. We propose an online sparse dictionary learning algorithm to train this model effectively, enabling it to handle very large training sets and big dimensions, obtaining large adaptable atoms that we call *trainlets*.

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MS4

Markov Chain Monte Carlo Methods for Inverse Problems Involving Partial Differential Equations

The application of MCMC methods to large-scale inverse problems presents many interesting challenges and research questions. In this talk, I will present two Markov chain Monte Carlo (MCMC) methods for inverse problems. I will first consider cases in which the forward model is linear and the regularization operator is defined by a partial differential equation, yielding a Gaussian Markov random field prior and a Gibbs sampler for sampling both the unknown parameters and the scaling parameters for the noise and prior. I will then move on to the case in which the forward model is defined by a partial differential equation, yielding a nonlinear inverse problem, and a Metropolis-Hasting method with a proposal defined via an application of an optimization method.

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MS4

A Large-Scale Ensemble Transform Method for Bayesian Inverse Problems Governed by PDEs

We present an ensemble-based method for transforming prior samples to posterior ones. This method avoids Markov chain simulation and hence discarding expensive work when a sample is rejected. The idea is to cast the problem of finding posterior samples into a large-scale linear programming problems for which efficient and scalable solver can be developed. Large-scale numerical results will be presented to demonstrate the capability of the method. Authors: Aaron Myers, Alexandre Thiery, Kainan Wang, and Tan Bui-Thanh

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MS4

Statistical Inversion In Electrical Impedance Tomography For Damage Detection In Concrete

In this presentation, we will present the formulation of the statistical inversion for damage detection in civil engineering structures using Electrical Impedance Tomography (EIT). We will present a recently proposed Pilot Adaptive Metropolis algorithm for image reconstruction. We will discuss our preliminary results using experimental data.

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MS5

Iterative Joint Regularization in Multichannel Image Reconstruction via Bregman Distances

Motivated by the idea to exploit the often encountered similarity of structures in different image channels we generalize and extend the concept of Bregman iterations [S. Osher et al., An iterative regularization method for total variation-based image restoration, SIAM Multiscale Model. Simul., 4 (2005), pp. 460-489] to multichannel data: For one-homogeneous functionals a joint subgradient is iteratively enforced by the use of Bregman distances between different channels. Focussing on TV regularization, we give a geometric interpretation of the Bregman distance and present some results on RGB-images illustrating how solutions with joint edge sets are promoted.

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MS5

Joint Mr-Pet Reconstruction Using Nuclear Norm Based Multi-Channel Tgv Regularization

We propose a joint MR-PET reconstruction approach that regards the two modalities as different channels of a single image and employs multi-channel total generalized variation regularization. The gradients of the two channels are coupled via a point-wise nuclear norm. This promotes sparsity of the singular values of the joint Jacobian and hence aligns edges independent of the image constrast. In-vivo experiments show a substantially improved reconstruction quality compared to both standard methods and separate regularization.

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MS5

Structural Regularization for fMRI

We present construction of a structural regularization for fMRI with sparsely sampled data. The anatomical prior information for the construction of the regularization functional is extracted from a densely sampled MRI frame which is acquired as part of the fMRI measurement protocol. The approach is evaluated using simulated measurement data and experimental data taken from a Wistar rat specimen using a 9.4T small animal MRI scanner.

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MS5

Molecular Particle Imaging: Basic Models, Mathematical Challenges and First Results

We will present the basic mathematical model of MPI and its related challenges. Our goal is to combine MPI with magnetic resonance imaging, which however, requires to register images displaying different physical quantities. i.e. the different reconstructions do not share dominant landmark structures besides the general morphological information contained in the region of interest of the MPI sources. We will outline our proposed approach for MPI-MR bimodal imaging.

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MS6

Curvature based Seeded Watershed for Clumped Object Segmentation

Segmentation of 3D images containing clumped objects of different characteristics is very important in many applications such as cell counting in biology, but can be quite challenging. In such applications, the watershed transform is efficient given reasonable set of markers, but otherwise leads to over-segmentation in the presence of low-contrast variation or excessive noise. Interpreting a 3D image as 3-manifold in 4D space, this talk will focus on seeded watershed using geometric properties of hypersurfaces.

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MS6

Multiphase Image Segmentation Via Equally Distanced Multiple Well Potential

We propose a family of functionals defined on vector valued functions that involve a multiple well potential of the type arising in diffuse-interface models of phase transitions. A potential with equally distanced wells makes it possible to retrieve the penalization of the true (i.e., not weighted) length of the boundaries.

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MS6

A Wavelet Frame Method with Shape Prior for Ultrasound Video Segmentation

Ultrasound video segmentation is a challenging task due to low contrast, shadow effects, complex noise statistics, and the needs of high precision and efficiency for real time applications such as operation navigation and therapy planning. In this paper, we propose a wavelet frame based video segmentation framework incorporating different noise statistics and sequential distance shape priors. The proposed individual frame nonconvex segmentation model is solved by a proximal alternating minimization algorithm and the convergence of the scheme is established based on the recently proposed Kurdyka- Lojasiewicz property. The performance of the overall method is demonstrated through numerical results on two real ultrasound video data sets. The proposed method is shown to achieve better results compared to related level sets models and edge indicator shape priors, in terms of both segmentation quality and computational time

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MS6

Image Segmentation with Dynamic Artifacts Detection and Bias Correction

The Chan-Vese (CV) model for region-based image segmentation fails when images are affected by artifacts (outliers) and illumination bias. Here, we introduce a model for segmenting such images. In a single energy functional, we introduce a dynamic artifact class preventing intensity outliers from skewing the segmentation, and in Retinex-fashion, we decompose the image into a piecewise-constant structural part and a smooth bias part. The segmentation only acts on the structure, only in regions not identified as artifacts, and is efficiently optimized using threshold dynamics.

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MS7

Efficient Hybrid Iterative Methods for Bayesian Inverse Problems

Inverse problems arise in various scientific applications, and Bayesian approaches are often used for solving statistical inverse problems, where unknowns are modeled as random fields and Bayes rule is used to infer unknown parameters by conditioning on measurements. In this work, we develop hybrid iterative methods for computing maximum a posteriori estimators, for problems where the prior covariance matrix is accessed directly. Our approach is different from previous approaches since we avoid forming (either explicitly, or matvecs with) the square root or inverse of the prior covariance matrix. Instead, we make an appropriate change of variables and consider a hybrid Golub-Kahan bidiagonalization iterative process with weighted inner products. The proposed algorithm is efficient and scalable to large problem sizes and has the benefit that regularization parameters can be determined automatically.

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MS7

Truncation Methods for Hybrid Regularization

Hybrid regularization methods allow efficient regularization of inverse problems after projection on a subspace. However, if convergence is slow, the memory requirements may be a problem. Hence we consider truncation techniques for hybrid methods.

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MS7

An Incremental Proximal Gradient Method for Spectral Computerized Tomography

In contrast to conventional computerized tomography (CT), spectral CT accounts for the polyenergetic nature of x-rays. Improved modeling can not only reduce artifacts but also provide additional information. However, the arising inverse problem is nonlinear and standard reconstruction techniques are not directly applicable. This presentation discusses a computationally efficient algorithm for spectral CT based on incremental proximal gradient methods. Joint work with Martin S. Andersen and Jakob S. Jorgensen, Technical University of Denmark.

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MS7

Robust Regression for Mixed Poisson Gaussian Model

We consider image deblurring problem with Poisson data and additive Gaussian noise. The maximum likelihood functional for this model can be approximated by a weighted least squares problem with the weights depending on the computed data. However, the least squares solution is not robust if outliers occur. We propose a modification of the data fidelity function using the idea of robust regression and test the resulting method on data with various types of outliers.

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MS8

A Convex Variational Approach for Restoring Blurred Images with Cauchy Noise

Over the years, many variational models have been introduced for removing Gaussian noise, Poisson noise, multiplicative noise, and impulse noise. In this talk, we focus on a very impulsive noise, the so-called Cauchy noise. Inspired by the ROF model, we propose a convex variational model, based on total variation as the regularization term, for restoring images with blur and Cauchy noise. Numerical experiments show that our approach outperforms other well-known methods.

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MS8

A Majorization-Minimization Generalized Krylov Subspace Methods for Lp-Lq Image Restoration

A new majorization-minimization framework for lp-lq image restoration is presented. The solutions are sought in generalized Krylov subspaces that are build up during the solution process. Computed examples illustrate that high-quality restorations can be determined with a modest number of iterations and that the storage requirement of the method is not very large. A comparison with related methods shows the competitiveness of the method proposed. Numerical examples with different p and q show the promising results for non-Gaussian noises.

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MS8

Maximum-A-Posteriori Image Registration for Noisy Data

We propose a unified framework for registration of noisy images by modeling the unperturbed image as additional unknown. Interpreting the motion as a linear operator on the image we are able to derive an optimal estimation of the unperturbed image for any fixed transformation. By this we obtain specific distance measures for each transformation and each data fidelity term associated to the image noise. We give an existence result for a wide range of data fidelity terms in case of the mass-preserving transformation operator. Finally, we show potential advantages of the proposed framework by experimental evaluation on synthetic datasets.

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MS8

A Gaussian Curvature Based Denoising Model for Non-Gaussian Noise.

In the last years, curvature based regularizers have become very popular in variational models for image denoising. However, up to our knowledge, all these models have been designed to deal with additive Gaussian noise only. In this work, we present a Gaussian curvature based model capable to remove fairly both Gaussian and Non Gaussian noise. Analisis and results of the model will be presented.

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MS9

Anatomically Constrained Large-scale Matrix Decomposition in Neuroimaging

Biomedical researchers increasingly turn to machine learning methods to go beyond prior hypotheses. However, such tools may not yield interpretable results. Prior-based eigenanatomy addresses this concern by allowing researchers to finely guide methods such as the singular value decomposition with existing hypotheses on the relationships within their data. We provide examples of these methods as applied to MRI data and show their value for increasing predictive power while retaining interpretability.

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MS9

Medical Image Analysis: Applications in Need for High-End Computing

Modern medical imaging studies involve complex and multi-faceted imaging data. Moreover, the problems being explored become increasingly complex themselves. We review two problems in our computational neuroimaging work, which require, or can potentially require intensive computations: 1) generative-discriminative learning in structural neuroimaging and in functional connectomics, 2) segmentation and registration of images with tumors.

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MS9

Sparse Kaczmarz Methods - Analysis via Bregman Projections for Convex Feasibility Problems

We propose a flexible algorithmic framework to compute sparse or minimal-TV solutions of linear systems. The framework includes both the Kaczmarz method and the linearized Bregman method as special cases and also several new methods such as a sparse Kaczmarz solver. Since the framework includes methods that do not work with the whole system matrix but with subset of the rows (or even only single rows at a time), it can be applied to huge scale problems. The algorithmic framework has a variety of applications and is especially useful for problems in which the linear measurements are slow and expensive to obtain. We present examples for online compressed sensing, TV tomographic reconstruction and radio interferometry.

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MS9

Joint Methods for Reconstruction and Background Field Removal of QSM

Quantitative Susceptibility Mapping (QSM) is a MRI technique that allows to image magnetic properties of tissue. QSM is applied increasingly, for example, in neuroscience, where iron concentration serves as a biomarker of certain neurological diseases. While the tissues susceptibility cannot be measured directly it can be reconstructed by solving a highly ill-posed inverse problem. In this talk, we will present joint methods for QSM reconstruction as well as the related subproblem of background field removal.

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MS10

A Scale-Adaptive Method for Retracing and Registering in Correlative Light-Electron Microscopy

Correlative light-electron microscopy (CLEM) aims at a better understanding of cell mechanisms by relating dynamics with structure. However, LM and EM images are of very different size, resolution, field-of-view, appearance, usually requiring manual assistance at one or several stages. We have defined an original automated CLEM retracing-and-registration method involving a common representation with adaptive scale for both types of images, and the specification of appropriate descriptors and similarity criterion for the EM patch search.

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MS10
Quantitative Cell Morphodynamics

The motility of cells is governed by a complex machinery operating at the molecular scale, eventually translating local mechanical forces into whole-cell deformation. Here we present a biophysical optical flow method to extract dense maps of internal pressure and forces directly from live cell imaging data. This is achieved by mapping the motion of fluorescently labeled intracellular structures with a fluid dynamics model of the cellular material, using image analysis, physical modeling and mathematical optimization techniques.

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MS10
Enabling Phenotypic Screening Through Image Analysis

Building on robust visual tracking methods we will present methods for characterising cellular states, in particular those that help to analyse different modes of cell death. It will be demonstrated how hierarchical Dirichlet processes can be used to identify such cellular states. In addition it will be discussed how tracking methods can be used to analyze macrophage epithelial interactions.

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MS10
Shape-Constrained Tracking with Active Contours

We propose a shape-constrained tracking framework based on active contours for the study of worm motility. The main ingredient of our approach is the formulation of a shape space, which defines a set of admitted transformations of the worm body. It allows for the decomposition of worm motion into a collection of modes, hence giving insights into the nature of the different locomotion patterns present in a dataset.

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MS11
Diffusion Tensor Imaging: Reconstruction Using Deterministic Error Bounds

Correct noise modelling in Diffusion Tensor Imaging is challenging: it involves the Rician distribution and the nonlinear Stejskal-Tanner equation. Linearization of the latter in the statistical framework would complicate the noise model even further. We propose an alternative approach based on regularization in Banach lattices, where errors are represented as bounds by means of the appropriate partial order and simple error structure is preserved under monotone transformations. We present reconstruction results on both synthetic and in-vivo brain data.

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MS11
5D Respiratory Motion Model Based Image Reconstruction Algorithm for 4D Cone-Beam Computed Tomography

We aim to develop a new 4DCBCT reconstruction method based on 5D model. Instead of reconstructing a temporal sequence of images after the projection binning, our method reconstructs time-independent reference image and vector fields without requirement of binning. The formulated optimization problem with total-variation regularization on both reference image and vector fields is solved by the proximal alternating minimization algorithm, of which the convergence analysis is provided. Validated by the simulation, our method has significantly improved image reconstruction accuracy due to reduced number of unknowns.

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MS11

Quantitative Ultrasound-Modulated Optical Tomography: Application of Linearised Models in Practical Imaging

Ultrasound-modulated optical tomography (UOT) is a hybrid imaging modality which uses the spatially localised acoustically driven modulation of coherent light as a probe of the structure and optical properties of biological tissues. A principle goal of this developing technology is the reconstruction of clinically relevant quantitative images of the absorption and scattering coefficients of biological media, with a spatial resolution exceeding that of purely optical techniques such as diffuse optical tomography (DOT). Significant effort has been expended in advancing the experimental technique in UOT, but less attention has been paid to the fundamental problem that such hybrid techniques can only recover quantitative images under some form of model-based reconstruction procedure. In this presentation I will begin by reviewing the coupled physics which enable this modality. I will introduce various approaches to forward modelling, including a computationally efficient linearised diffusion style formulation, solved by the finite element method. I will pose the inverse problem, and examine the Frchet derivatives of the forward mapping which define the sensitivity of the technique. Finally, I will demonstrate two approaches to the reconstruction. In the first, I will show a simulated reconstruction using an adjoint-assisted, gradient based formulation. In the second, I will show the use of a fully linearised reconstruction approach on experimental data acquired using photo-refractive crystal detection.

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MS11

Primal-Dual Optimization of Phase Retrieval Via Optimization Transfer

Optimization transfer can be used to minimize the nonconvex phase retrieval problem via a series of minimizations of convex majorizer functions. These majorizers, when combined with variable splitting methods, provide accelerated empirical convergence in both 1D and 2D robust phase retrieval. This presentation will focus on primal-dual methods for robust phase retrieval using both sparse regularization and image-domain constraints. Empirical results including Monte Carlo simulations and reconstructions of synthetic images will be presented.

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MS12

A Posteriori Error Control for the Binary Mumford-Shah Model

We present robust a posteriori error estimates for the area of the non-properly segmented region in the binary Mumford-Shah model. A suitable uniformly convex and non-constrained relaxation of the originally non-convex functional is investigated and Repin's functional approach for a posteriori error estimation is used to control the numerical error for the relaxed problem in the L^2-norm. In combination with a cut out argument, fully practical estimates for the area mismatch are derived.

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MS12

Adaptive Discretization of Liftings for Curvature Regularization

Curvature regularization of image level lines is a powerful tool in image processing. Using so-called functional lifting, this can be achieved by specific convex functionals in a higher-dimensional space. A major challenge in solving the resulting higher-dimensional problem are the corresponding high computational costs. We present an adaptive discretization with a local primal-dual gap as the refinement indicator and give some results for 2D- and 3D-images.

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MS12

Sublabel Accurate Lifting

We propose a novel spatially continuous framework for convex relaxations based on functional lifting. Our method can be interpreted as a sublabel-accurate solution to multilabel problems. We show that previously proposed functional lifting methods optimize an energy which is linear between two labels and hence require (often infinitely) many labels for a faithful approximation. In contrast, the proposed formulation is based on a piecewise convex approximation and therefore needs far fewer labels. In comparison to recent MRF-based approaches, our method is formulated in a spatially continuous setting and shows less grid bias. Moreover, in a local sense, our formulation is the tightest possible convex relaxation. It is easy to implement and allows an efficient primal-dual optimization on GPUs. We show the effectiveness of our approach on

several computer vision problems.

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MS12
Analysis L1-Minimization in Imaging

Compressive sensing predicts that sparse signals and images may be recovered from incomplete information via efficient algorithms including l1-minimization. This may be very useful for imaging techniques such as MRI. Instead of the standard assumption of sparsity in a basis, it is sometimes more appropriate to assume sparsity in a frame such as shearlets or curvelets. In this context, one replaces l1-minimization by analysis-l1-minimization where the analysis operator is plugged into the l1-norm. This talk presents new results on recovery of analysis-sparse images from variable density sampling of the Fourier transform.

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MS13
Graph Spectral Dictionary Learning for Distributed Signal Processing

We study the distributed processing of graph signals that are well represented by graph spectral dictionaries. We first analyze the impact of quantization noise in the distributed computation of polynomial dictionary operators that are commonly used in various signal processing tasks. We show that the impact of quantization depends on the graph geometry and on the structure of the spectral dictionaries. Then, we focus on the problem of distributed sparse signal representation that can be solved with an iterative soft thresholding algorithm. We define conditions on the dictionary structure to ensure the convergence of the distributed algorithm and finally propose a dictionary learning solution that permits to control the robustness to quantization noise. Experimental results for reconstruction and denoising of both synthetic and practical signals illustrate the tradeoffs that exist between accurate signal representation and robustness to quantization error in the design of dictionaries operators in distributed graph signal processing.

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MS13
Multiscale Geometric Methods for Statistical Learning and Dictionaries for Data and Images

We discuss a family of ideas, algorithms, and results for analyzing various new and classical problems in the analysis of high-dimensional data sets. These methods rely on the idea of performing suitable multiscale geometric decompositions of the data, and exploiting such decompositions to perform a variety of tasks in signal processing and statistical learning. In particular, we discuss the problem of dictionary learning, where one is interested in constructing, given a training set of signals, a set of vectors (dictionary) such that the signals admit a sparse representation in terms of the dictionary vectors. We discuss a multiscale geometric construction of such dictionaries, its computational cost and online versions, and finite sample guarantees on its quality. We then mention generalizations of this construction to other tasks, such as learning an estimator for the probability measure generating the data, again with fast algorithms with finite sample guarantees, and for learning certain types of stochastic dynamical system in high-dimensions. Applications to construction of multi-resolution dictionaries for images will be discussed.

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MS13
Learning Separable Co-Sparse Analysis Operators - Sample Complexity and Stochastic Gradient Descent

Analysis operator learning is referred to as learning a set of filters which, when applied to the signal class of interest, yields sparse filter responses. As such, it may serve as a prior in inverse problems, for structural analysis of images, or even for registration of bimodal images, like e.g. RGB-D. It is well known in practice that it is advantageous to consider filters with separable structure. In this talk, we will give an upper bound on the sample complexity for the learning process and link this result to a stochastic gradient method for efficiently learning separable analysis operators.

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MS13
Dictionary Learning for Graph-Structured Data

One of the challenges in dictionary learning for irregularly structured data is incorporating the intrinsic structure of the data into the dictionary. We present a dual graph regularized dictionary learning method that takes into account the underlying structure in both the feature and the manifold domains. Furthermore, we explore the dependency between the dictionary and the underlying graph and propose a joint learning framework in which this graph is adapted alongside the dictionary learning process.

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MS14

Inflow-Based Gradient Finite Volume Method for Level Set Equation

We propose a cell-centered gradient defined by flux values to numerically solve a propagation in normal direction on unstructured meshes. Under a suitable assumption, the proposed discretization of absolute gradient is an extension of well-known Rouy-Tourin scheme into 3D with the second order upwind difference. A high order of convergence, performance in parallel computation, and a recovery of signed distance function from a sparse data are illustrated in numerical examples.

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MS14

High Quality Image Compression Using Pde-Based Inpainting with Optimal Data

Finding good reconstruction data is a key problem for PDE-based inpainting within the context of image compression. Not only the location of important pixels but also their corresponding colour values should be optimal. In this talk we discuss how the spatial and tonal optimisation are related and provide strategies to retrieve this data. Finally we present a concrete application of a lossy image compression codec that outperforms state-of-the-art approaches.

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MS14

Mathematical Models and Numerical Methods for Early Embryogenesis Computational Reconstruction

In the talk we present mathematical models and numerical methods which lead to vertebrate early embryogenesis reconstruction and extraction of the cell trajectories and the cell lineage tree from large-scale 3D+time microscopy image sequences. Robust and efficient numerical schemes for solving nonlinear PDEs related to filtering, object detection, segmentation and tracking in 3D and 4D images were designed, parallelized for massively parallel computer clusters and applied to the above mentioned fundamental tasks of developmental biology. The presented results were obtained in cooperation of groups at Slovak University of Technology, Bratislava, CNRS, Gif-sur-Yvette, Ecole Polytechnique, Paris and University of Bologna.

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MS14

Atlas Based Image Segmentation

The new automatic image segmentation algorithm extending conventional segmentation methods with an influence of prior knowledge of segmented shape is presented in this talk. Algorithm is applied to Active Contours and also to Geodesic Active Contours method. Original contributions are mainly: automatic solving of curve correspondence problem, registration of planar curves and estimation of prior shape, based on the current segmentation and computed eigenshapes calculated from atlas of shape patterns, using Principal Component Analysis.

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MS15

Structural Priors in Image Reconstruction

Natural images exhibit geometric structures that can be exploited to improve reconstruction. We propose two methods that estimate the local geometry of an image and define adaptive regularizers that reconstruct images of higher quality from fewer measurements. Both techniques alternate two steps: 1)estimation of the local image structure; 2)reconstruction with a regularizer adapted to this structure. This two-step procedure improves accuracy and leads to efficient algorithms for denoising, deblurring, and compressed sensing.

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MS15

Solution-driven Adaptive Total Variation Regularization

In our talk we discuss adaptive variants of total variation (TV) regularization for image restoration tasks. While the straightforward approach is to exploit the input data to steer the adaptivity, we particularly focus on strategies, where the adaptivity is determined by the solution of the problem (referred to as solution-driven). Our approach is described in terms of a fixed-point problem, for which we provide theory on existence and uniqueness.

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MS15

Joint Reconstruction Via Infimal Convolution of

Bregman Distances with Applications to PET-MR Imaging

Joint image reconstruction methods exploit the existence of similar geometric structures to provide reconstructions in presence of degraded data. We use the infimal convolution of Bregman distances with respect to the total variation to couple edge information during a joint reconstruction [Moeller et al., Color Bregman TV, SIAM Journal on Imaging Sciences, pp. 2771-2806, vol. 7(4), 2014.]. Among theoretical results including an explicit representation of the functional we present a suitable primal-dual minimization scheme. Finally, we show promising results on artificial PET-MR data.

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MS15

Joint Hydrogeophysical Inversion Using Structure Similarity Measures

In this study we solve a coupled hydrogeophysical inverse problem to estimate the hydrological states. To overcome the need to determine the relationship between geophysical and hydrological variables we focus on investigating numerical techniques which use only structure similarity measures, such as cross gradient field product or joint total variation. Similarity measure then becomes another term in the coupled objective function which also contains data misfits and regularization terms for both hydrological and geophysical models.

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MS16

Sparse Representation on Non-Flat Domains with Application in Classifications

Wavelet frames, or more generally, multiscale representation of functions is well studied in the past thirty years. They have been successfully applied to various types of practical problems, notably image processing and analysis. In recent years, it has been noted that many of the current applications in data analysis are concerned with data that can be naturally organized on non-flat domains such as surfaces, manifolds, point clouds and graphs. Therefore, there has been an increasing interest in constructing wavelet-like representation of functions directly on these non-flat domains. In this talk, I will present one of our recent work on generic characterization and construction of tight wavelet frames on manifolds/graphs. Applications to high-dimensional classification will also be discussed.

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MS16

Intrinsic Methods for Image Segmentation on Manifolds and Extensions to Data Classification

In this talk, I will present our work on variational PDEs methods for image segmentation on Riemannian manifolds. Based on our work of methods solving geometric PDEs on manifolds, we are able to naturally generalize different image segment models and associated fast algorithms on Riemannian manifolds. Furthermore, I will also discuss an extension of this idea to handle general data classification problems.

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MS16

Fuzzy Image Segmentation Based on Tv Regularization and L1-Norm Fidelity

In this work, we propose a variational multiphase image segmentation model based on fuzzy membership functions and L1-norm fidelity. Then we apply the alternating direction method of multipliers to solve an equivalent problem. All the subproblems can be solved efficiently. Specifically, we propose a fast method to calculate the fuzzy median. Experimental results and comparisons show that the L1-norm based method is more robust to outliers such as impulse noise and keeps better contrast than its L2-norm counterpart. Theoretically, we prove the existence of the minimizer and analyze the convergence of the algorithm.

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MS17

Accelerated Stochastic ADMM with Variance Reduction

We present a novel accelerated stochastic alternating direction method of multipliers(SADMM) for stochastic convex optimization problems with linear equality constraints. We incorporate a multi-step acceleration scheme to achieve an optimal rate for the smooth part in the model. Our framework also employs variance reduction to improve the dependence of variance resulted by random sampling. The efficiency of our method is demonstrated with numerical experiments on both simulated and real data.

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MS17

Image Reconstruction in Diffuse Optical Tomography Using Sparsity Constraint

In this talk, a sparsity constrained reconstruction formulation in Diffuse Optical Tomography (DOT) for determining the optical parameters from boundary measurements will be presented. The sparsity of the inclusion with respect to a particular basis is assumed a priori. The proposed approach is based on a sparsity promoting l1-penalty. We will present simulation results using sparsity approach in DOT.

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MS17

Fast Decentralized Gradient Descent Method and Applications in Seismic Tomography

We consider the decentralized consensus optimization problem on a connected network where each node privately holds a part of objective function and data. The goal is to find the minimizer for the whole objective function while each node can only communicate with its neighbors during computations. We present a fast decentralized gradient descent method whose convergence does not require diminishing step sizes as in regular decentralized gradient descent methods, and prove that this new method can reach optimal convergence rate. Numerical experiments also show that it significantly outperforms existing methods. Applications to seismic tomography on large-scale wireless sensor networks will be presented.

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MS17

An Optimal Randomized Incremental Gradient Method

We present a randomized incremental gradient method and show that it possesses unimprovable rate of convergence for convex optimization by developing a new lower complexity bound. We provide a natural game theoretic interpretation for this method as well as for the related Nesterov's optimal method. We also point out the situations when this randomized algorithm can significantly outperform the deterministic optimal method.

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MS18

A Convex Variational Model for Restoring Blurred Images with Large Rician Noise

In this talk, a new convex variational model for restoring images degraded by blur and Rician noise is proposed. The new method is inspired by previous works in which the non-convex variational model obtained by maximum a posteriori (MAP) estimation has been presented. Based on the statistical property of Rician noise, we put forward to adding an additional data-fidelity term into the non-convex model, which leads to a new strictly convex model under mild condition. Due to the convexity, the solution of the new model is unique and independent of the initialization of the algorithm. We utilize a primal-dual algorithm to solve the model. Numerical results are presented in the end to demonstrate that with respect to image restoration capability and CPU-time consumption, our model has good performance in both medical and natural images.

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MS18

Optimal Learning Approaches for the Determination of Noise Models in Image Restoration

We aim to identify the type and structure of noise in variational models by using a bilevel optimization approach. First, optimal spatially dependent weights are investigated, which yield an insight into the noise structure of the images at hand. Second, a new model for mixed noise is derived consistently with the statistical assumptions on the noise through MAP estimation and combining standard fidelity terms used for single-noise denoising in an infimal convolution fashion.

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MS18

Unbiased Noise Injection in Variance-Stabilized Range

The design, optimization, and validation of many image processing or image-based analysis systems often requires testing of the system performance over a dataset of images corrupted by noise at different signal-to-noise ratio (SNR) regimes. For instance, virtual clinical trials use images of the same patient at different radiation doses in order to identify the optimal dose. A noise-free ground-truth image may not be available, and different SNRs are simulated by injecting extra noise into an already noisy image. We consider the additive injection of signal-dependent noise in variance-stabilized range. In particular, we design special forward and inverse variance-stabilizing transformations that compensate the bias which otherwise arises when returning to the original range.

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MS18

Noise Estimation Based on a Non-Parametric Detection of Homogeneous Image Regions

We propose a two-step algorithm that automatically estimates the noise level function of stationary noise from a single image, i.e., the noise variance as a function of the image intensity. First, the image is divided into small square regions and a non-parametric test is applied to decide whether each region is homogeneous or not. Based on Kendall's τ coefficient (a rank-based measure of correlation), this detector has a non-detection rate independent on the unknown distribution of the noise, provided that it is at least spatially uncorrelated. Moreover, we prove on a toy example, that its overall detection error vanishes with respect to the region size as soon as the signal to noise ratio level is non-zero. Once homogeneous regions are detected, the noise level function is estimated as a second order polynomial minimizing the ℓ^1 error on the statistics of these regions. Numerical experiments show the efficiency of the proposed approach in estimating the noise level function. We illustrate the interest of the approach for an image denoising application.

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MS19

Automatic Detection of Heart Anomalies in Cardiac Ultrasound Data

We consider the problem of automatic classification of heart defects from cardiac ultrasound. Currently this imaging modality is used by expert physicians in the diagnosis of patients with heart abnormalities. With the advent of automation in image processing and machine learning tools it may be possible to use such devices to continuously monitor patients in hospital settings where it would not be practical to have an expert cardiologist on hand at all times. Such a monitoring device requires continuous automated processing of the data to alert hospital staff about changes in the patient's status. In this talk we discuss possible ways of doing this using a combination of imagine processing as a preprocessing step for machine learning tools to separate out different classes of patients.

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MS19

A Fast Solver for Constrained Diffeomorphic Image Registration

We present new algorithms for diffeomorphic image registration. We use a PDE-constrained formulation, where the constraints are the transport equations for the template image. We introduce a semi-Lagrangian formulation and a two-level coarse grid Hessian preconditioner, which—in combination with a globalized, matrix-free, inexact Newton–Krylov method—results in an orders of magnitude speed-up over the state of the art.

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MS19

Efficient Lung CT Registration Using Large Deformation Diffeomorphic Metric Mappings

The topic of the talk is 3D lung CT image registration using the Large Deformations Diffeomorphic Metric Mapping Method (LDDMM) method. It is well known that LDDMM has large memory requirements as flows over time are modeled. We will discuss techniques to handle this challenge for the registration of full resolution lung CT scans. Furthermore, we will talk about changing the distance measure to Normalized Gradient Fields to cope with inhale-exhale scans.

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MS19

Diffeomorphic Image Matching and the Choice of the Metric

In medical image applications, diffeomorphic image matching has been extensively developed and variational methods are among the most often used. Usually, these methods consist in the minimization of an energy which is the sum of two terms, a similarity measure and a regularization on the deformation. For instance, in the so-called large deformation diffeomorphic metric mapping, a differential operator has to be chosen usually via a regularizing kernel, which is also the case in the framework of stationary velocity fields. The choice of the regularizing term has an important impact on the results of the methods, namely the registration itself, and as a consequence on further analysis that can be built upon. In this talk, we will present some propositions to improve the choice of the regularization and in particular we will present a variational framework to learn the regularization from the data.

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MS20

Inferring Causality in Molecular Processes Using Live Cell Microscopy

One of the challenges in the study of complex molecular pathways is adaptation of the system to experimental perturbation. While perturbation of one component may lead to an observable phenotype, it is impossible to deduce from it the function the targeted component. To overcome this problem we exploit basal pathway fluctuations observed by live cell imaging and employ time series analysis approaches to reconstruct the connectivity and kinetics of information flows between pathway components.

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MS20

Computational Imaging Methods to Study Cardiac Development and Function

Optical microscopy allows observing cardiac development in zebrafish larvae, which offer direct optical access to migrating cardiac cells, tissue reorganization and blood flow within the beating heart. This dynamic environment makes imaging and analysis of individual components challenging. We have developed methodologies based on accurate temporal registration of movies of the beating heart that allow leveraging its quasi-periodic beat to separate image components, computationally improve the temporal resolution of the movies as well as their signal to noise.

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MS20

Quantitative Aspects of the Analysis of Superresolution and Single Molecule Experiments

Image analysis is a central component of single molecule based super resolution microscopy. For example, in localization based super resolution microscopy the improvement in resolution over conventional techniques depends crucially on the quality of the image analysis. The analysis of imaging experiments for dynamics in three dimensions has particular challenges. We will discuss recent results that illustrate the use of information theory for experiment design and the evaluation of image analysis approaches.

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MS20

Tracking and Registration for Analyzing Live Cell Microscopy Images

We present approaches for cell tracking, particle tracking, and registration of dynamic cell microscopy images. We developed an approach for cell tracking and cell cycle quantification which integrates tracking-by-detection, mitosis detection, feature-based classification, and error correction using a state transition model. For analyzing the motion of virus particles, we introduced a probabilistic tracking approach based on particle filters and Kalman filters. We also developed non-rigid registration approaches for spatial normalization of the image data.

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MS21

Photoacoustic Imaging and Thermodynamic Attenuation

We consider a mathematical model for photoacoustic imaging to take into account attenuation due to thermodynamic dissipation. The propagation of acoustic waves is governed by a scalar wave equation coupled to the heat equation for the excess temperature. We seek to recover the initial acoustic profile from knowledge of boundary measurements. This inverse problem is a special case of boundary observability for a thermoelastic system. This leads to the use of control/observability tools to prove the unique and stable recovery of the initial acoustic profile in the weak thermoelastic coupling regime. We propose and implement (numerically) a reconstruction algorithm.

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MS21

Optoacoustic Tomography of the Breast: Image Reconstruction and Signal Detectability

Optoacoustic tomography (OAT) is an emerging hybrid method for clinical breast imaging. In this talk, we describe the development and evaluation of advanced optimization-based image reconstruction methods for OAT. These methods account for the instrument response and imaging physics. Concepts from statistical decision theory are employed to quantify image quality based on a signal detection task.

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MS21

A Dissipative Time Reversal Technique for Photoacoustic Tomography in a Cavity

We consider the inverse source problem arising in thermo- and photo- acoustic tomography. It consists in reconstructing the initial pressure from the boundary measurements of the acoustic wave. Our goal is to extend versatile time reversal techniques to the case when the boundary of the domain is perfectly reflecting, effectively turning the domain into a reverberant cavity. Standard time reversal works only if the solution of the direct problem decays in time, which does not happen in the setup we consider. In this talk, we propose a novel time reversal technique with a non-standard boundary condition. The error induced by this time reversal technique satisfies the wave equation with a dissipative boundary condition and, therefore, decays in time. For larger measurement times, this method yields a close approximation; for smaller times, the first approximation can be iteratively refined, resulting in a convergent Neumann series for the approximation.

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MS21

Thermo-Acoustic Tomography on Bounded Domains

We study the mathematical model of thermoacoustic tomography in bounded domains with perfect reflecting boundary conditions. We propose an averaged time reversal (ATR) algorithm which solves the problem with an exponentially converging Neumann series. Numerical reconstruction based on this ATR algorithm is implemented and compared with the reconstruction using the Landweber iteration algorithm. This is based on joint work with Plamen Stefanov.

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MS22

ShapeFit: Exact Location Recovery from Corrupted Pairwise Directions

We consider the problem of recovering a set of locations given observations of the direction between pairs of these locations. This task arises from the Structure from Motion problem from machine vision, in which 3d structure is to be inferred from 2d images. We introduce a tractable convex program called ShapeFit and prove that it can recover a synthetic set of locations exactly when a fraction of the measurements are adversarially corrupted.

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MS22

Probably Certifiably Correct K-Means Clustering

Recently, Bandeira introduced a new type of algorithm (the so-called probably certifiably correct algorithm) that combines fast solvers with the optimality certificates provided by convex relaxations. This talk introduces such an algorithm for the problem of k-means clustering. First, we observe that a certain semidefinite relaxation of k-means is tight with high probability under a certain distribution of planted clusters. Next, we show how to test the optimality of a proposed k-means solution using the relaxation's dual certificate in quasilinear time. (Joint work with Takayuki Iguchi, Jesse Peterson and Soledad Villar.)

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MS22

Robust Camera Location Estimation by Convex Programming

3D structure recovery from a collection of 2D images requires the estimation of the camera locations and orientations, i.e. the camera motion. For large, irregular collections of images, existing methods for the location estimation part, which can be formulated as the inverse problem of estimating n locations $\mathbf{t}_1, \mathbf{t}_2, \ldots, \mathbf{t}_n$ in R^3 from noisy measurements of a subset of the pairwise directions $\frac{\mathbf{t}_i - \mathbf{t}_j}{\|\mathbf{t}_i - \mathbf{t}_j\|}$, are sensitive to outliers in direction measurements. In our work, we firstly provide a complete characterization of well-posed instances of the location estimation problem, by presenting its relation to the existing theory of parallel rigidity. For robust estimation of camera locations, we introduce a two-step approach, comprised of a pairwise direction estimation method robust to outliers in point correspondences between image pairs, and a convex program to maintain robustness to outlier directions. In the presence of partially corrupted measurements, we empirically demonstrate that our convex formulation can even recover the locations exactly. Lastly, we demonstrate the utility of our formulations through experiments on Internet photo collections.

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MS22

Efficient Global Solutions to K-Means Clustering Via Semidefinite Relaxation

k-means clustering aims to partition a set of n points into k clusters in such a way that each observation belongs to the cluster with the nearest mean, and such that the sum of squared distances from each point to its nearest mean is minimal. In the worst case, this is a hard optimization problem, requiring an exhaustive search over all possible partitions of the data into k clusters in order to find the optimal clustering. At the same time, fast heuristic algorithms for k-means are often applied, despite only being guaranteed to converge to local minimizers of the k-means objective. Here, we consider a semidefinite programming relaxation of the k-means optimization problem. We discuss two regimes where the SDP provides an algorithm with improved clustering guarantees compared to previous results in the literature: (a) for points drawn from isotropic distributions supported in separated balls, the SDP recovers the globally optimal k-means clustering under mild separation conditions; (b) for points drawn from mixtures of distributions with bounded variance, the SDP solution can be rounded to a clustering which is guaranteed to classify all but a small fraction of the points correctly. This talk is based on papers Relax no need to round: integrality of clustering formulations (joint work with P. Awasthi, A. Bandeira, M. Charikar, R. Krishnaswamy and R. Ward) and Clustering subgaussian mixtures by semidefinite programming (joint work with D. Mixon and R. Ward).

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MS23

Functorial Metric Clustering with Overlaps: Possibilities and Impossibilities

It is natural to attempt extending the range of functorial dissimilarity-based clustering methods beyond partitions and dendrograms (as introduced by Carlsson and Mémoli) to allow the treatment of clustering with overlaps. We characterize the possible domains of classifiers (combinatorially and metrically), and derive a common generalization of Kleinberg's impossibility result and the Carlsson-Mémoli characterizations of single linkage hierarchical clustering. We also explore connections between functorial clustering and the split-decomposition/projection methods of Bunemann and Bandelt-Dress.

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MS23

A Matching Algorithm for Reducing Complexes in Multidimensional Persistence

An algorithm is presented that constructs an acyclic partial matching on the cells of a given simplicial complex from a vector-valued function defined on the vertices. The resulting acyclic partial matching is used to construct a reduced complex with the same multidimensional persistent homology as the original complex filtered by sublevel sets of the function. Numerical tests on triangle meshes show that the achieved rate of reduction is substantial.

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MS23

Persistence Weighted Gaussian Kernel for Topological Data Analysis

In topological data analysis(TDA), persistence diagrams are widely used to describe the robust and noisy topological properties in data. In this talk, I will propose a kernel method on persistence diagrams to develop a statistical framework in TDA. Then, a new distance on persistence diagrams is defined by our kernel and has a stability property. The main contribution of our method is the flexibility to control the effect of persistence. As an application, we show that our method can clearly detect the glass transition temperature in SiO2.

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MS23

Multiscale Mapper: Topological Summarization Via Codomain Covers

Summarizing topological information from datasets and maps defined on them is a central theme in topological data analysis. Mapper, a tool for such summarization, takes as input both a possibly high dimensional dataset and a map defined on the data, and produces a summary of the data by using a cover of the codomain of the map. This cover, via a pullback operation to the domain, produces a simplicial complex connecting the data points. The resulting view of the data through a cover of the codomain offers flexibility in analyzing the data. However, it offers only a view at a fixed scale at which the cover is con- structed. Inspired by the concept, we explore a notion of a tower of covers which induces a tower of simplicial complexes connected by simplicial maps, which we call multiscale mapper. We study the resulting structure, and design practical algorithms to compute its persistence diagrams efficiently. Specifically, when the domain is a simplicial complex and the map is a real-valued piecewise-linear function, the algorithm can compute the exact persistence diagram only from the 1-skeleton of the input complex. For general maps, we present a combinatorial version of the algorithm that acts only on vertex sets connected by the 1-skeleton graph, and this algorithm approximates the exact persistence diagram thanks to a stability result that we show to hold.

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MS24

Low-complexity Semidefinite Programming Methods and Applications in Computer Vision

Semidefinite programming is a classical method for relaxing non-convex problems into convex problems. In this talk, we present alternatives that relax non-convex and discrete problems into a bi-convex form. This alternative method allows us to solve very large-scale semidefinite programs with extremely low complexity. Applications to image segmentation and machine learning will be discussed.

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MS24

Ingredients for Computationally Efficient Diffuse Optical Tomographic Reconstruction

In diffuse optical tomography the goal is to reconstruct a map of the absorption and/or diffusion coefficient from measurements on the surface. The forward model is the diffusion equation, which makes the problem computationally challenging. We describe how to combine parametric level sets (PaLS) with a trust region regularized GN approach and model order reduction to bring the computational costs down dramatically. We show results that highlight the success of the combined approach.

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MS24

A Direct Reconstruction Method for Anisotropic Electrical Impedance Tomography

Electrical Impedance Tomography (EIT), also known as Electrical Resistance Tomography (ERT) is a relatively new imaging technique that is non-invasive, low-cost, and non-ionizing with excellent temporal resolution. In geophysics, EIT data consists of electrical boundary measurements, of voltages measured on electrodes arising from applied currents on the electrodes, that are used to determine the unknown electrical condutivity in the interior of the medium. EIT has wide variety of applications including medical imaging and geophysical prospecting. This talk presents a direct reconstruction scheme for 2-D estimation of an anisotropic conductivity from EIT data that includes prior knowledge of the anisotropy tensor. The linearized Calderon–based scheme makes use of a special type of CGO solutions known as Oscillating Decaying solutions to a related problem to recover the spatially dependent anisotropic conductivity values.

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MS24

Sparsity in Fluids - Vorticity Estimation via Compressive Sensing

In recent years compressive sensing has been applied successfully to various imaging problems where sparsity in informative basis structures played a key role. In fluids, vortex methods (e.g. Rankine or Lamb-Oseen) were used to model the evolution of flows related to Navier-Stokes. The aim of this talk is to present a new model combining compressive sensing and vortex methods for fluid problems in imaging. Besides an analysis of approximations in the limiting case we will highlight numerical results for vorticity estimation in image sequences motivated by eddies in oceanic sciences.

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MS25

A Scalable Space-Time Multiresolution Model for Activation and Connectivity in Fmri Data

Abstract not available.

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MS25

Modeling and Data Visualization of Electroencephalograms

Abstract not available.

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MS25

Structural Connectivity: Challenges and Future Outlook

Abstract not available.

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MS26

How the Brain Represents Images: Biologically Inspired Algorithms for Classification and Recognition

Making inferences from partial information constitutes a ubiquitous and fundamental aspect of intelligence. Our brains constantly complete patterns in the context of interpreting speech and narratives, when discerning social interactions or when visually analyzing scenes. I will discuss the problem of pattern completion during recognition of heavily occluded objects. The type of extrapolation required to complete occluded objects is not trivial. Given an image containing an occluded object, there are infinite possible ways to interpret and complete the image. Yet, the brain is capable of typically and rapidly landing on a single interpretation. I will present behavioral and physiological data constraining possible solutions. Next, I will present a computational model that combines a bottom-up hierarchical architecture with recurrent connectivity. This model displays many of the interesting pattern recognition properties of deep convolutional networks and at the same type has attractor states that allow the system to dynamically modify the representation when presented with partial information. The proposed biological plausible circuits provide initial steps to elucidate the mechanisms by which the brain can extrapolate and make inferences from minimal information.

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MS26

Lagrangian Transforms for Signal and Image Classification

Invertible image representation methods (transforms) are routinely employed as low-level image processing operations based on which feature extraction and recognition algorithms are developed. Most transforms in current use (e.g., Fourier, Wavelet, etc.) are linear transforms, and, by themselves, are unable to substantially simplify the representation of image classes for classification. Here we describe a nonlinear, invertible, low-level image processing transform based on combining the well known Radon transform for image data, and the 1D Cumulative Distribution Transform proposed earlier. We describe a few of the properties of this new transform, and with both theoretical and experimental results show that it can often render certain problems linearly separable in transform space.

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MS26

Scotopic Recognition - The Dark Side of Vision

Images are obtained by counting the photons that hit a sensor within a given amount of time. Thus, 'images' are a convenient engineering abstraction. In the real world there are only individual photons traveling through space and hitting a pixel at a given time. I will discuss how vision can be formulated in the context of such a stream of photons, without ever forming a conventional image. This has practical importance: in many applications only few photons are available and decisions have to be made as quickly as possible - just when the sufficient amount of information has been captured. Examples are biomedical imaging, security, astronomy. I will discuss a framework that allows a machine to classify objects with as few photons as possible, while maintaining the error rate below an acceptable threshold. The framework also allows for a dynamic and asymptotically optimal speed-accuracy tradeoff. I will briefly touch upon detection and control applications as well.

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MS26

Adaptive Piecewise Data Representation: Learning Manifolds and Dictionaries

In this talk, I will discuss a class of algorithms to learn data representation from unsupervised data. The class of proposed methods exploit the geometry of the data distribution to build piecewise data representations. Analyzing

their performance requires tools from geometry and probability, with connection to diverse ideas such as vector quantization, wavelets, and decision trees.

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MS27

Data Refactoring: Using Auditors for Next Generation Storage Systems

Common compression schemes are limited for scientific due to under-utilization of apriori domain knowledge. We propose a new scheme, an auditor, which exploits this additional knowledge. An auditor performs a low cost computation to track the data over a spatio-temporal interval. The difference from the auditors results and the actual data is stored as entropy coded deltas alongside the auditors parameters. This combination allows the data to be regenerated at machine precision while approaching the optimal compression ratio. The dual layer structure of the compressed data is also ideal for modern storage hierarchies, allowing variable precision access to data.

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MS27

Parallel Tensor Compression for Large-Scale Scientific Data

As parallel computing trends towards the exascale, scientific data produced by high-fidelity simulations are growing increasingly massive. For instance, a simulation on a three-dimensional spatial grid with 512 points per dimension that tracks 64 variables per grid point for 128 time steps yields 8 TB of data. By viewing the data as a dense five-way tensor, we can compute a Tucker decomposition to find inherent low-dimensional multilinear structure, achieving compression ratios of up to 10000 on real-world data sets with negligible loss in accuracy. So that we can operate on such massive data, we present the first-ever distributed-memory parallel implementation for the Tucker decomposition, whose key computations correspond to parallel linear algebra operations, albeit with nonstandard data layouts. Our approach specifies a data distribution for tensors that avoids any tensor data redistribution, either locally or in parallel. We provide accompanying analysis of the computation and communication costs of the algorithms. To demonstrate the compression and accuracy of the method, we apply our approach to real-world data sets from combustion science simulations. We also provide detailed performance results, including parallel performance in both weak and strong scaling experiments.

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MS27

Compressed Floating-Point Arrays for High-Performance Computing

We present ZFP: a compressed floating-point array primitive that supports a user-specified storage budget and high-speed read and write random access. ZFP arrays use C++ operator overloading to mimic regular multidimensional C++ arrays, which facilitates application integration. We demonstrate several use cases of ZFP arrays in high-performance computing applications, including inline compression of simulation state and streaming compression that reduces I/O and disk storage by up to 100 times without compromising visual quality.

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MS27

Compressed Sensing and Reconstruction of Unstructured Mesh Datasets: Optimal Compression

We investigate Compressive Sensing (CS) as a method to compress scientific simulation data. CS works by sampling the data on the computational cluster within an alternative function space, then reconstructing back to the original space on visualization platforms. While much work has gone into exploring CS on structured datasets, we investigate its usefulness for point-clouds such as unstructured mesh datasets. We achieve compression ratios up to 100 with minimal visual deterioration in the reconstructed data.

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MS28

Sparse Sampling Methods for Neutron Tomography

This talk will focus on mathematics developed to help with the mathematical challenges face by the DOE at the experimental facilities. This talk will discuss sparse sampling methods and fast optimization developed specifically for neutron tomography. Sparse sampling has the ability to provide accurate reconstructions of data and images when only partial information is available for measurement. Sparse sampling methods have demonstrated to be robust to measurement error. These methods have the potential to scale to large computational machines and analysis large volumes of data.

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MS28

Total Fractional-Order Variation Regularisation and Its Applications

We analyse and develop a fractional-order derivative based nonlocal regulariser, which can outperform the currently popular high order regularization models and has been used to substantially reduce the staircase effect of the total variation based model. Two new frameworks of noise removing in image restoration and nonlocal deformation in non-rigid image registration are presented. Numerical experiments show that the proposed models can produce highly competitive results.

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MS28

Parsing Local Signal Evolution Directly from Single-shot MRI Data Using a Second Order Approximation in Time

Most current methods of MRI reconstruction interpret signal as samples of the Fourier transform. Although this is computationally convenient, it neglects relaxation and off-resonance evolution in phase, both of which can occur to a significant extent during typical MR data acquisition. A more accurate model (SS-PARSE) takes the time evolution of the signal into consideration. Our reconstruction scheme for such models relies on decomposing the signal into time-frames and ℓ_1 regularization.

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MS28

Fast Robust Phase Retrieval from Local Correlation Measurements

Certain imaging applications such as x-ray crystallography require the recovery of a signal from magnitude-only measurements. This is a challenging problem since the phase encapsulates a significant amount of structure in the underlying signal. In this talk, we develop an essentially linear-time algorithm for solving the discrete phase retrieval problem using local correlation measurements. We present theoretical guarantees and numerical results demonstrating the method's speed, accuracy and robustness.

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MS29

Multi-GPU Strategies for Computing Frame Based 3D Reconstructions in Cone-Beam CT

Frame-based methods for cone beam tomography result in iterative schemes demanding high-performance computing strategies, particularly in the context of system optimization and image quality studies. Two issues must be addressed: fast projections and memory management for redundant expansions. Multi-GPU systems are a convenient way to leverage thousands of cores and dozens of gigabytes of memory to address both issues. We discuss a multi-GPU implementation and demonstrate its applicability to an image quality study.

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MS29

Sparsity-Exploiting Image Reconstruction for Volume Ct Using Algorithms with Truncated Iteration Number

Optimization-based image reconstruction for CT is computationally expensive. Only first-order algorithms are available for solving optimization problems of interest accurately, requiring thousands of iterations. In practice, it is desirable to operate at 10 or less iterations. Accurate solution is not possible with such low iteration numbers, but it is still possible to achieve high quality volume reconstructions with such a constraint. We will present algorithm designs exploiting image gradient sparsity, which can provide useful images within ≈ 10 iterations.

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MS29

Iterative Reconstruction for Practical Interior Problems in X-Ray Tomography Using a Dual Grid Method

In many practical non-medical x-ray CT applications, it is often the case that the measured projection data are severely truncated, creating a problem of extreme interior tomography. To accurately reconstruct such datasets using iterative methods, it is necessary for the reconstruction grid to cover the entire object support, creating infeasible computational and memory demands. We present a simple dual grid approach to mitigate these demands, with computational burden of only approximately double the non-truncated case.

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MS29

Fast Prototyping of Advanced Tomographic Reconstruction Algorithms

The need for advanced reconstruction techniques in tomography is growing and it has become computationally feasible to apply such techniques to large tomographic datasets. However, coupling complicated algorithms to existing (high performance) codes is often challenging and currently hampers their application in practice. Since these algorithms often require only simple operations of the forward operator (multiplication, transpose) we propose an abstract linear operator framework for tomographic reconstruction. With this framework, the algorithm can be developed with a generic linear operator in mind, while the underlying computations can be handled by highly optimized code. Such a framework has the added benefit that individual components can be tested separately, thus guaranteeing the fidelity of the resulting code. We present a specific example in Matlab, where we use a high-end GPU tomography toolbox as backend.

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MS30

Non-Unique Games Over Compact Groups and Orientation Estimation in Cryo-Em

Let G be a compact group and let $f_{ij} \in L^2(G)$. We define the Non-Unique Games (NUG) problem as finding $g_1, \ldots, g_n \in G$ to minimize $\sum_{i,j=1}^{n} f_{ij}(g_i g_j^{-1})$. We devise a relaxation of the NUG problem to a semidefinite program (SDP) by taking the Fourier transform of f_{ij} over G, which can then be solved efficiently. The NUG framework can be seen as a generalization of the little Grothendieck problem over the orthogonal group and the Unique Games problem, and includes many practically relevant problems, such as the maximum likelihood estimator to registering bandlimited functions over the unit sphere in d-dimensions and orientation estimation in cryo-Electron Microscopy.

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MS30

Algorithmic and Computational Challenges in Single Particle Reconstruction

I will give a short introduction to the modern algorithmic and computational challenges in single particle reconstruction using cryo-electron microscopy. I will discuss some of the approaches that are currently being employed, and explain why and how tools from different branches of mathematics such as representation theory, random matrix theory, and convex optimization play an important role in advancing this imaging technique.

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MS30

Orthogonal Matrix Retrieval in Cryo-Electron Microscopy

In single particle reconstruction (SPR) from cryo-electron microscopy (EM), the 3D structure of a molecule needs to be determined from its 2D projection images taken at unknown viewing directions. Zvi Kam showed already in 1980 that the autocorrelation function of the 3D molecule over the rotation group $SO(3)$ can be estimated from 2D projection images whose viewing directions are uniformly distributed over the sphere. The autocorrelation function determines the expansion coefficients of the 3D molecule in spherical harmonics up to an orthogonal matrix of size $(2l + 1) \times (2l + 1)$ for each l=0,1,2... We will show how techniques for solving the phase retrieval problem in X-ray crystallography can be modified for the cryo-EM setup for retrieving the missing orthogonal matrices. Specifically, we present two new approaches that we term Orthogonal Extension and Orthogonal Replacement, in which the main algorithmic components are the singular value decomposition and semidefinite programming. We demonstrate the utility of these approaches through numerical experiments on simulated data.

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MS30

Fast Steerble Principal Component Analysis

Cryo-electron microscopy nowadays often requires the analysis of hundreds of thousands of 2D images as large as a few hundred pixels in each direction. Here we introduce an algorithm that efficiently and accurately performs principal component analysis (PCA) for a large set of two-dimensional images, and, for each image, the set of its uniform rotations in the plane and their reflections. For a dataset consisting of n images of size LL pixels, the computational complexity of our algorithm is $O(nL^3 + L^4)$.

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MS31

An Inverse Problem of Combined Photoacoustic and Optical Coherence Tomography

Photoacoustic and optical coherence tomography are emerging non-invasive biological and medical imaging techniques. However, it is well known by now that without additional assumptions on the medium, it is not possible to uniquely reconstruct all physical parameters from either one of these modalities alone. As both methods give information about the light propagation in the medium (photoacoustics involving mainly the absorption, optical coherence tomography mainly the scattering properties), they complement each other and thus a combined experiment per-

forming photoacoustic and optical coherence tomography at once could provide enough data to make a quantitative reconstruction possible. In this talk, we want to present a mathematical model for this dual experiment and show in a simplified setting that we can uniquely recover all physical parameters.

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MS31
Lorentz Force Impedance Tomography in 2D

Lorentz Force tomography, aslo known as Magneto-Acousto-Electric Tomography (MAET), is a novel hybrid modality that represents a stable, high-resolution alternative to the Electrical Impedance Tomography (EIT). Similar to EIT, MAET aims at imaging the non-uniform conductivity inside an object. To this end the object is placed in a magnetic field and subjected to ultrasound waves. The charged particles moving in a magnetic field a subjected by the Lorentz force, which generates currents that are then measured outside of the object. After a short theoretical introduction into MAET, I will present the design of a prototype MAET scanner we have built, and will demonstrate some of the first MAET images ever obtained.

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MS31
Stability and Statistics for Shear Stiffness Imaging

Abstract not available.

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MS31
Quantitative Pat for Molecular Imaging

Fluorescence photoacoustic tomography (fPAT) is a molecular imaging modality that combines photoacoustic tomography (PAT) with fluorescence imaging to obtain high-resolution imaging of fluorescence distributions inside heterogeneous media. The objective of this work is to study inverse problems in the quantitative step of fPAT where we intend to reconstruct physical coefficients in a coupled system of radiative transport equations using internal data recovered from ultrasound measurements. We derive uniqueness and stability results on the inverse problems and develop some efficient algorithms for image reconstructions. Numerical simulations based on synthetic data are presented to validate the theoretical analysis.

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MS32
Novel Algorithms for Vectorial Total Variation

While Total Variation is an extremely popular regularizer for scalar-valued functions, there exists a multitude of possible generalizations to the vector-valued setting. In my talk, I will introduce some recent developments which make use of geometric measure theory and $\ell^{p,q,r}$-norms in order to derive a unified framework for vectorial total variation models. A detailed analysis and experimental evaluation of the arising models reveals which ones are best suited for color image denoising and other inverse problems.

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MS32
A Generalized Forward-Backward Splitting

This work introduces a generalized forward-backward splitting algorithm for finding the zeros of the sum of maximal monotone operators $A+\sum_{i=1}^{n} B_i$ on Hilbert space, where A is also co-coercive. While the forward-backward algorithm deals only with $n = 1$ operator, our method generalizes it to the case of arbitrary n. Our method makes an explicit use of the co-coercivity of A in the forward (explicit) step and the resolvents of B_i's are activated separately in the backward (implicit) step. We establish (weak and strong) convergence properties of our algorithm as well as its robustness to summable errors in the implicit and explicit steps. We then specialize the algorithm for the case of composite variational problems to minimize convex functions of the generic form $f + \sum_{i=1}^{n} g_i$, where f has a Lipschitz-continuous gradient and the g_i's are simple. Applications to inverse problems in imaging demonstrate the advantage of the proposed framework.

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MS32

Coherence Pattern-Guided Compressive Sensing with Unresolved Grids

Highly coherent sensing matrices arise in discretizing with a grid spacing below the Rayleigh threshold or representing the objects by a highly redundant dictionary. Compressed sensing algorithms based on techniques of band exclusion and local optimization can circumvent coherent or redundant sensing matrices and accurately reconstruct sparse objects separated by up to one Rayleigh length independent of the grid spacing.

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MS32

PhaseLift: Exact Phase Retrieval via Convex Programming

We present a novel framework for phase retrieval, a problem arising in Xray-crystallography, diffraction imaging and many other applications. Our framework, called PhaseLift, combines multiple structured illuminations together with ideas from convex programming to recover the phase from intensity measurements. PhaseLift also comes with theoretical guarantees for exact and stable recovery, and can be modified to exploit sparsity. We will overview some of the many new developments since PhaseLift in the phase-retrieval and related communities.

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MS33

The Unexpected Geometry of "Real" High-Dimensional Data

We describe a surprising property of high-dimensional data sets, which we first observed while studying large sets of images and subsequently found in many other "real" data sets as well. Our observations suggest that real high-dimensional data sets have a tremendous amount of structure, so much so that a mere projection onto a random 1D subspace of the data space is likely to uncover some of that structure. This has important implications in the area of automatic recognition and database indexing. For example, we have developed an ultra-fast method based on random 1D projections for clustering a high-dimensional data set. Note that, if the data points had been drawn from a mixture of Gaussians (or any other density function representing clusters in the traditional sense) in the initial high-dimensional space, then the data could not effectively be clustered using such method. Thus the geometry at hand is a lot more complex than previously thought. This work is in collaboration with my graduate student Sangchun Han (now at Google).

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MS33

A Variational Approach to the Consistency of Spectral Clustering

We consider clustering of point clouds obtained as samples of a ground-truth measure. A graph representing the point cloud is obtained by assigning weights to edges based on the distance between the points they connect. We investigate the spectral convergence of both unnormalized and normalized graph Laplacians towards the appropriate operators in the continuum domain. We obtain sharp conditions on how the connectivity radius can be scaled with respect to the number of sample points for the spectral convergence to hold. In addition, we show that the discrete clusters induced by the spectrum of the graph Laplacian, converges towards a continuum partition of the ground truth measure. Such continuum partition minimizes a functional describing the continuum analogue of the graph-based spectral partitioning.

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MS33

Layered Diffusion: Towards a Theory of Interconnected Networks

Real world social networks consist of agents (as nodes) with associated states, and connected through complex topologies. Such an instance may include, for example, information sources accessed by agents which are themselves interconnected and follow some dynamics and hence evolve over time. In this work we propose a novel network model with a tractable hierarchical and interconnected structure, with learned diffusion dynamics subsequently exploited in the tracking and prediction of future states of each node

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MS33

On Geometric Problems in Structure from Motion

Abstract not available.

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MS34

Phase Tracking: Interpretation of Seismic Records in Terms of Atomic Events

Interpretation of seismic shot records in terms of coherent atomic events can be formulated as a hard, nonconvex optimization problem. I will present a method that empirically finds the global minimum of this functional in the case of simple synthetic shot records, even when events cross. The idea is to slowly grow a trust region for phases and amplitudes in a way that reminds of continuation, or tracking. The ability to solve this problem has important implications for low-frequency extrapolation and full waveform inversion. Joint work with Yunyue Elita Li.

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MS34

Joint Inversion of Gravity Data and Seismic Traveltimes Using a Structural Parametrization

We propose a structural approach for the joint inversion of gravity data and seismic traveltimes. Two geophysical properties including the density contrast and the seismic slowness are simultaneously inverted in the inverse problem. We develop a level set parametrization to maintain the structural similarity between multiple geophysical properties. Since density and slowness are different model parameters of the same survey domain, we assume that they are similar in structure in terms of how each property changes and where the interface exists, and we use the level set function to parameterize the common interface shared by these two model parameters. The interpretation of gravity data and seismic data are coupled by minimizing a joint data-fitting function with respect to the density distribution, the slowness distribution as well as the level set function. An adjoint state method is incorporated in the optimization algorithm to handle the non-linear constraint arisen from traveltime tomography. We test our algorithm in plenty of numerical examples, including the 2-D ovoid model and the SEG/EAGE salt model. The results show that the joint-inversion algorithm signicantly improves recovery of the subsurface features.

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MS34

Frozen Gaussian Approximation and Its Applications

We propose the frozen Gaussian approximation for the computation of high frequency wave propagation. This method approximates the solution to the wave equation by an integral representation. It provides a highly efficient computational tool based on the asymptotic analysis on phase plane. Compared to geometric optics, it provides a valid solution around caustics. Compared to the Gaussian beam method, it overcomes the drawback of beam spreading. We will present numerical examples as well as preliminary application in seismology to show the performance of this method.

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MS35

On Local and Non Local Covariant Derivatives and Their Applications in Color Image Processing

The Euclidean gradient operator and its non-local extension are involved in many variational models used in image analysis and processing. We present a generalization of these operators and variational models by replacing the standard differentiation of functions on the Euclidean space by the covariant differentiation of sections on a vector bundle, a geometric structure generalizing the concept of manifold. We show the efficiency of the generalization proposed for image denoising and contrast reduction/enhancement.

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MS35

Locally Adaptive Frames in the Roto-Translation Group SE(d)

Locally adaptive differential frames are used in differential invariants and PDE-flows on d-dimensional images. However, at complex structures, these frames are not well-defined. Therefore, we propose locally adaptive frames on (invertible) data representations defined on the coupled space of positions and orientations $SE(d)/(\{0\} \times SO(d-1))$. This allows for multiple well-defined frames per position, one for each orientation. We compute these frames via local exponential curve fits to the data. Applications include improved crossing-preserving vesselness filtering and diffusions.

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MS35

Locally Rigid Averaging of stretchable non-rigid shapes

We present a new approach for generating the mean structure of non-rigid stretchable shapes. Such structure is then used for inferring normal and abnormal characteristics of a given population. Following an alignment process, which supports local affine deformations, we translate the search of the mean shape into a diagonalization problem where the structure is hidden within the kernel of a matrix. This approach is fast, robust, and is suitable for stretchable non-rigid structures, unrelated to their global coordinate frames.

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MS35

On the Geometry of Shading and Color

We consider the shape-from-shading inference problem on image patches modelled with Taylor polynomials of any order. A boot-strapping tensor framework and generic constraint allows us to relate a smooth image patch to all of the polynomial surface solutions (under any light source). Color flows impact material judgements.

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MS36

Spectral Decompositions Via One-Homogeneous Regularization Functionals

To analyze linear filters for image and signal analysis, one typically considers the spectral decomposition of the corresponding linear operator. This talk discusses the possibility to introduce similar concepts for nonlinear transformations arising from the solution of variational, scale space, or inverse scale space methods. In particular, the possibility to decompose input data in into a linear combination of generalized eigenvectors with respect to one-homogeneous regularization functionals will be presented.

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MS36

A Dirichlet Energy Criterion for Graph-Based Image Segmentation

We consider a graph-based approach for image segmentation. We introduce several novel graph construction models which are based on graph-based segmentation criteria extending beyond—and bridging the gap between—segmentation approaches based on edges and homogeneous regions alone. The resulting graph is partitioned using a criterion based on the sum of the minimal Dirichlet energies of partition components. We propose an efficient primal-dual method for computing the Dirichlet energy ground state of partition components and a rearrangement algorithm is used to improve graph partitions. The method is applied to a number of example segmentation problems. We demonstrate the graph partitioning method on the five-moons toy problem, and illustrate the various imagebased graph constructions, before successfully running a variety of region-, edge-, hybrid, and texture-based image segmentation experiments. Our method seamlessly generalizes region- and edge-based image segmentation to the multiphase case and can intrinsically deal with image bias as well.

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MS36

Fundamentals of Non-Local Total Variation Spectral Theory

Eigenvalue analysis based on linear operators has been extensively used in signal and image processing to solve a variety of problems such as segmentation, dimensionality reduction and more. Recently, nonlinear spectral approaches, based on the total variation functional have been proposed. In this context, functions for which the nonlinear eigenvalue problem $\lambda u \in \partial J(u)$ admits solutions, are studied. When u is the characteristic function of a set A, then it is called a calibrable set. If $\lambda > 0$ is a solution of the above problem, then $1/\lambda$ can be interpreted as the scale of A. However, this notion of scale remains local, and it may not be adapted for non-local features. For this we introduce in this paper the definition of non-local scale related to the non-local total variation functional. In particular, we investigate sets that evolve with constant speed

under the non-local total variation flow. We prove that non-local calibrable sets have this property. We propose an onion peel construction to build such sets. We eventually confirm our mathematical analysis with some simple numerical experiments.

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MS36

Multiscale Segmentation via Bregman Distances and Spectral TV Analysis

In biomedical imaging the automatic detection of objects of interest is a key problem to solve. In this talk we address the strong need for automatic and reliable segmentation methods by a robust, TV-based multiscale framework. We extent the forward scale-space by an inverse approach using Bregman iterations. A particular focus is the detection of multiple scales using spectral decomposition recently introduced for TV. Results for simulated and experimental cell data illustrate the methods effectiveness.

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MS37

Direct Sampling Methods for Electrical Impedance Tomography and Diffusive Optical Tomography

In this talk, we are concerned with the electrical impedance tomography (EIT) and the diffusive optical tomography (DOT) in the case when only one or two pairs of Cauchy data are available, which are known to be very difficult in achieving high reconstruction quality owing to their severely ill-posed nature. We propose simple and efficient direct sampling methods (DSM) to locate inhomogeneities inside a homogeneous background and attempt the two tomographies in both full and limited aperture cases. Following the pioneering works by Ito, Jin and Zou, we have now extended this method, which is originally only applicable to the inverse acoustic medium scattering problem, to a much wider class of severely ill-posed inverse problems, e.g. DOT and EIT. In each of the aforementioned tomography, a new family of probing functions is introduced to construct an indicator function for imaging the inclusions, which is defined as a dual product between the observed data and the probing functions under an appropriate choice of Sobolev scale. The newly proposed DSMs are easy to implement and computationally cheap. Numerical experiments are presented to illustrate its robustness against noise in the data, and its extremely effective in locating small abnormalities. This provides a new promising numerical strategy for solving the various problems in the inverse problem community.

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MS37

Compressed Sensing and Reconstruction of Unstructured Mesh Datasets: Performance and Accuracy

We show in-progess results from our Lab Directed Research and Development work with Compressive Sensing (CS) using second-generation wavelets to compress simulation data. With emphasis on in-situ, we examine impacts on performance and accuracy by compressing, with loss, while the simulation is running and then decompressing during post-processing. We will show the effects on simulation runtime, overall time to solution, and errors induced by the lossy compression. We compare CS with other popular compression schemes.

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MS37

Multi-Node Model-Based Image Reconstruction with GPUs

Model-based X-ray CT image reconstruction is normally performed by solving a computationally expensive numerical optimization problem with a large amount of data. The data size poses a challenge for any GPU implementation, where memory is often limited. We present a fast duality-based algorithm that interleaves memory transfers and computation to mitigate this problem. To handle even larger reconstructions, we extend this algorithm to multiple GPUs on a node and multiple network-connected nodes.

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MS37

Arock: an Algorithmic Framework for Asynchronous Parallel Coordinate Updates

Finding a fixed point to a nonexpansive operator, i.e., $x^* = Tx^*$, abstracts many problems in numerical linear algebra, optimization, and other areas of scientific computing. To solve fixed-point problems, we propose ARock, an algorithmic framework in which multiple agents (machines, processors, or cores) update x in an asynchronous parallel fashion. Asynchrony is crucial to parallel computing since it reduces synchronization wait, relaxes communication bottleneck, and thus speeds up computing significantly. At each step of ARock, an agent updates a randomly selected coordinate x_i based on possibly out-of-date information on x. The agents share x through either global memory or communication. If writing x_i is atomic, the agents can read and write x without memory locks. Theoretically, we show that if the nonexpansive operator T has a fixed point, then with probability one, ARock generates a sequence that converges to a fixed points of T. Our conditions on T and step sizes are weaker than comparable work. Linear convergence is also obtained. We propose special cases of ARock for linear systems, convex optimization, machine learning, as well as distributed and decentralized consensus problems. Numerical experiments of solving sparse logistic regression problems are presented.

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MS38

Multiscale Sparse Representations in Variational Image Reconstruction

In many problems of image reconstruction we encounter the issue of dealing with incomplete or corrupted data. Often the most efficient recovery models are tailored for specific classes of images. Our work is merging the models and methods of the applied harmonic analysis, compressive sensing and variational techniques to create highly adaptable methods for image analysis and reconstruction. Preliminary analysis of the image determines the presence of edges and dominant directions, if those exist. The operators designed based on this information are used in the variational image reconstruction. The efficiency of this approach is illustrated with numerical examples of denoising and inpainting of images from various classes.

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MS38

A Novel Fidelity and Regularity for Image Reconstruction

We propose a general framework for image reconstruction. The contributions are two-fold: instead of the traditional fidelity in measurement domain, we measure the closeness in a processing domain; for regularity, we selectively choose TV and fractional-order total variation in different regions to fuse the power and avoid drawbacks of each individual. Image measurements are projected onto one frame domain while regularizing the solution in another domain. Numerical experiments in non-uniform Fourier reconstruction show its advantages.

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MS38

A novel Backtracking Strategy for Accelerated ADMM and Applications to Image Reconstruction

In this talk, we propose a novel line search based accelerated alternating direction method of multiplier (ADMM) scheme for solving regularized large-scale and ill-conditioned linear inversion problems. The proposed scheme can be viewed as the accelerated alternating direction method of multiplier (AADMM) [Ouyang, etc.] with a relaxed line search condition. It allows more aggressive stepsize via conducting fewer number of line searches than that in AADMM to achieve better practical performance, while preserves the same accelerated rate of convergence as that for AADMM. Experimental results on total-variation based image reconstruction indicate the efficiency of the proposed algorithm.

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MS39

Predicting Performance of Sparsity-Regularized X-Ray Tomography: Experimental Results using Glass-Bead Data

Compressive sensing connects the undersampling level allowed by sparsity regularization to the sparsity level of the image. Our recent work with simulated data indicates a similar connection in X-ray tomography. This may allow one to predict how many projections will suffice for accurate reconstruction. In this talk we address validation with real micro-CT data of different-sized glass beads specifically acquired for the purpose. We describe the experi-

ment, first results and discuss implications.

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MS39

Development of Reconstruction Algorithms of Practical Utility in Sparse-Data X-Ray Tomographic Imaging

Abstract not available.

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MS39

fMRI Reconstruction Using a State Estimation Approach

Functional magnetic resonance imaging (fMRI) is an imaging modality that is widely used to study physiological processes. However, many of these processes occur too fast for adequate reconstruction by conventional approaches. In this talk we formulate the fMRI image reconstruction as a state estimation problem, where the highly under sampled data is complemented with both temporal and spatial prior information. The approach is tested with simulated and measured fMRI data.

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MS40

Classification of Cryo-Em Projections Using Low-Rank Covariance Estimation

Abstract not available.

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MS40

Elucidating Protein Structure at High Resolution by Cryo-EM: Advances and Challenges

Recent advances in the field of single particle cryo-electron microscopy (cryo-EM) have enabled the determination of protein structure at unprecedented atomic resolution. Improvements in electron detector technology as well as advances in image processing have contributed significantly to this achievement. Here, we present an overview of recent developments in the cryo-EM field and outline the many challenges still remaining of working with time-resolved extremely low SNR images of radiation sensitive biological specimens.

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MS40

Wavelet Frame Based Algorithm for 3D Reconstruction in Electron Microscopy

In electron microscopy, three-dimensional (3D) reconstruction is one key component in many computerized techniques for solving 3D structures of large protein assemblies using electron microscopy images of particles. Main challenges in 3D reconstruction include very low signal-to-noise ratio and very large scale of data sets involved in the computation. In this talk, we presented a wavelet tight frame based 3D reconstruction approach that exploits the sparsity of the 3D density map in a wavelet tight frame system. The proposed approach not only runs efficiently in a terms of CPU time but also requires a much lower memory footprint than existing framelet-based regularization methods. The convergence of the proposed iterative scheme and the functional it minimizes is also examined, together with the connection to existing wavelet frame based regularizations. The numerical experiments showed good performance of the proposed method when it is used in two electron microscopy techniques: the single particle method and electron tomography.

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MS40

Fast Algorithms for 3D Cryo-Em Reconstruction

Image reconstruction in cryo-electron microscopy is a computationally intensive process. Not only does it give rise to a non-convex optimization problem, the raw data is extremely noisy. Existing methods are generally based on some version of the expectation maximization method to solve a maximum likelihood problem, with a low resolution starting guess. We will present a collection of algorithms intended to accelerate the reconstruction - some based on fast algorithms for the computation of putative projections from the current model of the molecule, some based on accelerated fitting of data to that model and some based on a recursion in frequency that mitigates the difficulties associated with the non-convexity of the optimization task.

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MS41

Inverse Schroedinger Problem with Internal Measurements

We consider the problem of finding the Schrödinger potential from a few measurements of solutions to the Schrödinger equation corresponding to different source terms. This problem arises in hydraulic tomography where the goal is to image the hydraulic properties of an aquifer by injecting water in one well and measuring the change in pressure in other wells.

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MS41

Nonlinear Acoustic Imaging via Reduced Order Model Backprojection

We introduce a novel nonlinear acoustic imaging method based on model order reduction. The reduced order model

(ROM) is an orthogonal projection of the wave equation propagator on the subspace of snapshots of solutions of the acoustic wave equation. It can be computed entirely from the knowledge of the time domain data. The image is a backprojection of the ROM using the subspace basis for a known smooth kinematic velocity model. Implicit orthogonalization of solution snapshots is a nonlinear procedure that differentiates our approach from the conventional linear methods (Kirchhoff, reverse time migration - RTM). It allows for automatic removal of multiple reflection artifacts. It also doubles the resolution in range compared to conventional RTM.

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MS41

Stability from Partial Data in Current Density Based Impedance Imaging

I will present some recent progress on the stability problem in Current Density based Impedance Imaging (CDII) from partial data. This work explains the resolution and accuracy obtained in CDII pictures in the case of partial interior and boundary data. This is joint work with Carlos Montalto of University of Washington.

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MS42

Multistatic Imaging of Extended Targets

We develop iterative approaches for imaging extended inclusions from multistatic response measurements at single or multiple frequencies. Assuming measurement noise, we perform a detailed stability and resolution analysis of the proposed algorithms in two different asymptotic regimes: the Born approximation in the nonmagnetic case and a high-frequency regime in the general case. This talk is based on the paper H. Ammari, J. Garnier, H. Kang, M. Lim, and K. Solna, SIIMS, 5, 564-600 (2012).

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MS42

Fast Alternating Direction Optimization Methods

This talk will discuss recent advances in ADMM/Split Bregman methods for problems in imaging and machine learning. Will will focus on the application of Nesterov-type acceleration to achieve fast convergence rates. We will discuss a number of applications in distributed computing, machine learning, and image processing.

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MS42

Some Recent Advances in Primal-Dual Methods for Saddle-Point Problems

We showed that the primal-dual hybrid gradient (PDHG) method can be explained from the proximal point algorithm (PPA) perspective, and the work was published on SIIMS in 2012. This fact has enabled us to find more results of this important method, including the understanding of its convergence when one function of a saddle-point problem is strongly convex, the design an algorithmic framework of generalized PDHG methods, and the convergence analysis of some inexact versions of PDHG. I will present some of our recent results in this talk.

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MS42

Image Denoising Using Mean Curvature of Image Surface

We will discuss a variational model for image denoising using the L1-norm of mean curvature of the image graph as a regularizer. Besides eliminating noise and preserving edges, the model can keep image contrasts and sharp corners, and also remove the staircase effect. We will also address a fast algorithm for the model using augmented Lagrangian methods. Numerical experiments will be presented to show the features of the model. Recent progress will also be reported.

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MS43

Effective Algebra and Geometry for Images with Varied Topology

Topological summaries of geometric data, such as multiparameter persistent homology extracted from medical and biological images, require interpretable data structures for subsequent statistical analysis to proceed. Combinatorial commutative algebra provides a language to encode these summaries that clarifies the topological interpretation and illuminates potential pitfalls of the topological techniques but also indicates effective methods to overcome them. The main dataset leading to these developments consists of photographic images of fruit fly wings with varying topological patterns of veins, but the principles and data structures are general for multiparameter persistence.

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MS43

Local-to-Global Homology and Barcode Fields

Persistent homology lets us construct informative topological summaries of the shape of data. Using a kernel construction, we propose a localized form of homology represented by a continuous barcode field that is stable with respect to the Wasserstein metric and thus robust to noise and outliers. We also discuss applications to genetics of plant morphology.

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MS43

Directional Features, Projective Coordinates and Classification

Directional features in images have been shown to be fundamental in digit recognition and texture classification tasks. We will show in this talk how projective spaces can be used to model distributions of said features, and how data can be mapped onto these spaces.

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MS43

Topologically Accurate Digital Image Analysis Using Discrete Morse Theory

Our work with x-ray micro-CT images of complex porous materials has required the development of topologically valid and efficient algorithms for studying and quantifying their intricate structure. For example, simulations of two-phase fluid displacements in a porous rock depend on network models that accurately reflect the connectivity and geometry of the pore-space. These network models are usually derived from curve-skeletons and watershed basins. Existing algorithms compute these separately and may give inconsistent results. We have shown that Forman's discrete Morse theory, informed by persistent homology, provides a unifying framework for simultaneously producing topologically faithful skeletons and compatible pore-space partitions. Our code package, diamorse, for computing these skeletons, partitions and persistence diagrams is now available on GitHub. The code contains several optimisations that allow it to process images with up to 2000^3 voxels on a high-end desktop PC.

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MS44

Geometrical Learning and Cardinal Composition of Shape Elements in Imaging and Vision

The problem of interest is learning the main geometric components of a target object with reference to a dictionary of prototype shapes. The object characterization is through the composition of matching elements from the shape dictionary. The composition model allows set union and difference among the selected elements, while regularizing the problem by restricting their count to a fixed level. Convex cardinal shape composition (CSC) is a recent relaxation scheme to address this combinatorial problem. We discuss general sufficient conditions under which CSC identifies a target composition. We provide qualitative results on how well the CSC outcome approximates the combinatorial solution. We also propose a fast convex solver to address the problem. Applications vary from multi-resolution image segmentation, and recovery of the principal shape components, to optical overlapping character recognition.

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MS44

Prior Model Identification During Subsurface Flow Data Integration with Adaptive Sparse Representations

Abstract not available.

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MS44

Compressive Conjugate Directions: Linear Theory

We present a powerful and easy-to-implement iterative algorithm for solving large-scale optimization problems that involve L1/total-variation (TV) regularization. The method is based on combining the Alternating Directions Method of Multipliers (ADMM) with a Conjugate Directions technique in a way that allows reusing conjugate search directions constructed by the algorithm across multiple iterations of the ADMM. The new method achieves fast convergence by trading off multiple applications of the modeling operator for the increased memory requirement of storing previous conjugate directions. We illustrate the new method with a series of imaging and inversion applications.

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MS45

Fringe Analysis Using Curvature Models

The main goal of fringe analysis techniques is to recover accurately the local modulated phase from one or several fringe patterns; such phase is related to some physical quantities, such as shape, deformation, refractive index, and temperature. In this talk, we introduce a curvature based variational model for computing discontinuous phase maps from fringe patterns. The analisys of the model and its performance on experiments with both synthetic and real data are presented.

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MS45

Image Comparison Via Group Invariant Non-Expansive Operators

Two images are often judged equivalent if they are obtained from each other by applying a transformation belonging to a given group G of homeomorphisms (e.g., the group of isometries). In this talk we illustrate a G-invariant method for metric comparison of grey-level images represented by real-valued functions. This approach is based on the application of group invariant non-expansive operators to the images and on the computation of the corresponding persistent homology.

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MS45

Variational Frequencies Multiscale Models and the Generation of Nonlinear Eigenfunctions

Recent studies of convex functionals and their related eigenvalue problems show surprising analogies to harmonic analysis based on classical transforms (e.g. Fourier). Thus new types of models and processing algorithms can be designs, such as ones based on the Total-Variation Transform. This talk will further investigate the atoms of regularizers where a flow which can generate a large variety of nonlinear eigenfunctions and pseudo-eigenfunctions will be introduced, shining light on examples yet unknown.

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MS45

A Computational Model of Amodal Completion

We present a computational model that gives the most likely scene interpretation from a planar image; the interpretation includes both the disoccluded objects and their ordering according to depth. We use a Bayesian model which depends on the global complexity of the objects conforming the scene plus the effort of bringing them together. To compute the disoccluded objects we use a geometric inpainting method based on Eulers elastica, relatability and convexity.

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MS46

Variational Motion Estimation for Cell Migration

Our aim is to track and to analyze migrating leukocytes. Therefore, we use 4d in vivo fluorescence microscopy data, which offers a variety of mathematical challenges. We perform a combination of registration, segmentation and flow estimation, whereas the latter will be the focus of this talk. To detect the intracellular and extracellular motion of the cells, we present ideas for variational flow models that combine the abilities to recover smooth transitions and sharp edges.

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MS46

Precise Relaxation for Motion Estimation

Variational motion estimation problems, such as optical flow and depth from stereo, often exhibit highly irregular and nonconvex data terms. Lifting-based convex relaxation methods promise to find good minimizers by approximating the original energy. However, their resolution has so far been limited by the number of artificial labels, and obtaining accurate solutions requires to solve very large problems. In this talk, we present a strategy for precisely relaxing non-convex energies in a way that allows to find accurate solutions that are not limited by the number of labels. This greatly reduces the problem size and makes application to many real-world problems feasible. We demonstrate the usefulness on several variational problems in the context of image restoration and motion estimation.

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MS46

Adaptive Regularization of the Non-Local Means for Video Denoising

We derive a denoising method based on an adaptive regularization of the non-local means. The NL-means reduce noise by using the redundancy in natural images. They compute a weighted average of pixels whose surroundings are close. This reduces significantly the noise while preserving most of the image content. While it performs well on flat areas and textures, it suffers from two opposite drawbacks: it might over-smooth low-contrasted areas or leave a residual noise around edges and singular structures. We introduce a variational approach that corrects the over-smoothing and reduces the residual noise of the NL-means by adaptively regularizing non-local methods with the total variation. We use the weights computed in the NL-means as a measure of performance of the denoising process. These weights balance the data-fidelity term in an adapted ROF model, in order to locally perform adaptive TV regularization. Besides, this model can be adapted to different noise statistics and a fast resolution can be computed in the general case of the exponential family. We adapt this model to video denoising by using spatio-temporal patches. Compared to spatial patches, they offer better temporal stability, while the adaptive TV regularization corrects the residual noise observed around moving structures.

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MS47

An L1 Regularization Algorithm for Reconstructing Piecewise Smooth Functions from Fourier Data Using Wavelet Projection

Several important applications use Fourier sampling. Often it is advantageous to reduce samples counts. Regularizations seeking piecewise smooth solutions are popular in compressed sensing. Total Variation denoising is a successful technique; but it suffers from so called staircase artifacts that can be removed with Generalized Total Variation. We offer an alternative using a polynomial annihilation edge detector and a Wavelet basis. This has a simple, robust implementation.

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MS47

Sar Moving Target Imaging in Complex Scenes Using Sparse and Low-Rank Decomposition

We present a method to image complex scenes with spotlight mode SAR with the presence of moving targets. Recent methods that use sparsity-based reconstruction coupled with phase error corrections of moving targets cannot handle realistic scenarios because they assume the scene itself is sparse. Our method makes use of the sparse and low-rank (SLR) matrix decomposition. We demonstrate with the GOTCHA Volumetric SAR dataset that SLR can accurately image multiple moving targets in complex scenes.

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MS47

Sar Imaging using Special Regularization Methods

Synthetic Aperture Radar (SAR) imaging is a technique used to construct usually 2-D approximations of a scene by detecting scattered waves off of the scene. These scattered wave measurements take the form of high frequency Fourier coefficients. In this talk we present ℓ_1 regularization approaches for SAR image formation.

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MS47

Image Reconstruction from Non-Uniform Fourier Data

Nonuniform Fourier data are routinely collected in applications such as magnetic resonance imaging, synthetic aperture radar, and synthetic imaging in radio astronomy. We will discuss in this talk the image reconstruction from its finite non-uniform Fourier samples. Specifically, we provide a mathematical foundation of this problem through Fourier frames and admissible frames. As a result, a stable and efficient algorithm based on that will also be presented.

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MS48

Accelerating Optical Projection Tomography Using Compressed Sensing

Abstract not available.

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MS48

Limited Angle Tomography and Discretization of Continuous Inverse Problems

We consider the question how inverse problems posed for continuous objects, for instance for continuous functions, can be discretized. This means the approximation of the problem by finite dimensional inverse problems. We will consider a linear inverse problem $m = Au + \epsilon$. Here function m is the measurement, A is an ill-conditioned linear operator, e.g. operator modeling the limited angle X-ray imaging, u is an unknown function, and ϵ is random noise. The inverse problem means determination of u when m is given. The traditional solutions for the problem include the generalized Tikhonov regularization and the estimation of u using Bayesian methods. To solve the problem in practice u and m are discretized, that is, approximated by vectors in a finite dimensional vector space. We show positive results when this approximation can successfully be done in the context of Tikhonov regularization and of the Bayesian analysis. Also, we show problems that can surprisingly appear in these methods. As a particular example, we consider the total variation (TV) regularization and the Bayesian analysis based on total variation prior and the Besov priors. Also, we consider the effects caused by the fact that the Gaussian white noise, considered as a function on an interval or a square, is not L^2-valued function but a generalized function (i.e., a distribution).

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MS48

Tomographic Reconstruction Using Adaptive Mcmc in Terms of Parametric Curves

The inverse problem of reconstructing of 2D shape of a homogeneous phantom using Adaptive MCMC in term of Non-Uniform Rational B-Splines (NURBS) is presented. The proposed method assesses the boundary shape of the phantom by estimating the control points in NURBS curve out of sparse tomography measurements. The attenuation parameter of the inside material, in this case sugar crystal, is recovered as well. The computations result is quite promising, though it has a heavy computation.

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MS48

Computed Tomography from Limited Data Using a Robust and Automated Discrete Algebraic Reconstruction Technique

Obtaining accurate reconstruction from limited projection data is of high importance in tomography applications. Discrete tomography achieves this goal by incorporating prior knowledge of the scanned object in terms of its limited number of material compositions. In this work, we propose a robust discrete algebraic reconstruction technique, TVR-DART, which imposes both soft discrete priors and sparsity constraints. Both numerical and experimental results show that the proposed algorithm performs accurate reconstructions under practical limited data conditions.

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MS49

Dose Fractionated Cryo-EM Images: Advances and Fundamental Limits in Movie Alignment

The introduction of direct electron detectors in cryo-electron microscopy (cryo-EM) has had transformative effects in the field. These detectors provide the capability of acquiring time-resolved data in movie-mode allowing for correction of stage and beam induced motion which are important resolution limiting factors. In this talk, we present recent advances in motion correction of cryo-EM images as well as fundamental limits in more general multi-image registration that reveal the conditions under which alignment is possible.

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MS49

Denoising and Covariance Estimation of Single Particle Cryo-EM Images

The problem of image restoration in cryo-EM entails correcting for the effects of the Contrast Transfer Function (CTF) and noise. Popular methods for image restoration include 'phase flipping', which corrects only for the Fourier phases but not amplitudes, and Wiener filtering, which requires the spectral signal to noise ratio. We propose a new image restoration method which we call 'Covariance Wiener Filtering' (CWF). In CWF, the covariance matrix of the projection images is used within the classical Wiener filtering framework for solving the image restoration deconvolution problem. Our estimation procedure for the covariance matrix is new and successfully corrects for the CTF. We demonstrate the efficacy of CWF by applying it to restore both simulated and experimental cryo-EM images. Results with experimental datasets demonstrate that CWF provides a good way to evaluate the particle images and to see what the dataset contains even without 2D classification and averaging.

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MS49

Symmetry Detection by Auto-Correlation Kernels

We consider the problem of identifying the type of spacial symmetry group of a biological molecule from its noisy cryo-EM projections from unknown viewing directions. Our approach is to estimate the auto-correlation kernel functions of the projections and to compute the spectra of the kernels, following Kam's theory in 1980s. According to a classical theorem of Klein, the "ranks" of the auto-correlation kernels encode the type of the symmetry that the molecule has. We test the algorithm on synthetic and real-world data sets.

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MS49

Angular Reconstitution for Molecules with C_4 Symmetry

We present an algorithm for determining the three-dimensional structure of molecules that have a 4-way rotational symmetry. Our algorithm is based on self-common-lines which induce identical lines within the same image. We show that the location of self-common-lines is related to the underlying image's viewing-direction tilt angle, and that it admits quite a few favorable geometrical constraints, thus enabling a high detection rate even in a noisy setting.

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MS50

Emerging Applications for Radar Intelligence, Surveillance, and Reconnaissance

From the first experiments in the late 19th century to today, radar has continually evolved and become an indispensable tool in the area of Intelligence, Surveillance, and Reconnaissance (ISR). Todays applications include military, intelligence, homeland security, resource management, and scientific missions. As new needs arise, radar offers the possibility of further evolution to meet those needs. We discuss in this presentation some of the emerging applications for ISR to which radar imaging might offer utility.

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MS50

Electromagnetic Time Reversal

We apply the Time Reversal algorithm in a multiple-scattering environment to discover resonances for a collection of scatterers.

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MS50

A Functional Analytic Approach to Sar Image Reconstruction

In this work we draw the connection between backprojection reconstruction and best linear unbiased estimation in synthetic aperture radar imaging. It is found that in the ideal imaging scenario, i.e. unlimited bandwidth and aperture, the backprojected image and the best linear unbiased estimate are identical when using a microlocal criterion for determining the backprojection filter. From this analysis a reproducing kernel criterion is derived for the ideal backprojection filter in a more general sense. We also attempt to determine the ideal Hilbert space which contains the reflectivity function in SAR imaging.

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MS50

Design Considerations for Multistatic Radar Imaging

This talk describes design considerstions for multistatic radar imaging including geometry and pulse repetition frequencies for the system.

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MS51

The Difference of L1 and L2 for Compressive Sensing and Image Processing

A fundamental problem in compressed sensing (CS) is to reconstruct a sparse signal under a few linear measurements far less than the physical dimension of the signal. Currently, CS favors incoherent systems, in which any two measurements are as little correlated as possible. In reality, however, many problems are coherent, in which case conventional methods, such as L_1 minimization, do not work well. In this talk, I will present a novel non-convex approach, which is to minimize the difference of L_1 and L_2 norms (L_{1-2}) in order to promote sparsity. Efficient minimization algorithms will be discussed, including difference of convex function methodology and a proximal operator for L_{1-2}.

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MS51

Majorization-Minimization for Nonconvex Optimization

We propose an efficient optimization algorithm based on a majorization-minimization (MM) strategy for the solution of nonsmooth nonconvex minimization problems. The MM algorithms are based on the principle of successively minimizing upper bounds of the objective function. Each upper bound, or surrogate function, is locally tight at the current estimate, and each minimization step decreases the value of the objective functional. Analysis of convergence of the proposed approach are provided. Our experiments show that our method is competitive with the state of the art for the solution of nonconvex minimization problem.

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MS51

Algorithms for Minimizing Differences of Convex Functions and Applications

Several optimization schemes have been known for convex optimization problems. However, numerical algorithms for solving nonconvex optimization problems are still underdeveloped. A progress to go beyond convexity was made by considering the class of functions representable as differences of convex functions. In this talk we present a number of algorithms for minimizing differences of convex functions. Then we introduce some applications of these algorithms to solve problems of facility location and clustering.

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MS51

Nonconvex Sorted L1 Minimization for Sparse Approximation

In this paper, we consider a weighted ℓ_1 penalty with the set of the weights fixed and the weights are assigned based on the sorting of all the components in magnitude. The smallest weight is assigned to the largest component in magnitude. This new penalty is called nonconvex sorted ℓ_1. Then we propose two methods for solving nonconvex sorted ℓ_1 minimization problems: iteratively reweighted ℓ_1 minimization and iterative sorted thresholding, and prove that both methods will converge to a local minimizer of the nonconvex sorted ℓ_1 minimization problems. We also show that both methods are generalizations of iterative support detection and iterative hard thresholding, respectively. The numerical experiments demonstrate the better performance of assigning weights by sort compared to assigning by value.

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MS52

Automated Target Detection from Compressive Measurements

A novel compressive imaging model is proposed that multiplexes segments of the field of view onto an infrared focal plane array. Similar to compound imaging, our model is based on combining pixels from a surface comprising of different parts of the FOV. We formalize this superposition of pixels in a global multiplexing process reducing the number of detectors required of the FPA. We then apply automated target detection algorithms directed on the measurements of this model in a scene. Based on quadratic correlation filters, we extend the target training and detection processes directly using these encoded measurements. Preliminary results are promising.

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MS52

An Automated Design Scheme for Improved Point Spread Function Engineering

Abstract not available.

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MS52

Compressive Sensing of Very High-Dimensional Images and Videos

Abstract not available.

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MS52

Through-the-Wall Radar Imaging Using Discrete Prolate Spheroidal Sequences

A challenge when detecting stationary targets through walls is to locate the targets in the presence of wall EM reflections, which are relatively strong compared to behind-the-wall target return. Given limited measurements of a stepped-frequency radar signal, we discuss techniques for mitigating wall return and detecting stationary targets by using Modulated Discrete Prolate Spheroidal Sequences (DPSSs), a time-frequency analysis tool that offers an efficient basis for representing sampled bandpass signals.

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MS53

Fast Scattered Data Interpolation

The problem of interpolating irregularly spaced multidimensional data to a regular grid plays an important role in geophysical imaging. I describe a fast $O(N)$ algorithm for solving this problem, where N is the size of the output grid. The algorithm is analogous to the method of natural neighbor interpolation and is based on computing the distance function and the distance gradient by solving the eikonal equation.

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MS53

Babich's Expansion and the Fast Huygens Sweeping Method for the Helmholtz Wave Equation at High Frequencies

Starting from Babich's expansion, we develop a new high-order asymptotic method, which we dub the fast Huygens sweeping method, for solving point-source Helmholtz equations in inhomogeneous media in the high-frequency regime and in the presence of caustics. The new method enjoys the following desired features. First, it precomputes the asymptotics in Babich's expansion, such as traveltime and amplitudes. Second, it takes care of caustics automatically. Third, it can compute the point-source Helmholtz solution for many different sources at many frequencies simultaneously. Fourth, for a specified number of points per wavelength, it can construct the wavefield in nearly optimal complexity in terms of the total number of mesh points, where the prefactor of the complexity only depends on the specified accuracy and is independent of frequency. Both two-dimensional and three-dimensional numerical experiments have been carried out to illustrate the performance, efficiency, and accuracy of the method.

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MS53

Affine invariant geodesics and their applications

Natural objects can be subject to various transformations yet still preserve properties that we refer to as invariants. Here, we use definitions of affine-invariant arc-length in order to extend the set of existing non-rigid shape analysis tools. We show that by re-defining the surface metric as its equi-affine version, the surface with its modified metric tensor can be treated as a canonical Euclidean object on which most classical Euclidean processing and analysis tools can be applied. The new definition of a metric is used to extend the fast marching method technique for computing geodesic distances on surfaces, where now, the distances are defined with respect to an affine-invariant arclength.

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MS53

Joint Fwi and Traveltime Tomography

The full waveform inversion (FWI) is a non-linear optimization problem, which is solved by iterative methods like Gauss Newton. Using such methods, the resulting solution is highly sensitive to the existence of low-frequency data, which is hard to collect. Therefore FWI is often initialized by traveltime tomography, which is achieved by solving the inverse Eikonal equation. In this talk we extend this approach and jointly apply FWI and traveltime tomography to strengthen the influence of the low-frequencies obtained from the latter on the minimization process. Synthetic examples show that this strategy leads to a better recovery of the underlying medium when low-frequency data is missing.

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MS54

Learning Matrix-Valued Kernels for Shape Classification in the Large Deformation Framework

Abstract not available.

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MS54

Matrix-Valued Kernels for Shape Deformation Analysis

Abstract not available.

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MS54

Statistical Shape Analysis Heavy Weight and Light Weight Approaches

Generating concise, accurate, robust descriptors of shape remains an important problem in image analysis. While many conventional methods for shape analysis have relied on a relatively small set of shape descriptors, recently technologies have been proposed that work directly on shape spaces, with metrics that account for the high-dimensional properties of shapes and the associated invariants. Such shape metrics introduce associated heavy-weight problems of either finding geodesics on a shape manifold or finding a dense set of correspondence points. Recently, researchers have discovered that analysis of a *population* of shapes helps in the tractable computation of correspondences and associated metrics. In this talk we discuss recent work on automatic generation of correspondences and shape transformtions using populations of shapes, as well as population-based methods that forgo transformations all together.

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MS54

Atrophy-Constrained Longitudinal Registration of Shapes Extracted from Brain Images

Diffeomorphic registration using optimal control on the diffeomorphism group and on shape spaces has become widely used since the development of the Large Deformation Diffeomorphic Metric Mapping (LDDMM) algorithm. More recently, a series of algorithms involving sub-riemannian constraints have been introduced, in which the velocity fields that control the shapes in the LDDMM framework are constrained in accordance with a specific deformation model. Here, we extend this setting by considering, inequality constraints, in order to estimate surface deformations that only allow for atrophy. We will present experimental results in longitudinal surfaces registration, which exhibit an increased robustness when the constraint is imposed, in a way which is reminiscent of unidimensional

monotonic regression.

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MS55

Explorations on Anisotropic Regularisation of Dynamic Inverse Problems by Bilevel Optimisation

We explore anisotropic regularisation methods in the spirit of Holler & Kunisch, 2014. Based on ground truth data, we propose a bilevel optimisation strategy to compute the optimal regularisation parameters of such a model for the application of video denoising. The optimisation poses a challenge in itself, as the dependency on one of the regularisation parameters is non-linear such that the standard existence and convergence theory does not apply. Moreover, we analyse numerical results of the proposed parameter learning strategy based on three exemplary video sequences and discuss the impact of these results on the actual modelling of dynamic inverse problems.

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MS55

Reconstructing Highly Accelerated Dynamic MR Data Using Spatio-Temporal ICTGV Regularization

We propose a variational method for reconstructing image sequences from accelerated dynamic magnetic resonance (MR) data. Our approach uses the infimal convolution of total generalized variation functionals (ICTGV) as regularization, which suitably combines higher-order spatial and temporal regularity assumptions. By exploiting temporal redundancy, it yields a high reconstruction quality even in the case of strong undersampling. This was in particular confirmed on real data by achieving the second place in the 2013 ISMRM challenge.

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MS55

Joint 4D Reconstruction and Perfusion Estimation via Sparsity and Low-Rank

In biomedical imaging for brain perfusion and myocardial blood flow, e.g. via 4D-CT, ASL-MRI or SPECT/PET, tracer-kinetic field theory can unify among different modalities. However, standard models for 4D reconstruction and tracking reach their limits, mainly due to oversimplified spatial localization and misinterpretations of imbalanced sequences according to space-time. We present a new framework for tracking via sparsity and low-rank sequence decomposition and its added value for joint 4D ill-posed inverse problems in those fields.

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MS55

Tomographic Imaging of Moving Objects: A Space-Time Approach

The classical level set method approach for inverse problems is based on modelling the unknown coefficient as a binary function: zero outside the level set and constant inside. This is achieved by composing a smooth level set function with the Heaviside step function. It was shown in [Kolehmainen, Lassas and Siltanen, SIAM J. Sci. Comput. 30 (2008)] that for sparse-data X-ray tomography it is advisable to replace the Heaviside function by x^+ (which is zero for negative real arguments and identity for non-negative arguments). The the X-ray attenuation function is modelled as zero outside the level set and by the smooth level set function inside the level set. In particular, that approach helps suppress the stretching artefacts typical in limited-angle tomography. Regularization is provided in the method by a penalty term involving the square norms of the derivatives of the level set function up to order n. In the theoretical part of this report we show that the x^+-based level set method is equivalent to constrained Tikhonov regularisation when $n = 1$, and the choice $n > 1$ leads to a novel, nonlinear level set method. The solution in the case n¿1 is defined as a minimizer of a nonlinear functional; we prove that there exists at least one such minimizer. In the computational part we apply the level set method with $n = 2$ to dynamic tomographic data interpreted as being measured from a space-time target. The new method gives superior results compared to filtered back-projection, constrained Tikhonov regularisation, and total variation regularisation.

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MS56

Gaussian Models for Texture Synthesis

I will discuss a series of work that uses Gaussian random fields for texture synthesis. Results show that several natural textures are well reproduced using a Gaussian model.

I will also describe an algorithm that summarizes a texture sample into a synthesis-oriented texton, that is, a small image for which the discrete spot noise simulation (summed and normalized randomly-shifted copies of the texton) is more efficient than the classical convolution algorithm.

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MS56

Processing Textures in the Spectral Total-Variation Domain

In this talk we will outline the recently proposed spectral total-variation domain and explain how textures can be isolated and manipulated easily within this representation. Some theoretical aspects related to nonlinear spectral representations and nonlinear eigenvalue problems will be discussed.

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MS56

New Multifractal Parameters for Texture Classification Based on P-Exponents and P-Leaders

Mutifractal analysis supplies classification parameters for natural or artificial textures (e.g. paintings). Their derivation is based on the interplay between local and global regularity exponents. We will explain the mathematical ideas behind this derivation, and show the advantage of using p-wavelet leaders in this derivation. Illustration cover both simulations of random fields, and real-life textures. This is joint work with P. Abry, R. Leonarduzzi, C. Melot, S. Roux, M. E. Torres and H. Wendt

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MS56

Local Laplacian Filters: Theory and Applications

Standard image pyramids have been long considered ill-suited for edge-aware image manipulation the intuition being that one needs discontinuous kernels like that of the bilateral filter for instance to model sharp edges. In this talk, I will introduce the Local Laplacian Filters, a new class of operators based on standard Gaussian and Laplacian pyramids. These filters achieve state-of-the-art results on edge-aware applications like tone mapping and texture enhancement, thereby demonstrating that image pyramids based on smooth Gaussian kernels can actually accurately handle edges. This is a joint work with Sam Hasinoff, Jan Kautz, Matthieu Aubry, and Frdo Durand.

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MS57

Multiple Continuum Limits for Discrete Image Inpainting

In the course of their work on Coherence Transport*, Marz and Bornemann proposed a continuum limit for a class of discrete image inpainting algorithms. This limit was useful because was able to explain the cause of certain undesireable behaviour in existing algorithms, facilitating the design of new algorithms overcoming these difficulties. However, careful numerical experiments have revealed additional undesireable behaviour not explained by this limit. In this talk I will show that a second, alternative continuum limit exists accounting for this behaviour and which is “closer’ to the discrete algorithm in a sense that I will make precise. I will then show how this limit can be used as a guide to design algorithms with further improvements. *Folkmar Bornemann and Tom Marz. Fast image inpainting based on coherence transport. Journal of Mathematical Imaging and Vision, 28(3):259-278, 2007.

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MS57

Directional Total Variation Regularization for Imaging Problems

We introduce a reformulation of directional total variation (DTV) based on standard total variation (TV). DTV can be a useful regularization tool for applications with directional information, and we show that it has the same essential properties as TV. Using automated estimation of direction(s) in the object, we demonstrate the improvement of using DTV as a regularizer compared to standard TV. Numerical simulations are carried out for a practical computed tomography reconstruction problem.

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MS57

A Relaxed Normal Two Split Method and An Effective Weighted TV Algorithm for Euler’s Elastica Image Inpainting

In this talk, we introduce two novel methods for solving Euler’s elastica-based inpainting model. The energy functional of Euler’s elastica model involves high order derivatives and is nonsmooth and nonconvex, hence it is very complex to minimize. Our new methods are based on the two powerful algorithm ideas: operator splitting and alternating direction method of multipliers. We relax the normal vector in the curvature term and we propose a Relaxed Normal Two Split (RN2Split) method. In theory, we show that the limit point of a converging sequence satisfies the Karush–Kuhn–Tucker conditions. The second method considers solving the Euler’s elastica model in form of a weighted total variation. We prove the convergence under a mild assumption. We present numerical results for solving several image inpainting problems, and we show that our algorithms compare favorably with state-of-art algorithms.

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MS57

Augmented Lagrangian Method for An Euler's Elastica Based Segmentation Model That Promotes Convex Contours

We discuss a new image segmentation model using an L1 variant of Euler's elastica as boundary regularization. An interesting feature of this model lies in its preference for convex contours. To minimize the associated functional, we propose a novel augmented Lagrangian method that employs fewer Lagrange multipliers than those in the previous works. Numerical experiments validate the efficiency of the algorithm and demonstrate new features of this model, including shape driven and data driven properties.

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MS58

Augmented Lagrangian Methods for Constrained Optimal Control Applied to Shape Registration

We have recently developed shape registration methods that solve optimal control problems in the diffeomorphism group subject to equality or inequality constraints that are linear in the control and possibly non-linear in the state variable. After providing examples of applications of the approach, which include multi-shape diffeomorphic registration, registration with atrophy, or normal motion constraints, we will describe our implementation, which is based on the augmented Lagrangian method, and provide theoretical results that assess the existence of solutions to these problems, together with the consistency of discrete approximations.

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MS58

Advances in Lesion Quantification from PET/CT and PET/MR Scans

PET/CT and PET/MR scanners provide both structural and functional information. They are frequently needed by clinicians for diagnosing and characterizing the disease type accurately. However, all diagnostic measurements require precise segmentation of functional and anatomical images, which is a challenging task due large variations of pathologies, and difficulty in combining structural and functional information in the same settings. To address these challenges, I will present novel methods for accurate segmentation and quantification of lesions from PET/CT and PET/MR images.

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MS58

A Fast Algorithm for Structured Low-Rank Matrix Completion with Applications to Compressed Sensing MRI

A powerful new class of MRI reconstruction techniques pose recovery from undersampled k-space measurements through matrix lifting. In the lifted domain, the problem is to recover a structured and low-rank matrix from its partial entries. These techniques provide superior reconstruction quality and flexibility in sampling. However, this approach is computationally intensive, requiring SVD of several large dense matrix inversions per iteration. To address this problem, we propose a novel, fast algorithm for a class of structured and low-rank matrix completion problems.

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MS58

Towards Robust Voxel-Wise Quantification of Perfusion in Low SNR Dynamic Pet Imaging

We present a novel image processing pipeline for robust voxel-wise quantification of perfusion in low SNR dynamic PET imaging. Physiologically similar voxels are clustered together based on time activity curves to obtain a tighter control on bias (resolution) and reduce noise-induced bias. Moreover, the parameter estimation problem is split to facilitate identifiability of physiologically meaningful parameters. The proposed framework improves quantitative accuracy, and has long-term potential to enhance detection, staging and management of coronary artery disease.

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MS59

Solving Ptychography with a Convex Relaxation

Ptychography is a powerful imaging technique that transforms a collection of low-resolution images into a high-resolution sample reconstruction. Unfortunately, most algorithms that currently solve this reconstruction problem lack stability, robustness, and theoretical guarantees. This talk first presents a convex formulation of the ptychography problem, which has no local minima and can be solved using a wide range of algorithms. It then considers a specific algorithm, based on low-rank factorization, whose runtime and memory usage are near-linear in the size of the output image. Experiments demonstrate that this approach offers a 25% lower background variance on average than alternating projections, the ptychographic reconstruction algorithm that is currently in widespread use. Finally, this talk considers an extension of this new algorithm to the reconstruction problem in 3D diffraction tomography.

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MS59

Phase Retrieval with Missing Data

Missing data in coherent X-ray diffraction imaging arises in experiment from, for example, the beam stop. We show how to modify algorithms for missing data and then evaluate their ability to recover both the phase and missing data from experiments. We then discuss regularization and addressing confidence in the experimental values.

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MS59

Reconstruction Algorithms for Blind Ptychographic Imaging

In scanning ptychography, an unknown specimen is illuminated by a localised illumination function resulting in an exit-wave whose intensity is observed in the far-field. A ptychography dataset is a series of these observations, each of which is obtained by shifting the illumination function to a different position relative to the specimen with neighbouring illumination regions overlapping. Given a ptychographic data set, the blind ptychography problem is to simultaneously reconstruct the specimen, illumination function, and relative phase of the exit-wave. In this talk I will discuss a nonsmooth optimisation framework which interprets current state-of-the-art reconstruction methods in ptychography as (non-convex) alternating minimization-type algorithms. Within this framework, a proof of global convergence to critical points using the Kurdyka-Lojasiewicz property is provided.

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MS59

Survey and Benchmarking of Compressive Sensing Phase Retrieval Methods

Compressive phase retrieval is a novel method for solving the phase problem. It exploits sparsity under some mathematical transformation of the quantity we wish to recover: rather than recovering the original non-sparse quantity, we apply a sparsifying transformation which "compresses" information into as few matrix elements as possible, and then proceeds to recover this simplified representation. We compare standard formulations of the compressive phase retrieval optimization problem, and perform benchmarking tests to evaluate algorithmic effectiveness.

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MS60

Reconstruction of Images from Highly Noisy and Sparse Observations Using Data-driven Priors

In many image analysis problems we seek to reconstruct a spatial field. In Bayesian inverse problems we need to construct likelihood and prior probability density functions. I will present a methodology that combines supervised learning with classical Gibbs measures for likelihood and smoothness priors to construct likelihood and prior functions. I will discuss the computational challenges in working with such probability functions and will present experimental results for an image segmentation problem.

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MS60

Optimal Experimental Design for Imaging Subsurface Flow

Designing experiments for imaging fluid flow requires the integration of the dynamical system describing the flow, the geophysical imaging technique, and historic data. In this talk we explore optimal experimental design methods for such problems, and demonstrate the applicability of the techniques for the problem of imaging subsurface flow using seismic methods.

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MS60

Multi-Level Accelerated Algorithm for Large-Scale Convex Composite Minimization

We propose a multi-level algorithm for solving convex composite optimization problems. Our method exploits the fact that many applications that give rise to large-scale problems can be modelled using varying degrees of fidelity. We show that it converges to a minimizer with optimal $\mathcal{O}(1/\sqrt{\epsilon})$ rate. Using numerical experiments we show that on large-scale computer vision problems our algorithm is several times faster than the state of the art.

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MS60

A Multilevel Solver for the Rada-Chen Selective Segmentation Model and Its Extensions

In medical imaging, selective segmentation for identification of abnormalities is incredibly important. It is also important that this segmentation be achieved quickly with minimal input from the user. In this talk I will discuss a fast multigrid solution for the Rada-Chen (2012) model and extensions to this model. The implementation of this allows very quick segmentation of user selected items within an image. Various results will be shown and open problems discussed.

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MS61

Nonconvex Regularization and Satellite Imagery

There are several benefits to regularizing the processing of images with nonconvex penalty functions, such as the ℓ^p norm with $p < 1$. Examples in the literature include preserving the shape of edges when denoising images, recovery of sparse images from fewer measurements, and better extraction of moving objects from video. In this talk, we will look at examples drawn from recent work at Descartes Labs, a company that processes huge amounts of satellite imagery to extract useful information.

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MS61

Reconstruction of Sparse Images with Emitter-Based Posterior Mean Estimates

Solving inverse problems with maximum a posteriori approaches often produces reconstruction artifacts in images. A well-known example is the so-called *night sky effect*, observed when the reconstructed image is constrained to be non-negative. We show that this artifact can be avoided by considering the posterior mean, estimated with an MCMC algorithm. To reconstruct sparse images, a non-convex model based on emitters can be used with a similar algorithm. Its usefulness is illustrated for super-resolution microscopy.

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MS61

Smoothness and Sparsity Enhanced Electroencephalogram Brain Image Reconstruction

Electroencephalography (EEG) is a non-invasive technique that reconstructs functional brain images by measuring scalp electrical potentials. In this work, we propose a Sparsity and Smoothness enhanced Method Of Optimized electrical TomograpHy (s-SMOOTH) to improve the reconstruction resolution and quality. Specifically, the Total Generalized Variation (TGV) defined on a triangular mesh is proposed to enhance high-order smoothness of EEG brain image, and the ℓ_{1-2} regularization is utilized to reduce localization error. A large variety of experiments on synthetic data with different source configurations and noise levels demonstrate the advantages of our method in terms of total reconstruction accuracy, localization accuracy and focalization degree. The tests on event-related potential data from normal subject further demonstrate the outstanding performance of the proposed method in practice.

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MS61

Transformed Schatten-1 Iterative Thresholding Algorithms for Matrix Rank Minimization

We study a non-convex low-rank promoting penalty function, the transformed Schatten-1 (TS1), and its applications in matrix completion. The TS1 penalty, as a matrix quasi-norm defined on its singular values, interpolates the rank and the nuclear norm through a nonnegative parameter $a \in (0, +\infty)$. We consider the unconstrained TS1 regularized low-rank matrix recovery problem and develop a fixed point representation for its global minimizer. The TS1 thresholding functions are in closed analytical form for all parameter values. The TS1 threshold values differ in subcritical (supercritical) parameter regime where the TS1 threshold functions are continuous (discontinuous). We propose TS1 iterative thresholding algorithms and compare them with some state-of-the-art algorithms on matrix completion test problems. For problems with known rank, a fully adaptive TS1 iterative thresholding algorithm consistently performs the best under different conditions, where ground truth matrices are generated by multivariate Gaussian with varying covariance. For problems with unknown rank, TS1 algorithms with an additional rank estimation procedure approach the level of IRucL-q which is an iterative reweighted algorithm, non-convex in nature and best in performance.

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MS62

Scalable Information Optimal Imaging: Recent Progress - EO/IR to X-Ray

Abstract not available.

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MS62

Lensfree Imaging

We present a thin form-factor lensless camera, FlatCam, that consists of a coded mask placed on top of a bare, conventional sensor array. FlatCam is an instance of a coded aperture imaging system in which each pixel records a linear combination of light from multiple scene elements. A computational algorithm is then used to demultiplex the recorded measurements and reconstruct an image of the scene. In contrast with vast majority of coded aperture systems, we place the coded mask extremely close to the image sensor that can enable a thin system. We use a separable mask to ensure that both calibration and image reconstruction are scalable in terms of memory requirements and computational complexity. We demonstrate the potential of our design using a prototype camera built using commercially available sensor and mask.

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MS62

Fast Reconstruction Methods for Spatiotemporally-Encoded MRI

This work examines image reconstruction tasks arising in magnetic resonance imaging (MRI) applications that are characterized by the use of a novel class of spatiotemporal (non-Fourier) acquisition sequences. We describe how the unique structure inherent to these imaging sequences may be leveraged and exploited in the reconstruction approach, yielding a flexible and computationally-efficient suite of reconstruction methods for these problems. Experimental evaluations demonstrate the efficacy of our approach for this novel imaging modality.

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MS62

Progress on Developing a Computational Imager Using Integrated Photonics

We will describe the development of a thin form-factor imager based on interferometric imaging and integrated photonics. The system is designed to measure specific components of the Fourier transform of the 2D intensity distribution of a scene. An image reconstruction algorithm is then used to create actual images. System design and reconstruction options will be discussed in detail. Results from an initial proof-of-concept experiment will be presented.

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MS63

Incorporating a Spatial Prior into Nonlinear D-Bar Eit Imaging for Complex Admittivities

Electrical Impedance Tomography imaging aims to recover the internal conductivity and permittivity distributions from electrical measurements taken at the surface of an object. The reconstruction task is a severely ill-posed nonlinear inverse problem that is highly sensitive to measurement noise and modeling errors. D-bar methods have shown great promise in producing noise-robust implementable algorithms by employing a low-pass filter in a nonlinear Fourier domain. Unfortunately, the low-pass filtering can lead to a loss of sharp edges in the reconstruction. Recently, [Alsaker and Mueller, "A D-bar Algorithm with a priori Information for 2-D Electrical Impedance Tomography', 2015] showed that incorporating spatial prior data, e.g. in the form of a CT scan that includes the approximate locations of major features such as the heart, lungs, spine etc., can greatly improve the spatial sharpness of a conductivity image by increasing the radius of the filter in the nonlinear Fourier domain. In this talk, the approach is extended to admittivity (conductivity as well as permittivity) EIT imaging. Noise-robust reconstructions are presented for simulated EIT data on chest-shaped phantoms extracted from CT scans.

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MS63

Direct Inversion from Partial Boundary Measurements by Data Extrapolation

In electrical impedance tomography, the assumption of full boundary data is not always practical. In this context we introduce the partial boundary inverse conductivity problem in a realistic setting and analyze the error that partial boundary measurements introduce. Additionally we propose an extrapolation approach of the measured data. For reconstructing the conductivity we apply a Born approximation. Computational convergence results and reconstructions are presented for medical motivated simulated data.

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MS63

Optimal Ultrasound Frequency for Lung Monitoring Through Ultrasound Informed Electrical Impedance Tomography: Numerical Simulations

Electrical Impedance Tomography images of the lung improve when anatomical and physiological prior information is available. Ultrasound Tomographic images can be a source of prior information for EIT inverse problems. Higher frequencies reflect at the pleura and are quickly absorved in the lung tissue. Lower ultrasound frequencies worsens the spatial resolution of ultrasound tomographic images. The present work investigates the optimal frequency for spatial resolution and penetration of ultrasound in the lung tissue.

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MS63

Edge detection in Electrical Impedance Tomography

In this talk we will present a new imaging method able to reconstruct discontinuities (e.g. edges of inclusions) of an electrical conductivity from boundary voltage and current measurements. The method combines the high contrast sensitivity of Electrical Impedance Tomography with improved spatial resolution obtained through introduction of a nonphysical (virtual) variable. This talk presents the theoretical background of the method as well as numerical reconstructions. This is a joint work with A. Greenleaf, M. Lassas, S. Siltanen and G. Uhlmann.

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MS64

Metamorphoses of Functional Shapes in Sobolev Spaces

We describe in detail a joint model of geometric-functional variability between signals defined on deformable manifolds. These objects called fshapes were first introduced in [Charon et al. 2015]. Building on this work, we extend the original L^2 model to treat signals of higher regularity on their geometrical support with stronger Hilbert norms (typically Sobolev). We describe the Hilbert bundle structure of such spaces and construct metrics based on metamorphoses, that groups into one common framework both shape deformation metrics and usual (flat) image metamorphoses. We then propose a formulation of matching between any two fshapes from the optimal control perspective, study existence of optimal controls and derive Hamiltonian equations describing the dynamics of solutions. Secondly, we tackle the discrete counterpart of these problems and equations as well as the important issue of Γ-convergence of discrete solutions to continuous ones. At last, we show a few results of this fshape metamorphosis approach for the classification of retinal tissues with thickness measurements.

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MS64

A Fast Iterative Algorithm to Compute Elastic Shape Distance Between Curves

We propose a fast iterative algorithm to compute an elastic shape distance between two closed curves. The shape distance is based on the square-root velocity functions proposed by Srivastava et al (PAMI,2011), and is invariant to scaling, translation, and rotation. We pose the distance computation as an energy minimization problem, where we compute the optimal seed, rotation, and diffeomorphism. We develop alternating iterations, using fast dynamic programming and nonlinear optimization for the diffeomorphism, and FFT for the seed and the rotation. Our algorithm results in subquadratic running times with respect the number of nodes of the curves.

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MS64

Irrotational Diffeomorphisms for Image Registration and Density Matching

Abstract not available.

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MS64

Scale Invariant Metrics of Volumetric Datasets

Nature reveals itself in similar structures of different scales. A child and an adult share similar organs yet dramatically differ in size. Comparing the two is a challenging task to a computerized approach as scale and shape are coupled. Here we show that a local measure based on the Scalar curvature can be used to normalize the local metric of the structure and then used to extract global features and distances. This approach is relevant for any dimension, and is extremely useful for 3-manifolds, such as Computed Tomography (CT) and Magnetic Resonance Imaging (MRI).

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MS65

A Non-Local Bayesian Method for Video Denoising

Advances in video sensor hardware have steadily improved the acquisition quality. However, video cameras are being used more each time, and in less favorable situations, resulting in high levels of noise. We present a new Bayesian patch-based video denoising method using 3D rectangular patches and not requiring motion estimation. The method compares favourably to the state-of-the-art, both in terms of PSNR and temporal consistency attained.

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MS65

Pewa: Patch-Based Exponentially Weighted Aggregation for Image Denoising.

We present a statistical aggregation method, which combines image patches denoised with conventional algorithms. We evaluate the SURE estimator of each denoised candidate image patch to compute the exponential weighted aggregation (EWA) estimator. The PEWA algorithm has an interpretation with Gibbs distribution, is based on a MCMC sampling and is able to produce results that are comparable to the current state-of-the-art. C. Kervrann. PEWA: Patch-based Exponentially Weighted Aggregation for image denoising. NIPS'14, Montreal, Canada, 2014.

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MS65

Boosting of Image Denoising Algorithms

A generic recursive algorithm for improving denoising algorithms is proposed. Given the initial denoised image, we suggest repeating the following 'SOS' procedure: (i) Strengthen the signal by adding the previous denoised image to the degraded input image, (ii) Operate the denoiser on the strengthened image, and (iii) Subtract the previous denoised image from the restored signal-strengthened outcome. The convergence of this process is studied, showing that the SOS acts as a graph Laplacian regularizer

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MS65

Towards Bias Reduction in Image Denoising Algorithms

Bias in image restoration can hamper further analysis, typically when the pixel intensities have a physical meaning. During this talk, we address the problem of modeling the different sources of bias arising in classical restoration techniques. Based on this study, we develop bias reduction techniques that apply to a large class of estimators, including recent variational and patch-based methods. We finally discuss the performance and relevance of reducing bias according to the focused applications.

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MS66

Title Not Available

Abstract not available.

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MS66

Computational Approaches for Massive Multi-

Frame Blind Deconvolution

In this talk we consider multi-frame blind deconvolution (MFBD). There are many optimization approaches that can be applied to these problems, but they are generally limited in the number of frames that can be processed. In this talk we consider efficient computational approaches to reduce a massive number of data frames to a computationally manageable set, while still preserving all information for MFBD algorithms.

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MS66

Local Solver for Seismic Full Waveform Inversion

In certain seismic problems, updates to the velocity model often have a highly localized nature. Numerical techniques such as full waveform inversion (FWI) require an estimate of the wavefield to compute the model updates. When dealing with localized problems it is wasteful to compute these updates in the global domain, when we only need them in our region of interest. Here we introduce a solver for efficiently generating the local wavefields required for local updates.

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MS66

Reduced-Order Models in Large-Scale Seismic Imaging

We developed a novel inversion approach based on the theory of projection-based model reduction. We construct a data-driven reduced-order model from the data sampled at the rate close to the Nyquist limit. The system corresponds to the full-scale system projected onto the subspace of orthogonalized time-domain solution snapshots. This orthogonalization removes the dominant part of all the multiples, and, consequently, avoids one of the key challenges in seismic inversion. Numerical examples will finalize the talk.

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MS67

On the Choice of Loss Functions and Their Estimations for Relevant Parameter Selection in Image Restoration

The Stein unbiased risk estimator provides an estimate of the square error in image restoration problems subject to Gaussian noise. It can be used as an objective for parameter selection. This square error estimator has been extended beyond Gaussian perturbations. However, in such cases, we will show that optimizing the square error can lead to selecting irrelevant parameters. In this talk, we consider more appropriate loss functions and discuss the challenging problem of estimating them.

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MS67

Automatic Parameter Selection for Total Variation Minimization in Image Restoration

In this talk we consider functionals consisting of one or two data-terms, a regularization-term, and parameters weighting the importance of the terms. Several different parameter choice rules for functionals containing only one parameter have been presented in the past, while the literature is rather scarce when more than one parameter has to been chosen. We revisit the disrcepancy principle and demonstrate how it can be used for finding parameters in functionals consisting of two data-terms.

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MS67

Function-driven Data Learning for Image Denoising

Motivated by the increased demand in robust predictive and reconstruction methods in image analysis, we present analysis techniques and numerical methods to explore new applications in tractable and robust automatic learning of functions and data structures in high dimension from the minimal number of observed samples. The performance and robustness of the constructed algorithms are demonstrated for tractable automatic learning of optimal regularization parameter for image denoising procedure.

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MS67

Non-Convex Objectives: Role of the Regularization Parameter in the Local and the Global Minimizers

Nonconvex nonsmooth objectives, composed of a data term and a regularization term weighted by a parameter, are widely used in imaging. For a large family of such objectives, the merely local (not global) minimizers are independent of this parameter. All algorithms converging to only local minimizers need a careful choice of the parameter even though the solution thus found is independent of it. Our talk gives insights into this visible contradiction.

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MS68

Statistical Modeling of Fmri Data for Pre-Surgical Planning

Spatial smoothing is essential in functional magnetic resonance imaging (fMRI) data analysis. In pre-surgical planning, using fMRI to determine functionally eloquent regions of the brain image, spatial accuracy is paramount. Methods that rely on global smoothing are not reasonable, blurring boundaries between activation and non- activation. Moreover, in standard fMRI analyses strict false positive control is de- sired. For pre-surgical planning false negatives are of greater concern. We present two Bayesian models that circumvent these problems.

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MS68

Topological Data Analysis for Functional Neuroimaging

Topological data analysis (TDA) is a relatively new development at the intersection of mathematics, statistics, and computer science. The approach, which focuses on topological features of a data set, is particularly suited for Big Data, often characterized by complicated structure such as images. In this talk, I will discuss the basics of TDA, emphasizing persistent homology and its uses for functional neuroimaging data.

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MS68

Functional and Imaging Data in Precision Medicine

Abstract not available.

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MS68

Local and Global Statistical Connectomic Testing

Abstract not available.

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MS69

Integrated Imaging: Creating Images from the Tight Integration of Algorithms, Computation, and Sensors

In this talk, we present research on imaging systems that integrate sensor design and reconstruction algorithms for applications in both materials and biological imaging. The applications include computed tomography (CT), transmission electron microscopy (STEM), synchrotron beam imaging, and scanning electron microscopy (SEM). In each of these examples, the key advantages result from the use of models of both the sensor and image along with the tight integration of reconstruction algorithms with the sensing system design.

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MS69

Multigrid-Based Optimization Approach for Multi-Modality Tomographic Reconstruction

Fluorescence tomographic reconstruction can be used to reveal the internal elemental composition of a sample while transmission tomography can be used to obtain the spatial distribution of the absorption coefficient inside the sample. In this work, we integrate both modalities and formulate an optimization approach to simultaneously reconstruct the composition and absorption effect in the sample. By using multigrid-based optimization framework (MG/OPT), significant speedup and improvement of accuracy has shown for several examples.

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MS69

Multi-Contrast MRI Reconstruction with Structure-Guided Total Variation

Magnetic resonance imaging is a versatile imaging technique that allows to change the contrast depending on the acquisition parameters. Many clinical imaging studies acquire data for multiple contrasts which makes the overall scanning procedure time consuming. Having one image of these contrasts available, we can reconstruct the other images from highly undersampled data exploiting the a priori similarity between the images. To achieve this goal we extend total variation regularization to accommodate a priori directional information.

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MS69

Integration of Photoacoustic and Ultrasound Com-

puted Tomography

We propose a paradigm shift in the way that images are reconstructed in hybrid photoacoustic/ultrasound computed tomography (PACT/USCT) imaging. We propose to jointly reconstruct the absorbed optical energy density and SOS distributions from a combined set of USCT and PACT measurements, thereby reducing the two reconstruction problems into one. A non-convex optimization problem is considered, which is solved by use of an alternating algorithm. Numerical studies reveal the numerical properties of this approach.

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MS70

Wavelet Frame Based Piecewise Smooth Image Model and It's Relation to Mumford-Shah Functional

Abstract not available.

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MS70

Simultaneous Tomographic Reconstruction and Segmentation with Class Priors

We consider tomographic imaging problems where the goal is to obtain both a reconstructed image and a corresponding segmentation. A classical approach is to first reconstruct and then segment the image. In this talk, I will introduce a hybrid approach that simultaneously produces both a reconstructed image and a segmentation. We incorporate priors about the desired classes of the segmentation through a Hidden Markov Measure Field Model, and we impose a regularization term for the spatial variation of the classes across neighboring pixels. Simulation experiments with artificial and real data demonstrate that our combined approach can produce better results than the classical two-step approach.

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MS70

A New Multiplicative Denoising Variational Model and its Fixed-point Proximity Algorithm

The restoration of images contaminated by Multiplicative noise (also known as speckle noise) is a key issue in coherent image processing. By exploring the intrinsic feature embedded in images that they are often highly compressible under suitably chosen transforms, this paper introduces a variational restoration model for multiplicative noise reduction that consists of a term reflecting the observed image and multiplicative noise, a quadrature term measuring the closeness of the underlying image in a transform domain to a sparse vector, and a sparse regularizer for removing multiplicative noise. Different from the popular existing models focusing on pursuing convexity, the proposed sparsity-aware model is nonconvex. We characterize the solutions of the nonsmooth and nonconvex model via coupled fixed-point equations that are derived from the proximity operators of the functions associated with the model. Based on the characterization, an algorithm for finding the critical points of the objective function of the model is developed and convergence of the algorithm is studied. Experimental results show that our method can remarkably outperform the state-of-art methods in terms of the quality of the restored images.

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MS70

A Universal Variational Framework for Sparsity Based Image Inpainting

Abstract not available.

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MS71

A Fast-Transform-Based, High-Resolution Computational Imager Using Virtual Channels

A joint sensing-reconstruction algorithm and architecture is presented that mathematically combines elements of a focal-plane array into coarse "virtual channels" representing distinct regions of a field of view (FOV). In this setup, the light field from an observed scene is partitioned and encoded using patterns on a spatial light modulator, and the light intensity of each channel is recorded. When a sufficient number of measurements have been obtained they are used to computationally reconstruct an image. Before observing the scene the optical system's response function

is measured and stored as a global "point-spread function" (PSF). The reconstruction algorithm incorporates the PSF to help correct for the system's optical aberrations, including distortions and crosstalk between channels. Further, by separating the PSF operator, which is fixed, from the sensing procedure, which is dynamic, we can efficiently implement image reconstruction using a fast transform associated with the measurement patterns (e.g., Hadamard). The virtual channel approach offers flexibility to create different sized (and not necessarily square) partitions of the FOV, which permits more freedom in trading different parameters to achieve desired reconstruction characteristics, e.g., frame rate versus resolution.

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MS71

Convex Cardinal Shape Composition

Abstract not available.

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MS71

Coherent Camera Arrays

Abstract not available.

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MS71

Gigapixel Phase Imaging

This talk will describe new methods for achieving gigapixel-scale 3D intensity and phase images in a commercial microscope, by computational imaging. We describe setups employing illumination-side and detection-side coding of angle (Fourier) space for capturing 4D phase-space (e.g. light field) and phase retrieval datasets with fast acquisition times. Experimentally, we achieve real-time 3D and phase imaging with digital aberration correction and mitigation of scattering effects. The result is a high-resolution image across a large field-of-view, achieving high space-bandwith-time product. Such computational approaches to optical microscopy add significant new capabilities to commercial microscopes without significant hardware modification.

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MS72

The Use of the Approximation Error Method and Bayesian Inference to Introduce Anatomical and Physiological Prior Information into EIT Reconstruction Algorithms

Some EIT reconstruction algorithms may have their resolution improved using the approximation error method and Bayesian inference to include prior information in the EIT inverse problem. Seeking for minimal modifications to EIT algorithms, these algorithms could be extended to generate voltages at electrodes after having generated an impeditivity distribution. Under these circumstances, modeling errors are incorporated to the noise probability distribution model by the application of the approximation error method and anatomical prior is introduced by Bayesian inversion method.

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MS72

A 3-D Analogue to the 2-D D-Bar Method

A direct 3-D D-bar reconstruction method is developed using the low frequency limit of complex geometrical optics solutions as proposed by Cornean et al (J Inverse and Ill-posed Problems 2006). This method varies from other 3-D algorithms in that it provides a 3-D analogue to the 2-D D-bar method. This algorithm was implemented for use in a rectangular prism geometry and simulated data was generated for this domain. Here we present the algorithm and results of the reconstruction of the simulated data. Extensions to other geometries will also be discussed.

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MS72

Convergence and Regularization for Monotonicity-Based EIT Shape Reconstruction

In electrical impedance tomography (EIT), the aim is to estimate internal electrical properties of an object by analyzing current and voltage data measured on its outer boundary. The idealized problem formulation is to solve for the conductivity distribution given the corresponding Neumann-to-Dirichlet (ND) map. This problem is ill-posed and thus, in practice, only limited information about the conductivity can be recovered. Recently it was shown that a simple monotonicity property of the linearized ND map can be used to characterize shapes of inhomogeneities in a known background conductivity. This talk focuses on a monotonicity-based shape reconstruction scheme that applies to approximative EIT measurement models, and regularizes against noise and modelling error. It is demonstrated that for admissible choices of regularization parameters the inhomogeneity shapes are detected, and under suitable assumptions, asymptotically exactly charac-

terized. The result is rigorously associated with the complete electrode model (CEM), and a monotonicity-based reconstruction algorithm is formulated for the CEM. Numerical reconstructions from both simulated and real-world measurement data are presented.

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MS72

On Uniqueness of An Inverse Problem for Time-Harmonic Maxwells Equations

Abstract not available.

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MS73

Multiscale Extremal Points on Plane Curves, With Applications to Shape Matching and Detection

Abstract not available.

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MS73

Parallel Transport of Distributions on Tangent Spaces on Shape Spaces

Abstract not available.

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MS73

Multiscale Covariance Fields and Shape Characterization in Euclidean Spaces

We introduce the notion of multiscale covariance tensor fields (CTF) associated with Euclidean random variables as a gateway to the shape of their distributions. Multiscale CTFs quantify variation of the data about every point in the data landscape at all spatial scales, unlike the usual covariance tensor that only quantifies global variation about the mean. We prove stability theorems with respect to the Wasserstein distance between probability measures, obtain consistency results, as well as estimates for the rate of convergence of empirical CTFs.

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MS73

Statistical Modeling of Geometries of Tree-Like Structures

We develop a framework for shape analysis of axonal trees represented by (1) a main branch viewed as a parameterized curve in $\mathbb{R}^3$, and (2) secondary branches that emanate from arbitrary points on the main branch. Our framework extends the previous elastic shape analysis of Euclidean curves to the space of such trees. The space inherits a Riemannian metric from the spaces of individual curves, which we use to compute distances and geodesics.

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MS74

Variance Stabilization for Noisy+Estimate Combinations in Iterative Poisson Denoising

We consider an iterative approach to progressively improve the effectiveness of variance-stabilizing transformations (VST) adopted by Gaussian filters for denoising Poisson data. At each iteration, a combination of the Poisson observations with the denoised estimate from the previous iteration is treated as scaled Poisson data and filtered through a VST scheme. Due to the slight mismatch between a true scaled Poisson distribution and this combination, a special exact unbiased inverse is designed. We present an implementation of this approach based on BM3D. With a computational cost only twice that of the non-iterative scheme, the proposed algorithm provides significantly better quality, particularly at low SNR, outperforming much costlier state-of-the-art alternatives.

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MS74

Understanding Symmetric Smoothing Filters Through Expectation-Maximization

This talk addresses the question of why does a symmetric smoothing filter yield better denoising performance than a non-symmetric smoothing filter. I will discuss our findings through an expectation-maximization (EM) algorithm of learning a model known as the product of Gaussians (PoG). I will also present an improved denoising algorithm based on the new PoG model.

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MS74

A Decomposition Framework for Image Denoising Algorithms

We present a novel framework for image denoising in which the components of a noisy image in a moving frame that encodes its local geometry are denoised and then used to generate a clean image. We show that the PSNR of the components is higher than that of the image along image contours, providing justification for this framework. Experiments confirm the improvement when using this approach in terms of both PSNR and SSIM.

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MS74

Turbo Denoising: Filter, Rinse, Recycle

We propose a new denoising algorithm for camera pipelines and other photographic applications. We aim for a scheme that is (1) fast enough to be practical even for mobile devices, and (2) handles content dependent noise that is more realistic for real camera captures. Our scheme consists of a simple two-stage non-linear processing. We introduce a new form of boosting/blending which proves to be very effective in restoring the details lost in the first denoising stage. We also employ IIR filtering to significantly reduce the computation time. Further, we incorporate a novel noise model to address for the content dependent noise. For realistic camera noise, our results are competitive with BM3D, but with nearly 400 times speedup.

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MS75

Selection Criterion for Source Encoding Weights in Nonlinear Inverse Problems with Large Data

We introduce a method to systematically select among random encoding weights, for inverse problem with multiple right-hand sides, when these weights are sampled from the uniform spherical distribution. Drawing from recent developments in optimal experimental design for infinite-dimensional Bayesian inverse problems, we introduce two Bayesian formulations of this weight selection problem. In addition, we rigorously formulate a bilevel Hessian-constrained optimization problem for the computation of weights that optimally verify our selection criterion.

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MS75

A Randomized Misfit Approach for Data Reduction in Large-Scale Inverse Problems

Abstract not available.

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MS75

A Parametric Level Set Approach to the Airborne Electromagnetic Inverse Problem

We propose a method to invert time or frequency domain airborne electromagnetic data using a parametric level set approach. This problem is computationally intensive due to its expansive domain size and multitude of source locations. Our approach reduces the parameter space by recovering best-fitting skewed Gaussian ellipsoids that represent electrical conductivity anomalies of interest. The package is developed in Julia and can be combined with conventional voxel based inversions to resolve additional smooth background features.

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MS75

Fast Algorithms for Hyperspectral Diffuse Optical Tomography with Many Measurements

Diffuse Optical Tomography is an imaging modality which uses measurements obtained using near-infrared light to image highly turbid media. The measurements can be used to produce spatial maps of parameters of interest by solving an ill-posed inverse problem. Solving the full nonlinear problem is very computationally expensive particularly for measurements at several wavelengths. The algorithms we propose bring down the computational cost by 1-2 orders of magnitude.

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MS76

Bilevel Parameter Learning for Higher-Order Total Variation Regularisation Models

We consider a bilevel optimisation approach for parameter learning in higher order TV image reconstruction models. Differentiability properties of the solution operator are verified and an optimality system derived. Based on the adjoint information, a quasi-Newton algorithm is proposed for the numerical solution of the problems. We propose a new cost functional, based on a Huber regularised TV-seminorm. Thanks to the bilevel optimisation framework, a detailed comparison between TGV2 and ICTV is presented.

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MS76

Learning Variational Models for Image Reconstruction

Existing image reconstruction methods are based on simple regularizers such as sparsity in the wavelet domain or Total Variation (TV). However, these simple and handcrafted regularizers make assumptions on the underlying image statistics. We propose to learn proper regularization of variational models, i.e. a set of filters and corresponding penalty functions, and focus on its application to MRI reconstruction. Our approach overcomes several limitations of existing reconstruction methods such as parameter selection problems.

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MS76

Should You Derive or Let the Data Drive? An Optimization Framework for Model Mis-specification Correction

While “all models are wrong...”, it is often possible to deduce a correction for a model, that offers improved predictive and / or prescriptive capabilities. In this talk we shall present a hybrid first-principles, data-driven optimization framework for model mis-specification correction. The approach balances between model fidelity, model complexity, and virtues associated with both the correction and the corrected forms.

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MS76

Computational Regularization in Learning and Inverse Problems

High dimensional estimation problems from random data require ever more efficient algorithms. A key observation towards this goal is that the computations should be taylored to the estimation accuracy allowed by the data. Based on this intuition we investigate methods exploiting the trade-offs between estimation and computational requirements. In particular, we focus on randomized/iterative regularization methods where regularization is achieved by early stopping. Results in the context machine learning and inverse problems are discussed.

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MS77

Learning the Structural Organisation of Neural Circuits from Neuroimaging Data

We will present a computational and statistical framework to learn the structural organisation of neural circuits from multimodal neuroimaging data. The method estimates typical configurations of neural circuits in the form of a collection of curve and surface meshes, which represent the main components of the brain architecture. The estimation of the typical variability of this configuration within a group of subjects include variations in the shape/geometry of the individual components, as well as the relative position of the white matter fiber tracts with respect to the grey matter structures, thus capturing changes in the structural connectivity. We will show that these modes of variability allow a better prediction of the presence of neurodevelopment disorders, such as Gille de la Tourette syndrome, than more traditional morphometric studies.

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MS77

Brain Microstructure Characterization Using Sparse Bayesian Inference and Multi-compartment Models Estimation

First, we demonstrate how sparsity can be introduced into a recent multi-resolution algorithm (RubiX) to estimate white matter fiber orientations from compressed (undersampled) diffusion MRI (dMRI) data. A sparse Bayesian algorithm combines data acquired at different spatial resolutions via a dictionary representation and priors which leverage the dependence between fiber orientations, and the spatial redundancy in data representation. Second, we introduce a data fitting procedure for biophysical models which relate quantities such as axonal radius and density to the dMRI data by predicting signal in the intra- and extra-axonal compartments. Using variable projection and stochastic global search algorithms, we present an efficient and robust method to estimate axonal radii and densities from non-invasive dMRI data.

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MS77

Thinking Outside the Voxel: A Joint Spatial-Angular Basis for Sparse Hardi Reconstruction

Sparse HARDI representations are of growing interest to reduce the large number of diffusion signal measurements. With few exceptions, sparsifying bases are considered for q-space with additional constraints of spatial regularity. In this work, we propose a single joint spatial-angular basis representation to model an entire HARDI dataset with an increased level of sparsity. With a globally compressed representation we can redefine HARDI processing, diffusion estimation, and feature extraction and reduce acquisition time.

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MS77

Compressed Sensing of Multi-shell HARDI in Six-dimensional (k,q) Space

Compressed Sensing (CS) has been widely successful in reducing the acquisition time for standard structural images such as MR and CT images. However, CS has not enjoyed the same level of success in making multi-shell high angular resolution diffusion imaging (MS-HARDI) clinically viable. In this work, we propose a novel CS method for fast acquisition of MS-HARDI and thus making it clinically viable. The method is based on applying CS to the 6D (k,q) space and directly achieving sparse reconstruction of the ensemble average propagators, which are probability density functions that capture the entire local diffusional information.

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MS78

Multidimensional Iterative Filtering Method for the Decomposition of High-Dimensional Non-Stationary Signals

Iterative Filtering, which is an alternative technique to the Empirical Mode Decomposition algorithm for the decomposition of non-stationary and non-linear signals,has been proved recently to be convergent for any L^2 signal. In this talk we introduce its extension to higher dimensions, called Multidimensional Iterative Filtering algorithm, and we show the performance of this new technique when applied to the decomposition of syntectic and real life 2D signals.

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MS78

Fast Algorithms for Elastic-Wave-Mode Separation and Vector Decomposition

Modern algorithms for seismic data analysis require an ability to find a sparse transform or dictionary for seismic data representation. We describe two methods, a slope decomposition based on nonstationary autoregression and

the nonstationary seislet transform. In combination, these tools provide a particularly sparse representation for multidimensional seismic data and find practical applications in denoising and data reconstruction problems.

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MS78

Seismic Imaging with Extrapolated Low Frequencies

The band-limited nature of seismic data has been prohibiting full waveform inversion from practical success. We propose two methods to extrapolate low frequencies from the band-limited data. The phase-and-amplitude tracking approach performs extrapolation as a data processing step. The extended demigration approach extrapolates the low frequency via forward and adjoint Born imaging. Both methods are based on the non-dispersive media assumption.

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MS78

When Harmonic Analysis Meets Medicine

We will discuss some recent developments of applied harmonic analysis and their application to medical problems; in particular, the anesthesia/sedation/sleep analysis based on different physiological signals and images.

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MS79

A Computationally Efficient Levenberg-Marquardt Algorithm and Its Application to Inverse Modeling

Inverse modeling seeks transitivity field given measurements of hydraulic heads. However, practical problems are often large scale, and conventional methods can be computationally expensive. We have developed a new, computationally-efficient Levenberg-Marquardt method for solving large-scale problems. Our method is based on a recycled-Krylov subspace technique. We apply our method to invert for a random transitivity field in parallel and obtain a significant speedup. Therefore, our new inversion method is a powerful tool for large-scale applications.

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MS79

Choice of TV Regularization Parameter for Electrical Resistance Tomography

In subsurface Electrical Resistance Tomography an image of electrical conductivity profiles is recovered from apparent resistivity measurements. L2 regularization smooths conductivity estimates, so Total Variation is used to detect sharp boundaries. The artifacts produced by TV regularization are mitigated by focusing on regularization parameter choices that result in identifying true anomalies. The methods are tested on measurements at the Boise Hydrogeophysical Research site, a field laboratory where conductivity regions are well understood.

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MS79

Hybrid and Iteratively Reweighted Regularization for Edge Enhancing Reconstructions

Tikhonov regularization for projected solutions is considered as the initial step in edge enhancing regularizers, by iterative reweighting and Split Bregman (SB) techniques. Determination of the L_2 regularization parameter is found using unbiased predictive risk estimation extended for the projected problem. The initial projected solution is enhanced by SB or TV Tikhonov iterations. The iterative approach stabilizes and it robust to the size of the projected problem and the determination of the regularization parameter. Examples for inverting geophysical data illustrate the effectiveness of the approach for large scale data.

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MS79

Spatio-Spectral Background Estimation in Remote Sensing Imagery

We investigate several approaches for estimating the target-free background at a given pixel in a remotely sensed image, based on both the local neighborhood around that pixel and on the global context of the full image. Since we seek this background estimate at every pixel in the image, and since we do not want to include the potentially target-contaminated pixel in this estimate, the problem is a kind of hybrid between noise reduction and in-painting.

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MS80

Bilevel Optimization for a Generalized Total-Variation Model

Analytical and, in particular, practical aspects for a confidence based automated choice rule for the regularization weight in a generalization of the renowned total variation regularization model in image restoration are discussed. For an associated bilevel optimization problem, a projection-type algorithm is introduced and a report on the qualitative behavior of the new model is given.

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MS80

The Primal-Dual Hybrid Gradient Method for Semiconvex Splittings

In this work we analyze a recent reformulation of the primal-dual hybrid gradient method which makes it applicable to nonconvex regularizers. In particular, we investigate variational problems for which the energy to be minimized can be written as $G(u) + F(Ku)$, where G is convex, F semiconvex and K a linear operator. We study the method and prove convergence in the case where the nonconvexity of F is compensated by the strong convexity of the G. The convergence proof yields an interesting requirement for the choice of algorithm parameters, which we show to not only be sufficient, but necessary. Additionally, we show boundedness of the iterates under much weaker conditions. Finally, we demonstrate effectiveness and convergence of the algorithm beyond the theoretical guarantees in several numerical experiments.

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MS80

On the Global Minimizers of a Family of L0 Penalized Models

Log-likelihood data terms combined with L0 penalty are widely used in imaging. A central question in optimization is to know whether these problems admit global minimizers. We will answer this question for a wide family of problems. The answer is not always positive even though algorithms can give satisfying results. In those cases, a better adapted (and better justified) formulation of the original problem might yield a consistent problem.

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MS80

Nonconvex ADMM: Its Convergence and Applications

ADMM has been surprising us with a lot of success at solving non-convex optimization problems in the literature! They, but not limited to, the minimization of l_q ($0 < q < 1$) quasinorm, Schatten-q quasinorm, SCAD, bi-linear, and bi-convex functions, as well as those subject to orthogonality and sphere constraints. We provide insights toward when and how ADMM converges on convex and non-convex problems with multiple blocks. We show that, roughly speaking, if the "last block" is smooth and its objective function "almost prox-regular" (by adding a quadratic function, the objective function becomes convex except for a small set) and if all the constraint coefficient matrices stay in the span of the last one, then ADMM provably converges. Note that all functions in the objective can be nonconvex! Also note that the convergence of ADMM extending to multiple blocks is ensured under our condition. In spite of the counter example by Chen et al, ADMM can work well for three or more blocks. Through examples, we highlight that the ADMM can converge on problems that ALM (the augmented Lagrangian method) diverges. We compare our work to other recent results of nonconvex methods. Finally, we present applications of non-convex ADMM with provable convergence and good performance.

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MS81

Regularization of Linear Inverse Problems with Total Generalized Variation

Total generalized variation (TGV) regularization has found many successful applications in mathematical image processing, quite often in the context of linear inverse problems such as, e.g., MRI reconstruction. We study essential functional analytic properties of TGV and put its regularization performance for general linear inverse problems on a rigorous basis. In particular, we derive non-standard convergence properties for vanishing noise level that result from the cascadic multi parameter setting that is inherent to TGV.

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MS81

What Do Regularisers Do?

Which regulariser is the best? Is any of them any good? Do they introduce artefacts? What other qualitative properties do they have? Based on an analytical study of bilevel optimisation, in a recent work with J. C. De Los Reyes and C.-B. Schnlieb, we have derived natural conditions on the data, showing regularisation to indeed improve images. I will discuss these results with a brief review on recent progress in the analytical study of artefacts.

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MS81

Anisotropic Mumford-Shah Model for Detection of Thin Structures

This talk is devoted to the Mumford-Shah model for the segmentation problem of thin structures, like tubes or thin plates in a 3-D image. A geometric interpretation of the parameters and necessary conditions will be given. If it can not be satisfied, a different approach will be proposed. The main ingredient is the introduction of an anisotropic setting. The analysis of this new model will be done, with gamma-convergence approximations and regularity results for the minimizers.

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MS81

Retinex by Higher Order TVL1 Decomposition

We propose a reflectance and illumination image decomposition model via high-order total variation and L1 decomposition. The proposed convex variational model can effectively decompose the gradient field of images into salient edges and relatively smoother illumination field through the first- and second-order total variation regularizations. Numerical experiments show the strength of the proposed model with applications to Retinex illusions, bias field removal, and color image correction.

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MS82

Passive Source Geolocation

Abstract not available.

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MS82

Multiscale Approach to Synthetic Aperture Radar

We consider Synthetic Aperture Radar (SAR) image formation in the situation when the propagation medium is complex. We carry out a scaling analysis. We discuss how different noise contribution and wave configuration parameters affect resolution.

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MS82

Synthetic Aperture Imaging of Direction and Frequency Dependent Reflectivities

We propose a synthetic aperture imaging methodology that accounts for directional and frequency dependent reflectivities. Our approach uses ℓ_1 minimization and is based on data segmentation in array sub-apertures and frequency sub-bandwidths. We present an analysis of this approach and asses its performance in an X-band radar regime. This is joint work with Liliana Borcea, Miguel Moscoso and George Papanicoloau.

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MS82

Transionospheric Synthetic Aperture Imaging

Earth's ionosphere may adversely affect the spaceborne SAR images, because the dispersion of radio waves causes distortions of radar signals that cannot be automatically accounted for by the matched filter. We propose to build a redundancy into the SAR dataset by probing the terrain, and hence the ionosphere, on two distinct carrier frequencies. It allows us to reconstruct the parameters of the ionosphere needed for correcting the filter and improving the quality of the image.

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MS83

Harvesting Nature: from Computational Imaging to Optical Computing

We investigate how a simple experiment of imaging with coherent light through a layer of multiply scattering material can be seen as an idealized physical implementation of compressed sensing. In reverse, we show how this system can be used as a computing device that provides a large number of random projections of incoming data - and demonstrate its effectiveness for classification tasks, e.g. physically approximating a given kernel.

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MS83

Photon-Efficient Reflectivity and Depth Imaging under Significant Ambient Light

LIDAR systems use single-photon detectors to enable long-range reflectivity and depth imaging. By exploiting a Poisson observation model and the typical structure of natural scenes, first-photon imaging demonstrates the possibility of accurate LIDAR with only 1 detected photon per pixel, where half of the detections are due to (uninformative) ambient light. Here we present spatially adaptive noise censoring to achieve similar performance when 90% of detections are due to ambient light, potentially further increasing range.

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MS83

Macroscopic Fourier Ptychography

Recent advances in ptychography have demonstrated that one can image beyond the diffraction limit of the objective lens in a microscope. We demonstrate a similar approach to imaging beyond the diffraction limit at long-ranges. We show that an appropriate phase retrieval based reconstruction algorithm can be used to effectively recover the lost high-resolution details from multiple low-resolution acquired images. Our experimental results from our proof-of-concept systems show resolution gains of 4x- 7x for real scenes.

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MS83

Lensless Imaging

Abstract not available.

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MS84

Challenges and Opportunities in Space Situational Awareness (SSA): An Air Force Perspective

With a rapidly increasing population of objects in space, the traditional Space Situational Awareness (SSA) construct from the Cold War era will no longer suffice. Modernizing the Air Force SSA to meet the challenges of today and tomorrow requires new technologies, applications and operating constructs as well as an expanded engagement with nations active in the space domain.

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MS84

High-resolution Speckle Imaging Through Strong Atmospheric Turbulence

We demonstrate that high-resolution imaging through strong atmospheric turbulence can be achieved by acquiring data with a system that captures short exposure (speckle) images using a range of aperture sizes and then using a bootstrap multi-frame blind deconvolution restoration process that starts with the smallest aperture data. Our results suggest a potential paradigm shift in how we image through atmospheric turbulence. No longer should image acquisition and post processing be treated as two independent processes: they should be considered as intimately related.

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MS84

Image Reconstruction using Sparse Aperture Tech-

niques for SSA

We will discuss the use of long-baseline optical interferometry for ground-based imaging of geosynchronous satellites. Aperture fill is achieved by collecting data with different telescope-baseline configurations. Sparse sampling techniques can be used to create images from fewer observations and reduce the length of an imaging campaign. Simulation results from various reconstruction algorithms are compared.

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MS84
High Resolution Imaging of Geosats at Lowell Observatory

Abstract not available.

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MS85
Tone Mapping and Gamut Mapping for Cinema

In this talk I will present recently proposed image processing techniques based on vision science that address two important problems in the motion picture and TV industries: tone mapping (making high dynamic range images suitable for standard dynamic range displays) and gamut mapping (modifying the color gamut of images so that they properly fit the color capabilities of a given display). Website: http://ip4ec.upf.edu/

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MS85
Texture Synthesis and Transfer Using Convolutional Neural Networks

We introduce a new model of natural textures based on the feature spaces of convolutional neural networks optimised for object recognition. Extending this framework to texture transfer, we introduce A Neural Algorithm of Artistic Style, which can separate and recombine the image content and style of natural images. Finally, we demonstrate how this allows us to produce new images of high perceptual quality that combine the content of an arbitrary photograph with the appearance of numerous well-known artworks.

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MS85
Video Temporal Consistency

In this talk, I will present my work on temporal consistency in videos. I will first briefly review my past work on this topic that sought to extend the notion of Gaussian filtering to the temporal domain and later formulated a curvature flow filter in the space of functions. Then, I will present in more details my most recent project that processes the image gradients. This technique is simple, applicable to a wide range of effects, and has the advantage of being amenable to a formal analysis in the Fourier domain. website: http://liris.cnrs.fr/ nbonneel/consistency/

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MS85
Nonlocal Image Editing

We introduce a new image filtering tool, based on the spectrum of global image affinities. The global filter derived from a fully connected graph representing the image, can be approximated by its leading eigenvectors. These orthonormal eigenfunctions are highly expressive of the coarse and fine details in the underlying image, thus endowing the filter with a number of important capabilities, such as sharpening, smoothing and tone manipulation.

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MS86
Image Restoration with Shannon Total Variation

Usual discretizations by means of finite differences for total variation (TV) based energy minimization models generally lead to images difficult to interpolate at sub-pixel scales. We propose a new Fourier-based estimate (called Shannon total variation), which behaves much better in terms of isotropy, artifact removal, and sub-pixel accuracy. This variant can be used with dual algorithms, and delivers images that can be easily interpolated without artifacts. Illustrations are provided for several classical TV-based restoration models.

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MS86

A Variational Approach for Color Image Enhancement

In this work, a novel approach for color image contrast enhancement is proposed. It is based on a variational framework increasing the global contrast. In the literature, the methods may over-contrast the results, and/or produce Hue distortions. The proposed approach makes the user able to control the contrast level intuitively, as for instance the scale of the enhanced details. Moreover, it avoids large modifications of the image histograms and thereby preserves the global illumination of the scenes. This technique is extended to color images into a variational framework that preserves the Hue. The color model is solved with a hybrid primal-dual algorithm which requires no post- or pre-processing. This is a joint work with Fabien Pierre, Aurelie Bugeau, Gabriele Steidl, and Vinh-Thong Ta.

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MS86

Semi-Inner-Products for Convex Functionals and Their Use in Image Decomposition

Semi-inner-products in the sense of Lumer are extended to convex functionals. A general expression for the one-homogeneous case is given. This facilitates the analysis of total variation and higher order functionals like total-generalized-variation (TGV). An angle between functions can be defined, where relations of the angle to the Bregman distance are shown. This construction is used to state a sufficient condition for a perfect decomposition of two signals using the spectral one-homogeneous framework.

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MS86

Image Deblurring Via Total Variation Based Structured Sparse Model Selection

In this talk, we study the image deblurring problem based on sparse representation over learned dictionary which leads to promising performance in image restoration in recent years. However, the commonly used overcomplete dictionary is not well structured. This shortcoming makes the approximation be unstable and demand much computational time. To overcome this, the structured sparse model selection (SSMS) over a family of learned orthogonal bases was proposed recently. In this paper, We further analyze the properties of SSMS and propose a model for deblurring under Gaussian noise. Numerical experimental results show that the proposed algorithm achieves competitive performance. As a generalization, we give a modified model for deblurring under salt-and-pepper noise. The resulting algorithm also has a good performance.

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MS87

Analytic Approaches to Study the Chronnectome (time-Varying Brain Connectivity)

Recent years have witnessed a rapid growth in moving functional magnetic resonance imaging (fMRI) connectivity beyond simple scan-length averages into approaches that capture time-varying properties of connectivity. In this perspective we use the term chronnectome to describe such metrics that allow a dynamic view of coupling. We discuss the potential of these to improve characterization and understanding of brain function, which is inherently dynamic, not-well understood, and thus poorly suited to conventional scan-averaged connectivity measurements.

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MS87

Using Complementary Assessments of Structural and Functional Brain Connectivity to Gain Insights into Neurodevelopment

Neuroimaging technologies provide complementary measures that need to be considered in concert to gain a full understanding of the elements that influence the emergence of brain function. I will describe the strengths and weaknesses of these complementary approaches that guide the development of model systems when assessing brain function at the macroscopic scale. We will describe how capturing development across different temporal and spatial scales will inform our knowledge of emerging functional brain dynamics.

Julia Stephen
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MS87

Modeling and Integration of Imaging and Genomics Data

I will present computational approaches on the integration of multi-scale genomic and imaging data. First, I will show how to correlate genomic and image data with sparse CCA for biomarker detection. Second, I will discuss how to integrate genomic, imaging and protein-protein interaction networks using a collaborative low rank regression model. Finally, I will present examples on improved diagnosis of schizophrenia with these integrative models.

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MS87

Neural Oscillations and Dynamic Functional Connectivity Analysis with MEG

Large populations of cortical neurons often exhibit coordinated electrical fluctuations, and these so-called neuronal oscillations are known to be critical for cognitive processing and neural computation. This presentation will describe the latest in oscillatory analysis methods, especially as applied to magnetoencephalography (MEG) data. Recent findings in the context of human motor control, working memory, attention, and neurological disease will be discussed, as will the directed dynamic functional connectivity analyses that oscillatory analysis methods often enable.

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MS88

On the Analysis of Multicomponent Images

The concept of multicomponent signals, defined as superpositions of AM/FM waves, plays a key role in the analysis of non-stationary signals in one dimension. Recent methods have been developed for analyzing and decomposing those signals, such as the empirical mode decomposition or the synchrosqueezed wavelet transform. I will present in this talk several extensions of these techniques in dimension 2, trying to underline their potential interest for the adaptive analysis of images.

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MS88

Conceft: Concentration of Frequency and Time Via a Multitapered Synchrosqueezed Transform

A new method is proposed to determine the time-frequency content of time-dependent signals consisting of multiple oscillatory components, with time-varying amplitudes and instantaneous frequencies. Numerical experiments as well as a theoretical analysis are presented to assess its effectiveness.

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MS88

Canvas Texture Analysis for Art Investigation

This talk introduces new techniques for the study of art history and art conservation. The first part introduces a new technique for separating canvas from digital photographs and X-ray images of paintings on canvas. It combines the cartoon-texture decomposition and an adaptive thresholding to isolate canvas. The second part will introduce a new canvas thread counting method based on 2D synchrosqueezed transforms that offers fine scale weave density and thread angle information for the canvas.

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MS88

Source Separation in Art Analysis: Digital Cradle Removal in X-Ray Images of Art Paintings

We propose a source separation algorithm for cradling artifacts removal in X-ray images of panel paintings, significantly improving X-ray image readability for art experts. The algorithm consists of grayscale inconsistency correction, based on physical properties of X-ray imaging, and cradling wood grain extraction, where a sparse Bayesian factor model is trained for blind separation of cradling and painting panel wood grain mixture, which is obtained as the texture of X-ray images from Morphological Component Analysis.

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MS89

On the Well-Posedness of Non-Convex Total Variation

Total variation models based on non-convex energies have been introduced to provide better match for observed gradient statistics in real-life images. In the functional analytical settings, these models are however highly ill-posed. For restoring well-posedness, I will discuss ideas based on multi-scale analysis.

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MS89

Bilevel Optimization of Nonconvex ℓ^q-Models in

Image Processing

This work concerns bilevel optimization of nonconvex ℓ^q-models. Based on the analysis of local minimizers of the nonconvex ℓ^q-model (as the lower-level problem), we impose qualification conditions for replacing the lower-level problem by its first-order optimality condition. A smoothing homotopy approach is proposed for the numerical solution of the bilevel problem, where each smoothed reduced subproblem is handled by a projected BFGS method. Numerical results on selected imaging applications are presented to support our theoretical findings.

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MS89

Proximal Iterative Hard Thresholding Methods for Wavelet Frame Based Image Restoration

The iterative thresholding algorithms were primarily proposed in the literature for solving wavelet based linear inverse problems, including image restoration problems with sparsity constraint. The analysis of iterative soft thresholding algorithms has been well studied and inspired much of the work for divers applications and related minimization problems. However, iterative hard thresholding methods are less understood due to its non-convexity and non-smoothness except some studies related to sparse signal recovery and image restoration. In this work, we propose two algorithms, namely extrapolated proximal iterative hard thresholding (EPIHT) algorithm and EPIHT algorithm with line-search (EPIHT-LS), for solving l0 norm regularized wavelet frame balanced approach for image restoration. Under the Kurdyka- Lojasiewicz property theoretical framework, we show that the sequences generated by the two algorithms converge to a local minimizer with linear convergence rate. Moreover, extensive numerical experiments on sparse signal reconstruction and wavelet frame based image restoration problems including CT reconstruction, image deblur, demonstrate the improvement of l0-norm based regularization models over some prevailing models, as well as the computational efficiency of the proposed algorithms.

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MS90

Second-Order Edge-Penalization in the Ambrosio-Tortorelli Functional

In this talk we discuss a variant of the Ambrosio-Tortorelli functional where the first-order penalization of the edge variable v is replaced by a second-order term depending on the Laplacian of v. This new energy provides an elliptic approximation of the Mumford-Shah functional in the sense of Gamma- convergence and presents many advantages in computational experiments, as we will show with several examples.

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MS90

Optimal Selection of the Regularisation Function in a Localised TV-Model

A bilevel optimization approach for the automated selection of a distributed regularization parameter in a total variation regularization based image restoration model is considered. While the lower level problem amounts to solving a variant of the renowned Rudin-Osher-Fatemi model, but with local regularization effects, the upper level objective is related to a statistics based variance corridor around the ideal reconstruction. Besides the model and its mathematical analysis, a numerical solution scheme is proposed and test results for image restoration including Fourier and wavelet transformations are reported on.

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MS90

Analytical Aspects of Spatially Adapted Total Variation Type Regularisation

Spatially adapted regularisation in image reconstruction has been used in order to preserve details like texture and other highly oscillating features that are naturally present in the image. The idea is to apply regularisation of different strength in different parts of the image by spatially varying the regularisation parameters. In this talk, we will study analytically the effect of the spatially varying parameters to the structure of solutions of total variation type regularisation.

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MS90

Cosparse Image Recovery from Few Tomographic Projections

We investigate the reconstruction problem of discrete tomography and present a relation between image cosparsity and sufficient number of tomographic measurements for exact recovery similar to the settings in Compressed Sensing. Further, known quantisation levels are used as prior knowledge to improve recovery using techniques from the field of discrete graphical models. Finally, regarding recovery algorithms, we focus on decomposition schemes that exploit the problem structure and scale up to large problem sizes.

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MS91

Imaging with Intensity Cross Correlations and Application to Ghost Imaging

We analyze an imaging method called ghost imaging that can produce an image of an object by correlating the intensities measured by a high-resolution (multi-pixel) detector that does not view the object and a low-resolution (single-pixel) detector that does view the object. We clarify the roles of the partial coherence of the source that illuminates the object and of the scattering properties of the medium through which the waves propagate.

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MS91

Crack Detection in Thin Plates

Abstract not available.

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MS91

Fluorescence Optical Tomography with Poisson noise

We consider the fluorescence optical tomography problem in which one excites fluorophores distributed in a mulitple scattering medium with a boundary source at the excitation wavelength, and then measures the light emitted by those excited fluorophores at the boundary. The objective is to reconstruct the distribution of fluorophores from those boundary measurements of the emitted light. In particular, we investigate explicitly modeling Poisson noise in the measurements. For that case, we develop a reconstruction method for a sparse distribution of fluorophores using the Sparse Poisson Intensity Reconstruction ALgorithm (SPIRAL). Through numerical experiments, we show highly accurate reconstructions using this method along with a nonconvex ℓ_p $(p < 1)$ penalty term even with nontrivial amounts of measurement noise.

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MS91

Imaging Point Sources in Unknown Environments

Reconstructing point sources from boundary or far-field measurements has many practical applications. There have been extensive studies on the reconstruction problem in homogeneous media and known inhomogeneous media. We study here two point source identification problems in an unknown smooth inhomogeneous medium. The first one is based on the Helmholtz equation while the second one is based on the transport equation (and its diffusion approximation). We present some stability results for the reconstruction, for instance, the stability of the reconstructed quantities with respect to changes of the medium, as well as some numerical simulations with synthetic data. This is a joint work with Yimin Zhong of UT Austin.

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MS92

Accelerated Douglas-Rachford Methods for Convex-Concave Saddle-Points Problems and Applications in Imaging

We discuss basic and accelerated versions of the Douglas-Rachford (DR) splitting method for the solution of convex-concave saddle-point problems that arise in variational imaging. While the basic DR iteration admits weak and ergodic convergence with rate $O(1/k)$ for restricted primal-dual gaps, acceleration enables, under appropriate strong convexity assumptions, to obtain convergence rates of $O(1/k^2)$ and $O(q^k)$ for $0 < q < 1$. The methods are applied, numerically, to non-smooth and convex variational imaging problems, such as total-variation denoising.

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MS92

A Three-Operator Splitting Scheme and its Optimization Applications

In this talk, we introduce a new splitting scheme that extends the Douglas-Rachford and forward-backward splitting schemes to monotone inclusions with three operators, one of which is cocoercive. We discuss why this algorithm works, derive several special cases, including a simple three-block ADMM algorithm, and introduce an acceleration that achieves the optimal rate of convergence for strongly monotone inclusions. Finally, we discuss several applications and future research directions.

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MS92

Gradient Sliding for Saddle Point Problems

We consider a class of nonsmooth optimization problem with saddle point structure. In order to compute an approximate solution to the saddle point problem, we propose two novel first-order methods, namely the mirror-prox sliding algorithm and the accelerated gradient sliding method with smoothing. Both propose methods could skip the computation of the gradient of the smooth component from time to time, so that the number of gradient evaluations is bounded by $\mathcal{O}(\sqrt{1/\varepsilon})$, while achieving a $\mathcal{O}(1/\varepsilon)$ complexity bound for solving SPP. As a byproduct, the proposed AGS algorithm can solve a class of smooth composite optimization problem, and skipping the gradient evaluation of one of the smooth component regularly, while achieving a $\mathcal{O}(\sqrt{1/\varepsilon})$ complexity.

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MS92

Convergence Analysis for a Randomized Multiblock ADMM and Its Applications

Global convergence and the rate of convergence for two block ADMM has been well established. However, a direct extension to more than two blocks may fail to converge. This talk will present a randomized version of the ADMM for handling general multiblock problem with general linear constraints. We will establish a sublinear convergence result for the general convex case and a linear convergence result for the strongly convex case (without smoothness requirement). The algorithm and its convergence results are further generalized to a problem setting where the objective involves stochastic multiblock functions. Numerical experiments will be shown on large-scale quadratic programs and also problems from machine learning and image processing.

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MS93

Multiframe Blind Deconvolution for Imaging Through Strong Atmospheric Turbulence

Abstract not available.

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MS93

High-Resolution Imaging of Satellites with and Without Adaptive Optics

Attainment of diffraction-limited resolution and high signal-to-noise ratio in images of space-based objects even when observed with adaptive optics (AO) is only possible in conjunction with subsequent deconvolution. Our aim is to develop deconvolution strategy which is reference-less, i.e., no calibration PSF is required, free of hyperparameters, extendable to longer exposures, and applicable to imaging with adaptive optics. The theory and resulting deconvolution framework were validated using simulations and real data from the 3.5m telescope at Starfire Optical Range.

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MS93

Reconstruction and Enhancement of Astronomical and Satellite Images Obtained Using Adaptive Optics

The Starfire Optical Range (SOR) has been collecting satellite images for several years using adaptive optics to correct for atmospheric distortions in real time. In this presentation, we will briefly review different techniques for atmospheric compensation of satellite imagery, including tilt and higher order correction. We will also discuss different techniques for sharpening images and for enhancing the presentation of the imagery to the user. These applications are used both for real-time image correction as well as post-capture image correction.

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MS93

3D Snapshot Imaging Via Rotating Psf for Space Surveillance

By placing a carefully designed spiral phase mask in the aperture of an imager, we may exploit the angular momentum of light to encode the axial distance of a point source in the rotation of the point spread function (PSF). Such rotating-PSF-based imagers can acquire unresolved sources in a large imaging volume in a single snapshot with high 3D localization accuracy, which can be employed for the monitoring of the debris field near space assets.

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MS94

Removing Camera Shake Via Fourier Burst Accumulation

Camera shake deblurring is typically addressed by solving an inherently ill-posed deconvolution problem. If the photographer takes a multi-image burst, we show that it is possible to combine them to get a clean sharp version. The algorithm is strikingly simple: it performs a Fourier weighted average, with weights depending on the Fourier spectrum magnitude. The rationale is that camera shake has a random nature and thus frames are differently blurred.

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MS94

Revisiting Total Variation Blind Deconvolution

We will revisit progress on blind deconvolution in the past few decades. We will highlight what we have learned about the problem formulation and, in particular, the choice of regularization prior. The presentation will focus more on recent progress with Variational Bayesian and Maximum a Posteriori methods. We will compare different approaches and illustrate what differences have a measurable effect on the image deblurring performance.

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MS94

Energy-Optimized Imaging

Programmable coding of light between an active source and a sensor has enjoyed broad use in 3D sensing and computational imaging applications. Little is known, however, about how to utilize the source's energy most effectively. In this talk, we discuss a novel framework to maximize energy efficiency by "homogeneous matrix factorization." Our framework yields energy-optimized codes that respect the physical constraints of modern projectors and has led to an extremely efficient depth camera—able to operate robustly even in direct sunlight with very low power. Website: http://www.dgp.toronto.edu/ motoole/energyefficientimaging.html

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MS94

Single Shot HDR Imaging Using A Hyperprior Bayesian Approach

Patch models with a Bayesian approach such as PLE achieve state-of-the-art results in several image restoration problems. Local patch models such as NLBayes yield state-of-the-art results for denoising, but become ill-posed for zooming, inpainting, debluring. We present a new framework that enables to use local priors for more general inverse problems by including a hyperprior on the model parameters. We apply this new framework to HDR imaging from a single snapshot with spatially varying exposure. website http://perso.enst.fr/∼gousseau/single_shot_hdr/

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MS95

Edge preserving image reconstruction for 3D magnetic particle imaging

Magnetic Particle Imaging [B. Gleich, J. Weizenecker, Tomographic imaging using the nonlinear response of magnetic particles, Nature, 2005] is an imaging modality where the concentration of magnetic nanoparticles is determined by measuring their non-linear magnetization response to an applied magnetic field. We propose fused lasso regularization for the image reconstruction as well as a near-isotropic discretization and derive a new minimization method based on the generalized forward-backward splitting [H. Raguet, J. Fadili, and G. Peyre, A generalized forward-backward splitting, SIAM Journal on Imaging Sciences, 2013] and the taut string algorithm [P. Davies and A. Kovac, Local extremes, runs, strings and multiresolution, Annals of Statistics, 2001]. We will illustrate our approach with several numerical examples as well as real experimental data.

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MS95

An Affine Invariant Similarity Measure for Non-Local Image Restoration

Many state-of-the-art methods employ a patch-based approach for image restoration and inpainting. Such methods are based on the phenomenon of self-similarity, usual in the natural images, and a patch comparison measure that exploits it. In this talk we will give an overview of a recently proposed affine invariant comparison measure which automatically transforms patches to compare them in an appropriate manner. We will illustrate the power of this technique on the image denoising problem.

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MS95

Path Optimization with limited sensing ability

Abstract not available.

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MS95

Inverse Problems with TV-ICE regularization

We propose a new variant of the celebrated Total Variation image denoising model, that provides results very similar to the Bayesian posterior mean denoising (TV-LSE) while showing a much better computational efficiency. This variant is based on an iterative procedure which is proved to linearly converge to a fixed point satisfying a marginal conditional mean property. We explore a generalization to image restoration and propose several converging schemes. The implementation is simple, provided numerical precision issues are correctly handled. Our experiments are very close to those obtained with TV-LSE and avoids as well the so-called staircasing artifact observed with classical Total Variation denoising.

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MS96

A hierarchical KrylovBayes iterative inverse solver for MEG with physiological preconditioning

The inverse problem of MEG is formulated in Bayesian framework and a hierarchical conditionally Gaussian prior model is introduced,including a physiologically inspired prior model accounting for the preferred directions of the source currents. The hyperparameter vector consists of prior variances of dipole moments,following a non-conjugate gamma distribution with variable scaling and shape parameters. A point estimate of dipole moments and their variances is computed using an iterative alternating sequential updating algorithm, shown to be globally convergent. The solution is an approximation of the dipole moments using a Krylov subspace iterative linear solver equipped with statistically inspired preconditioning and suitable termination rule. The shape parameters of the model are shown to control focality, and the scaling parameters can be adjusted to provide a statistically well justified depth sensitivity scaling. Computed examples are presented.

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MS96

On Preconditioning Newton Method For PDE Constrained Optimization Problems

Solving an inverse problem with second order methods is often prohibitive due to the computational overhead of solving the Hessian equation. Even though using Newton

methods provide better convergence rates, but this hidden cost usually outweighs the benefits. We will present novel methods for preconditioning the Hessian equation for problems with a variety of (nonlinear) parabolic constraints. In particular, we present results for a tumor growth problem, and show that significant speedups can be gained.

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MS96

Nonlinear Quantitative Photoacoustic Tomography with Two-photon Absorption

Two-photon photoacoustic tomography (TP-PAT) is a non-invasive optical molecular imaging modality that aims at inferring two-photon absorption property of heterogeneous media from photoacoustic measurements. In this work, we analyze an inverse problem in quantitative TP-PAT where we intend to reconstruct optical coefficients in a semilinear elliptic PDE, the mathematical model for the propagation of near infra-red photons in tissue-like optical media, from the internal absorbed energy data. We derive uniqueness and stability results on the reconstructions of single and multiple coefficients, and perform numerical simulations based on synthetic data to validate the theoretical analysis.

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MS96

Reduced Order Modeling in Photoacoustic Tomography

Photoacoustic tomography combines a rich optical contrast with the high resolution of ultrasound tomography. Mathematically it is an ill-posed inverse coefficient problem for a coupled wave equation and diffusion equation pair. Since the wave speed is assumed to be constant, to accelerate the inversion, we use a Hessian-based reduced order model for the wave equation. We demonstrate the computational gains on a synthetic problem motivated from neuroscience.

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MS97

Joint Denoising and Distortion Correction of Scanning Transmission Electron Microscopy Images of Crystalline Structures

Given a series of scanning transmission electron microscopy (STEM) images at atomic scale, we propose a novel method that jointly estimates the direction dependent STEM distortions in each image and reconstructs the underlying atomic grid of the material by fitting the atoms with bump functions. The resulting minimization problems are solved numerically using Trust Region. The method's performance is evaluated on both synthetic and real data and compared to an established non-rigid registration based method.

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MS97

2D Empirical Wavelets

Empirical wavelets were proposed recently as an alternative of the Empirical Mode Decomposition (EMD). We will present 2D empirical wavelets for image processing applications. We integrate the empirical philosophy into standard 2D wavelet like transforms (2D tensor wavelets, Littlewood-Paley wavelets, Ridgelets and Curvelets) and show that each case correspond different type of Fourier domain partitionings.

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MS97

Sparse Time-Frequency Decomposition for Signals with Multiple Measurements

In this talk, we consider multiple signals sharing same instantaneous frequencies. This kind of data is very common in scientific and engineering problems. To take advantage of this special structure, Based on the simultaneously sparsity approximation and fast Fourier transform, we develop an efficient algorithm. This method is very robust to the perturbation of noise. And it is applicable to the general nonperiodic signals even with missing samples or outliers. In the tests include synthetic and real signals, the performances of this method are very promising.

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MS97

2D-TV-VMD: Two-Dimensional Compact Varia-

tional Mode Decomposition

Decomposing images into spatially compact modes of wave-like nature makes components accessible e.g., for space-frequency analysis, demodulation, texture analysis, denoising, or inpainting. 2D-TV-VMD decomposes an image into modes with narrow Fourier bandwidth; to cope with sharp boundaries we introduce binary support functions, masking the narrow-band modes for image re-composition. L^1/TV-terms promote sparsity and spatial compactness. Restricting to partitions, we perform image segmentation based on spectral homogeneity.

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PP1

A Hybrid Spatio-Frequency Approach for Delineating Subsurface Structures in Seismic Volumes

Frequency-based edge detection methods such as phase congruency are generally fast and accurate but are sensitive to noise, and cannot capture subtle edges that are marked by a change in texture rather than a change in amplitude. On the other hand, spatial edge detection methods of textured data such as the Gradient of Texture (GoT), that we proposed in 2014, are more robust to noise, but are less localized in space, and are more computationally expensive. In this paper, we share a new hybrid spatio-frequency edge detection method, and show its effectiveness in salt dome delineation on 3D seismic data from the North Sea F3 Block.

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PP1

Non-Convex Color Image Enhancement Via Manifold Regularization

Direct regularization of non-convex image priors pose several challenges as the energies suffer from multiple minima. In this work we introduce a non-convex vectorial total variational based method for the problem of color image restoration. We exploit a novel intra-channel coupling derived from the geometry of an opponent space. We optimize our energy using a half-quadratic algorithm and show that our numerical scheme converge. We show competitive results compared to state-of-the-art vectorial total variation methods.

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PP1

A Coupled Regularizer for Color Image Enhancement Via Manifold Geometry

Color image enhancement poses an unsettled problem since the notion of color edges has no unique characterization. Existing vectorial total variation (VTV) methods have insufficient color channel coupling and thus may create color artifacts. We introduce a novel color channel coupling derived from the geometry of an opponent space. We show existence and uniqueness of a solution in the space of vectorial functions of bounded variation. Experimentally, we outperform state-of-the-art VTV methods w.r.t. color consistency.

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PP1

Density Modeling of Images Using a Generalized Normalization Transformation

We introduce a parametric nonlinear transformation for jointly Gaussianizing patches of natural images. The transformation is differentiable, can be efficiently inverted, and thus induces a density model. It achieves a significantly better fit than previous image models, including ICA and radial Gaussianization. Model samples are visually similar to natural image patches. We use the model for image restoration, and show that it can be cascaded to build nonlinear hierarchies analogous to multiscale representations.

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PP1

Applications and Generalization of the (p, q)-Laplace Operator

We study and extend a recently proposed family of operators called (p, q)-Laplace operators, which generalize the p-Laplace operator. In this work we have extended the (p, q) operator-class with spatially adaptive p,q coefficients. We present novel preliminary results on the regularity and well-posedness for the non-adaptive coefficient. We show, via empirical experiments, that our adaptive coefficient operator reduces the staircasing effect often seen in total variation whereas we still preserve fine details without loosing image contrast.

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PP1

Inverse Reaction-Diffusion Model for Tumor Source Localization

Reaction-diffusion models have been successfully used for cancer tumor growth prediction in, e.g., computed tomography. In this work we study the inverse growth problem with the aim to locate the tumor origin. We suggest a regularization method posing the inverse problem as a sequence of well-posed forward problems. Numerical results verifies the accuracy of our solution scheme by comparing the solution from the inverse problem with the corresponding synthetic tumor growth from the forward model.

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PP1

Connectionist Model of Wavelet Neural Network in Automatic Pattern Recognition

Inspired by the functioning of the nervous approach, we propose to build up a wavelet neural network (WNN) capable to identify geometric shapes of an image captured using a digital camera. We focus on the exploit of wavelet functions in the artificial neural network approach. The data used to train the WNN are 18 in total; nevertheless, the outcome confirmed the efficiency of the connectionist model of wavelet networks in the field of recognition.

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PP1

Learning Metrics to Enhance Morphological Categorization

In this presentation, we will present an approach to improve morphological categorization by introducing a metric learning method that lets us select a shape metric that optimizes shape classification among all metrics in a high-dimensional parametric family. To estimate the optimal shape metric, we use a Monte Carlo optimization technique. We will discuss the theoretical and practical aspects of the method, including applications to the classification of 3D skull data for several mouse strains. The results of this study help validate the proposed method, which in a forthcoming study will be applied to the enhancement of clinical diagnose of human facial dysmorphic syndromes.

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PP1

3D Shape Characterization of Vascular Remodeling in Pulmonary Arterial Hypertension As Depicted in Volumetric Ct Images

Pulmonary arterial hypertension is a difficult to diagnose and treat disease where the resistance of the small pulmonary arteries drastically increases resulting in upstream vascular remodeling. Image-based characterization of the vascular remodeling typically only uses the diameter of the pulmonary arterial trunk. As an alternative, more complete characterization, we combine automated graph-based recognition of the arterial tree structures with point-based, non-parametric 3D shape models to create a more informative model of the entire vascular remodeling.

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PP1

A Unified Hyperelastic Joint Segmentation/registration Model Based on Weighted Total Variation and Nonlocal Shape Descriptors

In this presentation, we propose a unified variational model for joint segmentation and registration in which the shapes to be matched are viewed as hyperelastic materials, and more precisely, as Saint Venant-Kirchhoff ones. The dissimilarity measure is based on weighted total variation and nonlocal shape descriptors inspired by the Chan-Vese model for segmentation. Theoretical results among which relaxation, existence of minimizers, description and analysis of a numerical method of resolution, and a Γ-convergence one are provided.

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PP1

A Flexible Approach to 2D-3D Image Registration

We propose an extended mathematical formulation aimed at intensity-based registration (alignment) of a deformed 3D volume to a 2D slice as an extension of the existing FAIR (Flexible Algorithms for Image Registration) toolbox. This framework will be evaluated on 2D-3D registration experiments of "in vivo" cardiac magnetic resonance imaging (MRI) aimed at computer assisted surgery. Target registration error (TRE), Jaccard and Dice indexes will be used to validate the accuracy of the registration scheme on both simulated and clinical experiments. The approach is flexible and various regularization schemes, similarity measures, and optimization approaches can be considered.

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PP1

A Discretize-Then-Optimize Approach to Coupled Super-Resolution Reconstruction and Motion Estimation

The process of recovering a high-resolution (HR) image from a set of distorted (i.e. deformed, blurry, noisy, etc.) low-resolution (LR) images is known as super-resolution. Super-resolution problem will require the reconstruction of the ideal HR image and an estimation of the motion between LR images. The proposed algorithm will attempt to recover the HR image and perform non-parametric motion estimation simultaneously using a joint regularized ill-posed inverse model followed by a discretize-then-optimize approach. Elastic regularization will be used for non-parametric motion estimation and total variation regularization for the super-resolved image. Preliminary results on surveillance image sequences will be presented.

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PP1

On the Asymptotic Optimality of Global Image Denoising

In this work, we focus on the global denoising framework recently introduced by Talebi & Milanfar and analyze the asymptotic behavior of its RMSE restoration performance when the image size tends to infinity. We introduce precise conditions both on the image and the global filter to ensure and quantify this convergence. We also discuss open issues concerning the most challenging aspect, namely optimal choice of basis.

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PP1

Radial Symmetric Point Spread Estimation and Uncertainty Quantification

Image deblurring techniques derived from convolution require, a priori, an estimate for the convolution kernel or point spread function (PSF). Standard techniques for estimating the PSF involve imaging a bright point source, but this is not always feasible (e.g. high energy radiography). We present a method for estimating and quantifying uncertainty that is suitable for applications where it is possible to image a sharp edge which requires an assumption of radial symmetry. Taking a Bayesian approach, we develop a Hilbert space that generalizes radial symmetry for our prior, and, using a novel marginalized Gibbs sampling algorithm, we compute a Monte Carlo estimate of the posterior distribution of the PSF.

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PP1

Applying Local Renyi Entropy to Enhance Electron Microscopy Images of the Nucleus

Local Renyi and Shannon entropy, have proven to be very powerful in image processing. Examples include, automated image quality measures, contouring, noise reduction and thresholding for object detection and segmentation performed on various images including biological. We demonstrate applying Renyi entropy for enhancing Electron Microscopy images of the cell nucleus. These results may be used in EM tomography to obtain 3D structures of the cell nucleus which relate to how DNA information is being accessed.

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PP1

Extracting Science from the Smallest Scales in Solar Imagery

All digital images are corrupted by noise. In most solar imaging, we have the luxury of high photon counts and low background contamination, which when combined with carful calibration, minimize much of the impact noise has on the measurement. Outside high-intensity regions, such as in coronal holes, the noise component can become significant and complicate feature recognition and segmentation. We create a practical estimate of noise in the high-resolution solar images across the detector CCD. A mixture of Poisson and Gaussian noise is well suited in the digital imaging environment due to the statistical distributions of photons and the characteristics of the CCD. Using state-of-the-art noise estimation techniques, the publicly available solar images, and point spread function estimates; we construct a maximum-a-posteriori assessment of the error in these images. The estimation and mitigation of noise not only provides a clearer view of solar features in the solar corona, but also provides a peek into the smallest physical scales observed on the sun.

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PP1

Restoration of Compressed Noisy Images

A noisy image $f+n$, where f denotes the original scene and n the additive noise is compressed. In order to restore f, we model the noise corrupting the compressed ideal image. It is typically sparse in the transformed domain used for the compression. We then propose a model for restoring f and describe a numerical scheme solving this model. We finally study the performances of the model.

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PP1

Models and Algorithms for 3D Corneal Biometry from Optical Coherence Tomography

Optical coherence tomography (OCT) is a noninvasive high resolution medical imaging modality based on near-infrared interferometry. Already a popular tool in ophthalmology, OCT has the potential to uncover detailed information about the interior of the eye that is unavailable through current technology. This presentation will address key issues involved in accurate reconstruction of the cornea from OCT data, including automatic outlier removal and image registration, data interpolation, and refraction correction for interior ocular surfaces.

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PP1

High-Level Fusion for Multimodal Brain Imaging Data Using Conditional Probabilities and Directed Information Flow Between Clustered Feature Spaces

We introduce an intuitive high-level multimodal data fusion framework based on Markov-style flows in an ambient "meta-space" of diverse features. Our approach quantifies directed information transfer between clinically relevant features of arbitrary type or dimensionality. We apply the framework in a large fMRI dataset to identify relationships between 4D spectrum, functional network connectivity, connectivity dynamism and schizophrenia.

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PP1

Stability of Information Theoretic K-Space Trajectories for Model-Based MR Thermal Image Reconstruction

An information theoretic analysis is presented to evaluate the stability of the most information-rich k-space trajectories in model-based magnetic resonance (MR) thermal image reconstruction. Novel Gauss-Hermite quadrature schemes were developed to compute mutual information between a nonlinear model-based image reconstruction and MR signal measurements. The stability of the most informative k-space samples is compared in several treatment scenarios for MR-guided laser induced thermal therapy in heterogeneous human brain tissue.

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PP1

A Stochastic Inverse Method for Highly Heterogeneous Aquifers

Aquifer properties such as permeability are often highly heterogeneous with significant variations occurring on the centimeter scale and sometimes smaller. For many hydrogeologic applications, an attempt is made to infer the aquifer properties by observing the aquifer's response to stimulation (e.g., pumping, tracer injection, etc.) at a number of monitoring wells that are sparsely distributed across a field whose length scale is often tens, hundreds, or thousands of meters. This disparity in scales makes it difficult, and perhaps impossible, for inverse methods to reproduce the small scale heterogeneities that are present in the actual aquifer. Most inverse methods that are in use produce fields (e.g., permeability fields) that are much smoother than we expect the actual field to be, essentially failing to represent the small scale heterogeneity at all. This failure is important because small scale heterogeneities can have a significant impact on transport (e.g., trapping in small, low-permeability lenses). We present an approach to inverse analysis that is capable of representing these small scale heterogeneities. We note that although this approach does represent small scale heterogeneities, it does not reproduce the actual small scale heterogeneities that exist in the aquifer. The representation of the small scale heterogeneities is stochastic, and, because of this, we call the method a stochastic inverse method.

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PP1

Enhanced Low-Rank Matrix Approximation

We propose to estimate low-rank matrices by formulating a convex optimization problem with non-convex regularization. We employ parameterized non-convex penalty functions in order to estimate the non-zero singular values more accurately than the nuclear norm. We further provide a closed form solution for the global optimum of the proposed objective function (sum of data fidelity and the non-convex regularizer). The closed form solution reduces to the singular value thresholding method as a special case.

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PP1

Efficient Optimal Recovery Based Spatially-Adaptive Multi-Frame Super-Resolution.

Our approach to multi-frame super-resolution based on the framework of optimal recovery was recently extended to a spatially-adaptive scheme whereby the block-by-block processing is modified based on local low-resolution image data using simple statistical quantities to define local bandwidth for the high-resolution image block. Simulations show the superiority of the adaptive scheme over other methods that are computationally fast. Our current work is focused on improving this approach based on: pre-optimized but fixed regularization parameter, automated linking of the block variances to the bandwidth parameter, incorporation of gradients and edge maps, and post-processing using deblocking.

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PP1

Color Image Processing By Vectorial Total Variation With Gradient Channels Coupling

We study a regularization method for multichannel images based on the vectorial total variation approach along with channel coupling for color image processing, which facilitates the modeling of inter channel relations in multidimensional image data. We focus on penalizing channel gradient magnitude similarities by using L^2 differences, which allow us to explicitly couple all the channels along with a vectorial total variation regularization for edge preserving smoothing of multichannel images. By using matched gradients to align edges from different channels we obtain multichannel edge preserving smoothing and decomposition. A detailed mathematical analysis of the vectorial total variation with penalized gradient channels coupling is provided. Extensive experimental are given to show that our approach provides good decomposition and denoising results in natural images. Comparison with previous color image decomposition and denoising methods demonstrate the advantages of our approach.

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PP1

Whitening of the Residual for Image Denoising

Most state-of-the-art denoising methods that rely on a white gaussian noise hypothesis do not guarantee the whiteness of the method-noise (residual between the noisy image and the estimated image). Typically, the areas where the method-noise is correlated convey wrong information. We propose a new variational approach with an energy defined to guarantee the local whiteness of the method-noise and ensure information conservation. It leads to applications such as denoising, performance eval-

uation, post-processing or multi-image denoising.

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PP1

Denoising of Images Using Redundant Wavelet Transform and Biorthogonal Slepian Filterbanks

The redundant discrete wavelet transform (RDWT) was originally developed as an approximation to the continuous wavelet transform by removing the downsampling operation from the critically sampled discrete wavelet transform. In this work, we analyze the performance of RDWT for image denoising under additive noise when the RDWT is implemented using biorthogonal filters rather than orthonormal filters. The filters to be used are derived from Slepian sequences which are the eigenfunctions of an energy maximization problem.

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PP1

Multiphase Segmentation For Simultaneously Homogeneous + Textural Images

In their seminal paper from 1989, Mumford and Shah proposed a model (but NP-hard due to the Hausdorff 1-dimensional measure $\mathcal{H}^1$ in R^2) for piece-wise smooth (for image restoration) and piece-wise constant (for image segmentation) by minimizing the energy functional. Later, Chan and Vese have proposed the active contour model for two phase image segmentation which is solved by a level set method. However, these models do not apply to the larger class of natural images that simultaneously contains texture and piecewise smooth information. By the calculus of variation, we design a bi-level constrained minimization model for a simultaneous multiphase homogeneous and textural (on a defined scale) image segmentation by solving a relaxed version of a non-convex (due to a binary setting of a non-convex set) minimization. The cornerstone of this minimization is to introduce novel norms which are defined in different functional Banach spaces (with the discrete setting), e.g. homogeneous regions, texture and residual are measured by directional total variation norm, directional G-norm and a dual of a generalized version of the Besov space, respectively. The key ingredients of this study are: (1) the assumption of the sparsity of a signal in some transform domains; (2) the Banach space G in Meyer's model to measure the oscillatory components e.g. texture, which do not have a small norm in $L_1(R^2)$ or $L_2(R^2)$; (3) a smooth surface and sharp edges in geometric objects in cartoon along with a smooth and sparse texture by the DG3PD model.

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PP1

Imaging of Contaminant Plumes Using Non-Nonnegative-Matrix Factorization

Contamination of groundwater water-supply resources poses significant social and environmental problems. Frequently, at the contamination sites, the groundwater is a mixture of waters with different origins (sources) that are commingled in the aquifer; several of these groundwater recharge sources might include contaminants. Typically, all these sources will have different geochemical signatures due to differences in their origins and flowpaths through the subsurface before infiltrating in the aquifer. The identification of the contamination/infiltration sources causing the observed geochemical concentrations in the aquifer can be very challenging at sites where complex physical and chemical processes occur. We propose mapping of the contaminant plumes based on a novel model-free machine-learning algorithm.

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