Computational Imaging
Poster Session Abstracts
Tuesday, March 19, 2019

SOURCE DETECTION IN 2D HIGH NOISE EMISSION TYPE PROBLEMS USING CONE DATA
Weston Baines, Texas A&M University

The development of methods for source detection in high noise environments is an important topic in single-photon emission computed tomography (SPECT) medical imaging and homeland security applications. The detection of low emission nuclear sources in the presence of significant background noise (SNR ? 0.01) is of great interest since such a robust detection system can prevent the smuggling of weapons-grade nuclear material. A source detection method based on the analysis of data obtained from Compton type cameras and their analogs using deep learning is developed and evaluated, and compared to previous statistical detection techniques.

The value of edge locations in image reconstruction from limited data
Victor Churchill, Dartmouth College

We present theoretical and empirical evidence that the knowledge of edge locations in an edge-sparse image is extremely valuable in image reconstruction from limited data. We also present an associated iterative inversion algorithm that performs well in terms of accuracy and speed using limited data. This computational method begins with an edge detection which is used to create a binary edge mask. That mask is used in a reconstruction step to regularize away from edges. Numerical results using multiple edge detection methods and phantoms are provided.

A probabilistic approach to seismic diffraction imaging
Luke Decker, The University of Texas at Austin

We propose a probabilistic method for imaging seismic diffractions. The method utilizes oriented velocity continuation (OVC) to generate a suite of slope decomposed diffraction images with different migration velocities. Treating each partial image in slope as independent allows us to construct an object resembling a probability field from the continuation output, which we may use to construct probability weights for each partial image in velocity that we interpret as the likelihood of a correctly migrated diffraction occurring at a location within the seismic image. Stacking these weighted partial images over velocity provides us with a probabilistic seismic diffraction image. We illustrate the principles of the method on a simple toy model, show its robustness to noise on a synthetic, and and apply it to a 2D field dataset from the Viking Graben. We find that the proposed approach creates diffraction images that better suppress noise, migration artifacts, and remnant reflections than typical diffraction imaging methods while simultaneously determining the most likely migration velocity.

Gaussian Process Landmarking
Tingran Gao, The University of Chicago

As a means of improving analysis of biological shapes, we propose a greedy algorithm for sampling a Riemannian manifold based on the uncertainty of a Gaussian process. This is known to produce a near optimal experimental design with the manifold as the domain, and appears to outperform the use of user-placed landmarks in representing geometry of biological objects. We provide an asymptotic analysis for the decay of the maximum mean squared prediction error (MSPE), which is frequently employed as a greedy criterion for similar variance- or uncertainty-based sequential experimental design strategies; to our knowledge this is the first result of this type for experimental design. The key observation is to link the greedy algorithm with reduced basis methods in the context of model reduction for partial differential equations. We apply the proposed landmarking algorithm to geometric morphometrics, a branch of evolutionary biology focusing on the analysis and comparisons of anatomical shapes, and compare the automatically sampled landmarks with the "ground truth" landmarks manually placed by evolutionary anthropologists; the results suggest that Gaussian process landmarks perform equally well or better, in terms of both spatial coverage and downstream statistical analysis.

Tackling 3D ToF Artifacts Through Learning and the FLAT Dataset
Qi Guo, Harvard University

Scene motion, multiple reflections, and sensor noise introduce artifacts in the depth reconstruction performed by time-of-flight cameras. We propose a two-stage, deep-learning approach to address all of these sources of artifacts simultaneously. We also introduce FLAT, a synthetic dataset of 2000 ToF measurements that capture all of these nonidealities, and can be used to simulate different hardware. Using the Kinect camera as a baseline, we show improved reconstruction errors on simulated and real data, as compared with state-of-the-art methods.

Hybrid Projection Methods with Recycling for Large Inverse Problems
Jiahua Jiang, Virginia Tech

Iterative hybrid projection methods have proven to be very effective for solving large linear inverse problems due to their inherent regularizing properties as well as the added flexibility of being able to select regularization parameters adaptively. However, the main disadvantage of hybrid methods compared to standard iterative methods is the need to store the basis vectors for solution computation. In this work, we present a framework that uses recycling approaches with the Golub- Kahan bidiagonalization to efficiently compute an accurate solution, even after the solution space has been compressed. Various techniques for subspace selection/compression can be incorporated, and the proposed recycling techniques can be coupled with a hybrid projection method for automatic regularization parameter selection. Numerical examples from image processing show the potential benefits of using recycling in hybrid methods for solving problems.

A Convex Formulation for Discrete Tomography
Ajinkya Kadu, Utrecht University

Discrete tomography is concerned with the recovery of binary images from a few of their projections (i.e., sums of the pixel values along various directions). To reconstruct an image from noisy projection data, one can pose it as a constrained least-squares problem. As the constraints are non-convex, many approaches for solving it rely on either relaxing the constraints or heuristics. We propose a novel convex formulation, based on the Lagrange dual of the constrained least-squares problem. The resulting problem is a generalized LASSO problem which can be solved efficiently. It is a relaxation in the sense that it can only be guaranteed to give a feasible solution; not necessarily the optimal one. In exhaustive experiments on small images (2×2, 3 × 3, 4 × 4) we find, however, that if the problem has a unique solution, our dual approach finds it. In the case of multiple solutions, our approach finds the commonalities between the solutions. Further experiments on realistic numerical phantoms and an experiments X-ray dataset show that our method compares favourably to alternative approaches, including Total Variation and DART.

Nonconvex Robust Low-rank Matrix Recovery
Xiao Li, University of Southern California

We study the problem of recovering a low-rank matrix from a number of random linear measurements that are corrupted by outliers taking arbitrary values. We consider a nonsmooth nonconvex formulation of the problem, in which we explicitly enforce the low-rank property of the solution by using a factored representation of the matrix variable and employ an ℓ_1-loss function to robustify the solution against outliers.
Under the Gaussian measurement model, we show that even when a constant fraction (which can be up to almost half) of the information-theoretically optimal number of measurements are arbitrarily corrupted, the resulting optimization problem is sharp and weakly convex. Consequently, we show that when initialized close to the set of global minima of the problem, a SubGradient Method (SubGM) with geometrically diminishing step sizes will converge linearly to the ground-truth matrix. We demonstrate the performance of the SubGM for the nonconvex robust low-rank matrix recovery problem with various numerical experiments.

Solution Uniqueness of Convex Piecewise Affine Functions Based Optimization with Applications to Constrained ℓ_1 Minimization
Seyedahmad Mousavi, University of Maryland, Baltimore County

We study the solution uniqueness of an individual feasible vector of a class of convex optimization problems involving convex piecewise affine functions and subject to general polyhedral constraints. This class of problems incorporates many important polyhedral constrained ℓ_1 recovery problems arising from sparse optimization, such as basis pursuit, LASSO, and basis pursuit denoising, as well as polyhedral gauge recovery. By leveraging the max-formulation of convex piecewise affine functions and convex analysis tools, we develop dual variables based necessary and sufficient uniqueness conditions via simple and yet unifying approaches; these conditions are applied to a wide range of ℓ_1-minimization problems under possible polyhedral constraints. An effective linear program based scheme is proposed to verify solution uniqueness conditions. The results obtained not only recover the known solution uniqueness conditions in the literature by removing restrictive assumptions but also yield new uniqueness conditions for much broader constrained ℓ_1-minimization problems.

Fracturing processes in stress-strain state media due to lunar-solar tides
Kseniia Nepeina, Research Station RAS

Energy source of fracture openings are presented by: planetary movements caused by lunar-solar physics, tectonic movements of lithospheric plates or internal motions of the lithosphere. Phased array techniques for three-component sensors gradient system (1m per 1 m) has to be applied. This scheme has many of the limitations of the wavefield classification scheme if we discuss seismic activity in 10-100 Hz range. This process requires a physical model of direct upward seismic waves from near-surface moving small structure (as fracture or crack). For comparison results from seismic gradient array, we made registration by available geophysical equipment and observed its correlation with lunar-solar tides curves.

SparsePPG: Towards Driver Monitoring Using Camera-Based Vital Signs Estimation in Near-Infrared

Ewa Nowara, Rice University

Car accidents are a leading cause of death in the US and the majority of these accidents are caused by driver's inattention. Changes in vital signs over time, such as heart rate variability can provide useful information about the driver's attention and health which can be used to predict if an accident is likely to happen. These measurements are possible because hemoglobin present in the blood absorbs in the visible light spectrum and a camera can register very small temporal rPPG signals associated with hemoglobin's varying concentration, while blood is flowing through the skin. The unique challenge for rPPG measurement in the car is that there are large illumination variations and motion of the driver's head and the camera due to the car moving. The noise caused by varying illumination and motion is significantly larger than the minuscule intensity-based rPPG signal. We have built a near-infrared illumination set up to overcome illumination variations in the car and I developed an optimization-based algorithm leveraging rPPG signal properties, such as low-rankness and sparsity in frequency domain, to recover rPPG in presence of large noise.

Nonlocal feature driven exemplar based image inpainting

Viktor Reshniak, Oak Ridge National Laboratory

Inpainting is a process of image restoration resulting in the visually plausible interpolation of the partially observed data. A broad variety of inpainting algorithms has been proposed based on different models for representing images, types of the damage to the image and the goals of the inpainting procedure. A significant portion of these algorithms seek for the unknown image as a minimizer of the appropriate energy functional. For example, nonlocal models view images as low dimensional manifolds embedded in the larger space of patches. Discrete representations of such manifolds are often interpreted as weighted graphs. The choice of weighting functions determines the flow of information in the graph and hence significantly impacts the quality and properties of such representations. In this project, we propose to solve the inpainting problem using graph based regularizers with selective weights acting as filters for the specific features of interest. Some examples include inpainting of geometric patterns, edges, textures, scale specific features, etc.

Thin Lensless Cameras: Applications and Possibilities

Jasper Tan, Rice University

This poster presents our lab's work in thin lensless cameras. Such cameras are built by replacing the lens with a thin mask that modulates the incoming light. By inverting this modulation, one can reconstruct the scene image. The result is then a very thin imaging device. In this poster, I present (a) how the technology works (both hardware and software), (b) the different applications we have used them in (examples include microscopy and face detection), and (c) future possibiltiies with lensless cameras.

Averaging Images through Averaging Diffeomorphisms

Zicong Zhou, University of Texas at Arlington

With some foundations in our mesh generation and image registration methods made available during my doctoral study, a novel approach to build image altas is proposed. A brief introduction of the algorithm of our approach and 2D simulation are shown in the poster for demonstrating its effectiveness.