

Approximation, Integration, and Optimization *Poster Session Abstracts*

Approximation of non-smooth multivariate functions

Anat Amir, Tel Aviv University

Approximations of singular functions return poor results in the vicinities of singularities. Most prior works solve this problem for univariate functions. In this work we introduce a method for approximating singular multivariate functions of a specific type.

Sparse Recovery with Fusion Frames

Ulas Ayaz, Rheinische Frederich-Wilhelms Universität Bonn

We consider the problem of recovering fusion frame sparse signals from incomplete measurements. These signals are composed of a small number of nonzero blocks taken from a family of subspaces. We show that, by using a-priori knowledge of a coherence parameter associated with the angles between the subspaces, one can recover fusion frame sparse signals with a significantly reduced number of vector-valued (sub-)Gaussian measurements via mixed l_1/l_2 -minimization.

Pointwise optimal multivariate spline method for recovery of twice differentiable functions on a simplex

Sergiy Borodachov, Towson State University

Let T be a non-degenerate d -simplex whose every face (of any dimension) contains its circumcenter. Let $W(T)$ be the class of functions f that are continuously differentiable on T and have uniformly bounded second order derivatives in any direction. We construct an optimal algorithm on the class $W(T)$ (in the worst-case error sense) for recovery of the function value $f(x)$ at an arbitrary given point x in T based on the information given by the values and gradients of f at the vertices of T . The optimal method is a linear-bi-linear spline over a certain polygonal partition of T related to the Voronoi diagram of the vertices of T . The pointwise error $E(x)$ on the class $W(T)$ of the optimal method can be considered as a multivariate analogue of the classical Euler spline of order 2.

Active Subspaces for Dimension Reduction

Paul Constantine, Colorado School of Mines

The active subspace of a multivariate function is the span of a set of direction constructed such that perturbations in the inputs along these directions change the function more on average than perturbations along orthogonal directions. We define the active subspace, propose a method to discover it for a given function, and describe ways to exploit it for approximation, optimization, and integration.

Masking Schemes for Image Manifolds

Seyed Hamid Reza Dadkhahi, University of Massachusetts

We consider the problem of selecting an optimal mask for an image manifold, i.e., choosing a subset of the dimensions of the image space that preserves the manifold structure present in the original data. Such masking implements a form of compressed sensing that reduces power consumption in emerging imaging sensor platforms. Our goal is for the manifold learned from masked images to resemble the manifold learned from full images as closely as possible. We show that the process of finding the optimal masking pattern can be cast as a binary integer program, which is computationally expensive but can be approximated by a fast greedy algorithm. Numerical experiments show that the manifolds learned from masked images resemble those learned from full images for modest mask sizes. Furthermore, our greedy algorithm performs similarly to the exhaustive search from integer programming at a fraction of the computational cost.

Spatio-temporal sampling schemes in evolutionary systems

Jacqueline Davis, Vanderbilt University/ICERM

When an evolving signal is to be reconstructed from samples of it, can fine time sampling compensate for coarse spatial sampling? This poster explores this question and shows that the answer is "yes" - under appropriate hypotheses, it is possible to exactly reconstruct a signal from coarse spatial samples taken at many time levels.

Simultaneous/Hybrid beta-Encodings and Their Applications

Halyun Jeong, Courant Institute of Mathematical Sciences

Fractional base expansions have several distinctive features, especially the redundancy of encodings. This offers a robust A/D conversion scheme when the quantizer is imperfect. Recently, this redundancy of fractional base expansions is exploited further to give simultaneous/hybrid encodings. In this poster, we present a filter sequence for the scheme and its several applications.

Locating Salient Regions in Images from Adaptive Compressive Samples

Xingguo Li, University of Minnesota

Many application domains of current interest are characterized by notions of saliency or anomalous behavior, where a nominally small subset of data or regions of interest are deemed "interesting" based on their deviation from some typical behavior exhibited by the bulk of the data. In this sense, saliency may be interpreted as a natural extension of the notion of sparsity, but one that is intrinsic to the data itself. Here we describe our recent work that builds upon the conceptual connection between saliency and sparsity, leveraging and extending recent advances in compressive and adaptive sensing to develop provably effective "adaptive compressive saliency sensing" methods. Our particular focus here is on identifying

anomalous regions in images, using a model where salient image characteristics are described in terms of local deviations from an otherwise common low-dimensional model. We describe a simple two-step adaptive compressive sensing strategy for identifying anomalous regions under this model, and show that our method succeeds using far fewer samples than comparable methods that require either the image itself or use image reconstruction as an intermediate step. We demonstrate the empirical performance of our method experimentally using images from the Microsoft Salient Object Database.

TBA

Lan Jiang, Illinois Institute of Technology

Compressive Parameter Estimation with EMD

Dian Mo, University of Massachusetts

Parameter estimation from compressed signals with small earth mover's distance via K-median clustering.

Randomized Sketches of Convex Programs

Mert Pilanci, University of California, Berkeley

Random projection (RP) is a classical technique for reducing storage and computational costs. We analyze RP-based approximations of convex programs, in which the original optimization problem is approximated by the solution of a lower-dimensional problem. We prove that the approximation ratio of this procedure can be bounded in terms of the geometry of constraint set. For a broad class of random projections, including those based on various sub-Gaussian distributions as well as randomized Hadamard and Fourier transforms, the data matrix defining the cost function can be projected down to the statistical dimension of the tangent cone of the constraints at the original solution, which is often substantially smaller than the original dimension. We illustrate consequences of our theory for various cases, including unconstrained and L1-constrained least squares, support vector machines, low-rank matrix estimation.

Optimization of Modified Bessel Function's Approximation and Integration

Juri Rappoport, Institute for Computer Aided Design of the Russian Academy of Sciences

The optimal realization of the Lanczos Tau Method with minimal residue is proposed for the numerical solution of the second order differential equations with polynomial coefficients including modified Bessel functions of imaginary order. The approximating scheme of Tau method is optimized for the system of hypergeometric type differential equations including modified Bessel functions of complex order. The numerical quadratures

of trapezoidal kind with optimal choice of the step are elaborated for modified Bessel functions computation.

Fast Algorithms for Compressive Sensing with Structured Sparsity

Ludwig Schmidt, Massachusetts Institute of Technology

Compressive sensing is a method for recording a k -sparse signal $x \in \mathbb{R}^n$ with (possibly noisy) linear measurements of the form $y = Ax$, where the matrix $A \in \mathbb{R}^{m \times n}$ describes the measurement process. Seminal results in compressive sensing show that it is possible to recover the signal x from $m = O(k \log n/k)$ measurements and that this is tight. The model-based compressive sensing framework overcomes the lower bound and reduces the number of measurements to $m = O(k)$. This improvement is achieved by limiting the supports of x to a structured sparsity model, which is a subset of all $\binom{n}{k}$ possible k -sparse supports. This approach has led to measurement-efficient recovery schemes for a variety of signal models, including tree-sparsity and block-sparsity. While model-based compressive sensing succeeds in reducing the number of measurements, the framework entails a computationally expensive recovery process. In particular, existing recovery algorithms perform multiple projections into the structured sparsity model. For several sparsity models, the best known model-projection algorithms run in time $\Omega(n^k)$, which can be too slow for large n and k . Our work offers a way to overcome this obstacle by allowing the model-projection algorithms to be approximate. We illustrate our extension of the model-based compressive sensing framework with fast approximation algorithms for the tree-sparsity model. Our algorithms give the asymptotically fastest recovery scheme for the tree-sparsity model and run in nearly-linear time. Moreover, our algorithms are practical and show competitive performance on real data. Joint work with Chinmay Hegde and Piotr Indyk. Based on papers presented at SODA'14, ISIT'14, and ICALP'14.

High-Dimensional Change-Point Estimation: Combining Filtering with Convex Optimization

Yong Sheng Soh, California Institute of Technology

This work proposes an algorithm that is suitable for estimating change-points in sequences of high-dimensional signals. The proposed algorithm is based on ideas from signal filtering and convex optimization. The key approach to dealing with the dimensionality aspects is firstly to recognize that high-dimensional signals encountered in practice frequently possess an intrinsic low-complexity structure, and secondly exploit knowledge of the signal structure within the change-point estimation process

Recycled Linear Classifiers for Multiclass Classification

Akshay Soni, University of Minnesota

Many machine learning applications employ a multiclass classification stage that uses multiple binary linear classifiers as building blocks. Among these, commonly used strategies can require learning a large number of hyperplanes, even when the number of classes to be discriminated among is modest. When the data being classified is inherently high-dimensional, the storage and computational complexity associated with the application of multiple linear classifiers can ignite critical resource management issues. This work describes a multiclass classification method based on efficient use of a single "recycled" linear classifier (or ReLiC), which addresses these storage and implementation complexity issues. Preliminary experimental evaluation on a standard dataset demonstrates the potential utility of the approach.

Geometry and algorithm for complete dictionary recovery

Ju Sun, Columbia University

Provide geometric analysis and practical algorithms for recovering square, invertible sparsely used dictionary

High Dimensional Integration using polynomial detrending

Mu Tian, Tulane University/Stony Brook University

The poster will focus on, but not limited to the results of using polynomial detrending for high dimensional integration. Compressive sensing will be actively involved in our modeling. Interpolation problem will also be involved depending on our research progress.

Asymptotic recovery guarantees for clustering algorithms

Maria Soledad Villar, University of Texas at Austin

We prove asymptotic recovery guarantee for k-medians clustering for an arbitrary number of clusters which points are drawn from arbitrary rotationally symmetric and continuous probability distributions supported in disjoint balls that may be arbitrarily close.