香港中文大學55周年
55th ANNIVERSARY OF CUHK

CUHK SCI
香港中文大學理學院
FACULTY OF SCIENCE
THE CHINESE UNIVERSITY OF HONG KONG

DEPARTMENT OF MATHEMATICS
THE CHINESE UNIVERSITY OF HONG KONG

INTERNATIONAL CONFERENCE ON SCIENTIFIC COMPUTING

5-8 DECEMBER, 2018
▪ HONG KONG

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Introduction

Scientific computing is an important and very general interdisciplinary research field and plays a crucial role in many application areas, e.g., weather forecast, seismic predictions, fluid simulations, material industry, oil field exploration, medical imaging, etc.

Due to the complexity of these realistic applications, traditional scientific computing techniques are insufficient to meet the need, and there is much on-going research in the past decade in order to tackle the challenges. While there are many successful approaches in literature addressing the difficulties in developing efficient numerical methods for scientific computing, there are still numerous challenges and open problems.

This international conference aims to provide a forum for researchers from the world to present and exchange their latest research achievements on various directions in scientific computing, as well as their related applications. It also aims to promote collaborative research in scientific computing between China and the rest of the world. This conference will encourage international collaboration and interactive activities in scientific computing and provide an opportunity for young researchers to learn the current state of the art in the fields and present their recent research results as well.

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Sponsors

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Zhong-Zhi BAI	Chinese Academy of Sciences
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Shuqin ZHANG	Fudan University
Xiaoqun ZHANG	Shanghai Jiaotong University
Hongkai ZHAO	University of California, Irvine

Schedule Overview

Date / Venue / Time	Dec 5	Dec 6	Dec 7	Dec 8
	LT7, YIA	**LT7, YIA**	**LT7, YIA**	**LT4, YIA**
08:50-09:00	Opening			
Chair	Jun Zou	Michael Ng	Tieyong Zeng	Eric Chung
09:00-09:30	Olof Widlund	Nick Trefethen	Lothar Reichel	Xiao-Chuan Cai
09:30-10:00	Kwai Lam Wong	Wai-Ki Ching	Yimin Wei	Yifei Lou
10:00-10:30	Jin Yun Yuan	Haiwei Sun	Xiaoqing Jin	Suhua Wei
10:30-10:50	*Coffee Break*	*Coffee Break*	*Coffee Break*	*Coffee Break*
10:50-11:20	Hong Yan	Xue-Cheng Tai	Marc Van Barel	Daniel Potts
11:20-11:50	Zhong-Zhi Bai	Xiaoqun Zhang	Shuqin Zhang	Xavier Bresson
11:50-12:20	Zhengjian Bai	Rongjie Lai	Haixia Liu	Michael Hintermueller
12:20-12:30	*Lunch (by invitation)*	*Group Photo*	*Lunch (by invitation)*	Raymond Chan
12:30-14:00		*Lunch (by invitation)*		
Chair	Jianfeng Cai	Wai-Ki Ching	Ronald Lui	
14:00-14:30	Nicola Mastronardi	Andrew Wathen	Roland Glowinski	
14:30-15:00	Luigi Brugnano	Eric Chung	Ken Hayami	
15:00-15:30	Xiaojun Chen	Yat Tin Chow	Furong Lin	
15:30-15:50	*Coffee Break*	*Coffee Break*	*Coffee Break*	
15:50-16:20	Esmond G. Ng	Zuowei Shen	Peter P. T. Tang	
16:20-16:50	Wen Li	Hongkai Zhao	Alan W. K. Wong	
16:50-17:10	Min Tao	Thomas P. Y. Yu	Qiang Zhang	
17:10-17:40	Ke Chen	Guojian Yin	Alfred Ma	
18:00-18:30			*Banquet Reception*	
18:30-21:00			*Banquet (by invitation)*	

Schedule of Talks

December 5, 2018 (Wednesday)

Venue: LT7, Yasumoto International Academic Park (YIA)

8:50-8:55	Opening
8:55-9:00	Opening speech by Prof. Zuowei Xie, Dean, Faculty of Science
Chair	Jun Zou
9:00-9:30	Olof Widlund *Domain Decomposition Algorithms for IGA and Linear Elasticity*
9:30-10:00	Kwai Lam Wong *Research Projects in the RECSEM REU Program*
10:00-10:30	Jin-Yun Yuan *Complexity Bounds for Optimization*
10:30-10:50	Coffee Break
10:50-11:20	Hong Yan *Tensor Models for Real-time Human Facial Expression Recognition*
11:20-11:50	Zhong-Zhi Bai *Computing Eigenpairs of Hermitian Matrices in Perfect Krylov Subspaces*
11:50-12:20	Zhengjian Bai *A Riemannian Derivative-Free Polak-Ribiere-Polyak Method for Tangent Vector Field*
12:20-14:00	Lunch (by invitation)
Chair	Jianfeng Cai
14:00-14:30	Nicola Mastronardi *The QR Steps with perfect shifts*
14:30-15:00	Luigi Brugnano *Line Integral Methods for Conservative Problems*
15:00-15:30	Xiaojun Chen *Spherical designs and non-convex minimization for recovery of sparse signals on the sphere*
15:30-15:50	Coffee break
15:50-16:20	Esmond G. Ng *Some Recent Results on the Combinatorial Aspect of Sparse Matrix Computation*
16:20-16:50	Wen Li *Numerical Analysis on multilinear PageRank*
16:50-17:10	Min Tao *Decomposition Methods for Computing Directional Stationary Solutions of a Class of Nonsmooth Nonconvex Optimization Problems*
17:10-17:40	Ke Chen *On Two New Variational Models for Selective Image Segmentation*

December 6, 2018 (Thursday)

Venue: LT7, Yasumoto International Academic Park (YIA)

Chair	Michael Ng
9:00-9:30	Nick Trefethen *Laplace Equation in a Polygon*
9:30-10:00	Wai-Ki Ching *A Higher-order Interactive Hidden Markov Model and Its Applications*
10:00-10:30	Haiwei Sun *Exponential Quadrature Rule for Fractional Diffusion Equations*
10:30-10:50	Coffee Break
10:50-11:20	Xue-Cheng Tai *Convex shape priori with level set representation*
11:20-11:50	Xiaoqun Zhang *Image Reconstruction by Splitting Deep Learning Regularization from Iterative Inversion*
11:50-12:20	Rongjie Lai *Understanding manifold-structure data via geometric modeling and learning*
12:20-12:30	Group Photo
12:30-14:00	Lunch (by invitation)
Chair	Wai-Ki Ching
14:00-14:30	Andrew Wathen *Preconditioning for non-symmetric Toeplitz matrices and its use in a parallel-in-time solver for evolutionary PDEs*
14:30-15:00	Eric Chung *Model reduction using deep learning*
15:00-15:30	Yat Tin Chow *Direct sampling methods for coefficient determination inverse problems*
15:30-15:50	Coffee break
15:50-16:20	Zuowei Shen *Image Restoration and Beyond*
16:20-16:50	Hongkai Zhao *Intrinsic Complexity and its Scaling Law:* *From Approximation of Random Vectors to Random Fields*
16:50-17:10	Thomas P.Y. Yu *Conforming vs non-conforming methods for solving geometric variational problems*
17:10-17:40	Guojian Yin *A contour-integral based method for generalized non-Hermitian eigenvalue problems*

December 7, 2018 (Friday)

Venue: LT7, Yasumoto International Academic Park (YIA)

Chair	Tieyong Zeng
9:00-9:30	Lothar Reichel *Generalized Krylov subspace methods for l_p-l_q minimization with application to image restoration*
9:30-10:00	Yimin Wei *Statistical Condition Estimates and Randomized Algorithms for Large-Scale Total Least Squares Problems*
10:00-10:30	Xiaoqing Jin *A preconditioned Riemannian Gauss-Newton Method for Least Squares Inverse Eigenvalue Problem*
10:30-10:50	Coffee Break
10:50-11:20	Marc Van Barel *Biorthogonal Extended Krylov Subspace Methods*
11:20-11:50	Shuqin Zhang *Simultaneous clustering of multiview biomedical data using manifold optimization*
11:50-12:20	Haixia Liu *Scattering Transform and Sparse Linear Classifiers for Art Authentication*
12:20-14:00	Lunch (by invitation)
Chair	Ronald Lui
14:00-14:30	Roland Glowinski *On the Numerical Solution of Some Nonlinear Eigenvalue Problems for the Monge-Ampère Operator*
14:30-15:00	Ken Hayami *Cluster Gauss-Newton method for sampling multiple solutions of nonlinear least squares problems - with applications to pharmacokinetic models*
15:00-15:30	Furong Lin *On the accuracy and stability of CN-WSGD schemes*
15:30-15:50	Coffee break
15:50-16:20	Peter P.T. Tang *Sparse coding by spiking neural networks: Convergence theory and computational results*
16:20-16:50	Alan W.K. Wong *Central Moments, Stochastic Dominance, Moment Rule, and Diversification*
16:50-17:10	Qiang Zhang *A Theory for the growth Rates of Fingers in Richtmyer-Meshkov Instability*
17:10-17:40	Alfred Ma *Implementation Shortfall for Algorithmic Trading*
18:00-18:30	Banquet Reception (by invitation)
18:30-21:00	Banquet (by invitation)

December 8, 2018 (Saturday)

Venue: LT4, Yasumoto International Academic Park (YIA)

Chair	Eric Chung
9:00-9:30	Xiao-Chuan Cai *Nonlinear Preconditioning and Applications*
9:30-10:00	Yifei Lou *A scale-invariant L^1 approach for sparse signal recovery*
10:00-10:30	Suhua Wei *Regularization Approach for x-ray Image Reconstruction and Restoration*
10:30-10:50	Coffee Break
10:50-11:20	Daniel Potts *Sparse high-dimensional FFT based on rank-1 lattice sampling*
11:20-11:50	Xavier Bresson *Convolutional Neural Networks on Graphs*
11:50-12:20	Michael Hintermueller *Structural total variation regularization with applications in inverse problems*
12:20-12:30	Raymond Chan

Titles and Abstracts of Talks

A Riemannian Derivative-Free Polak-Ribiere-Polyak Method for Tangent Vector Field

Zhengjian Bai

Xiamen University

Abstract

In this talk, we consider the problem of finding a zero of a tangent vector field on Riemannian manifold. The problem is reformulated as an equivalent Riemannian optimization problem. Then a Riemannian derivative-free Polak-Ribiere-Polyak method combined with a nonmonotone line search is proposed to solve the optimization problem and the global convergence is established under some assumptions. Finally, some numerical tests are reported to show the practical effectiveness of our method.

Computing Eigenpairs of Hermitian Matrices in Perfect Krylov Subspaces

Zhong-Zhi Bai

Chinese Academy of Sciences

Abstract

For computing the smallest eigenvalue and the corresponding eigenvector of a Hermitian matrix, by introducing a concept of perfect Krylov subspace we propose a class of perfect Krylov subspace methods. For these methods, we prove their local, semilocal and global convergence properties, and discuss their inexact implementations and preconditioning strategies.

In addition, we use numerical experiments to demonstrate the convergence properties and exhibit the competitiveness of these methods with a few state-of-the art iteration methods when they are employed to solve large and sparse Hermitian eigenvalue problems.

Convolutional Neural Networks on Graphs

Xavier Bresson

Nanyang Technological University

Abstract

Convolutional neural networks have greatly improved state-of-the-art performances in computer vision and speech analysis tasks, due to its high ability to extract multiple levels of representations of data. In this talk, we are interested in generalizing convolutional neural networks from low-dimensional regular grids, where image, video and speech are represented, to high-dimensional irregular domains, such as social networks, telecommunication networks, or words' embedding. We present a formulation of convolutional neural networks on graphs in the context of spectral graph theory, which provides the necessary mathematical background and efficient numerical schemes to design fast localized convolutional filters on graphs. Numerical experiments demonstrate the ability of the system to learn local stationary features on graphs.

Line Integral Methods for Conservative Problems

Luigi Brugnano

Università degli Studi di Firenze

Abstract

(In collaboration with Felice Iavernaro)

The numerical solution of Conservative Problems, namely problems characterized by constants of motion, has been recently attached by imposing the vanishing of a (discrete) line integral. For this reason, the resulting methods have been collectively named *Line Integral Methods* [1]. In this talk the main facts concerning such methods will be recalled, with a major emphasis on *Hamiltonian Boundary Value Methods (HBVMs)*, a class of energy-conserving methods for Hamiltonian systems.

References

[1] L. Brugnano, F. Iavernaro. *Line Integral Methods for Conservative Problems*. Chapman et Hall/CRC, Boca Raton, FL, 2016.

Nonlinear Preconditioning and Applications

Xiao-Chuan Cai

University of Colorado Boulder

Abstract

The basic idea of nonlinear preconditioning is to introduce a built-in machinery for the inexact Newton algorithm to deal with the situations when the nonlinearities of the nonlinear functions in the system are "nonlinearly ill-conditioned" or unbalanced. In this talk we discuss some recent progress in the applications of nonlinear preconditioners for some difficulty problems arising in computational biomechanics including both fluid dynamics and solid mechanics.

On Two New Variational Models for Selective Image Segmentation

Ke Chen

The University of Liverpool

Abstract

Image segmentation is one important problem in mathematical imaging research and computer vision applications. As the fast-growing technologies of imaging generate increasingly higher precision images, demand for fast and accurate solution techniques is equally high.

This talk will first discuss some models in variational image segmentation. Then it will focus on more recent works done at our Liverpool group to design robust models for segmentation of images with weak contrast. Our work can be sued to help preparation of AI training data which is a crucial step in deep learning. The talk covers joint work with several colleagues inducing M. Roberts, L. Burrows, J. Spencer (Exeter) and J. M. Duan (Imperial).

Refs:

[1] J Spencer, Ke Chen and J M Duan (2018), ``Parameter-Free Selective Segmentation with Convex Variational Methods", to appear in IEEE Transactions on Image Processing.

[2] M Roberts, Ke Chen and K Irion (2018), ``A Convex Geodesic Selective Model for Image Segmentation", to appear in Journal of Mathematical Imaging and Vision.

Spherical designs and non-convex minimization for recovery of sparse signals on the sphere

Xiaojun Chen

The Hong Kong Polytechnic University

Abstract

This talk considers the use of spherical designs and non-convex minimization for recovery of sparse signals on the unit sphere $\mathbb{S}^2$. The available information consists of low order, potentially noisy, Fourier coefficients for $\mathbb{S}^2$. As Fourier coefficients are integrals of the product of a function and spherical harmonics, a good cubature rule is essential for the recovery. A spherical t-design is a set of points on $\mathbb{S}^2$, which are nodes of an equal weight cubature rule integrating exactly all spherical polynomials of degree $\leq$ t. We will show that a spherical t-design provides a sharp error bound for the approximation signals. Moreover, the resulting coefficient matrix has orthonormal rows. In general the L_1 minimization model for recovery of sparse signals on $\mathbb{S}^2$ using spherical harmonics has infinitely many minimizers, which means that most existing sufficient conditions for sparse recovery do not hold. To induce the sparsity, we replace the L_1-norm by the L_q-norm ($0<q<1$) in the basis pursuit denoising model. Recovery properties and optimality conditions are discussed. Moreover, we show that the penalty method with a starting point obtained from the re-weighted L_1 method is promising to solve the L_q basis pursuit denoising model. Numerical performance on nodes using spherical t-designs and t_ε-designs (extremal fundamental systems) are compared with tensor product nodes. We also compare the basis pursuit denoising problem with $q=1$ and $0<q<1$.

A Higher-order Interactive Hidden Markov Model and Its Applications

Wai-Ki Ching

The University of Hong Kong

Abstract

In this talk, we propose a higher-order Interactive Hidden Markov Model (IHMM), which incorporates both the feedback effects of observable states on hidden states and their mutual long-term dependence. The key idea of this model is to assume the probability laws governing both the observable and hidden states can be written as a pair of high-order stochastic difference equations. We also present an efficient procedure, a heuristic algorithm, to estimate the hidden states of the chain and the model parameters. Real applications in SSE Composite Index data and default data are given to demonstrate the effectiveness of our proposed model and corresponding estimation method.

Direct sampling methods for coefficient determination inverse problems

Yat Tin Chow

University of California, Riverside

Abstract

In this talk we will discuss Direct Sampling Methods (DSMs) for coefficient determinations in inverse problems when only one or two measurements are available. Direct sampling methods are a family of simple and efficient inversion methods which aim at providing a good estimate of the locations of inhomogeneities inside a homogeneous background representing various physical media with a single or a small number of boundary measurement events in both full and limited aperture cases. In each of the inverse problem concerned, e.g. electrical impedance tomography, diffusive optical tomography and the heat potential inverse problem, a family of probing functions is introduced and an indicator function is defined using a dual product between the observed data and the probing function under an appropriate choice of Sobolev scale. Numerical results have illustrated that the index function is effective in locating small abnormalities, and is cost-effective, computationally simple method and robust against noise.

This talk is based on joint works with Kazufumi (North Carolina State University), Keji Liu (Shanghai University of Finance and Economics) and Jun Zou (Chinese University of Hong Kong).

Model reduction using deep learning

Eric Chung

The Chinese University of Hong Kong

Abstract

In this talk, we present a deep-learning-based approach to a class of multiscale problems. For these problems, model reductions are necessary in order to solve them efficiently and accurately. The key ingredients of the methodology include multiscale basis functions and coarse-scale parameters, which are obtained from solving local problems in each coarse neighborhood. Given a fixed medium, these quantities are pre-computed by solving local problems in an offline stage, and result in a reduced-order model. However, these quantities have to be re-computed in case of varying media. The objective of our work is to make use of deep learning techniques to mimic the nonlinear relation between the multiscale inputs and the reduced models, and use neural networks to perform fast computation of coarse-scale parameters repeatedly for a class of media. We provide numerical experiments to investigate the predictive power of neural networks and the usefulness of the resultant multiscale model in solving channelized porous media flow problems.

On the Numerical Solution of Some Nonlinear Eigenvalue Problems for the Monge-Ampère Operator

Roland Glowinski

University of Houston

Abstract

The main goal of this lecture is to discuss the numerical solution of two families of ***nonlinear eigenvalue problem for the Monge-Ampère operator***. Namely, we are looking for pairs (u, λ), with $u \neq 0$, $\lambda > 0$, solutions of

(i) First family

$$\begin{cases} -\det \mathbf{D}^2 u = \lambda u \ \text{ in } \ \Omega, \\ u = 0 \ \text{ on } \ \partial\Omega, \end{cases} \tag{1}$$

(ii) Second family

$$\begin{cases} \det \mathbf{D}^2 u = \lambda u^2 \ \text{ in } \ \Omega, \\ u = 0 \ \text{ on } \ \partial\Omega. \end{cases} \tag{2}$$

In (1) and (2), Ω is a bounded convex domain of $\mathbf{R}^2$ and $\mathbf{D}^2 u (=: (\partial^2 u / \partial x_i \partial x_j)_{1 \le i, j \le 2})$ is the Hessian of function u. A particular attention will be given to convex solutions u, implying that $u \le 0$, necessarily.

Albeit quite different from each other, problems (1) and (2) are solvable by a methodology, reminiscent of the ***inverse power method*** from Numerical Linear Algebra. This methodology is a kind of generalization of the one developed in [1] for the solution of the elliptic ***Monge-Ampère-Dirichlet problem***

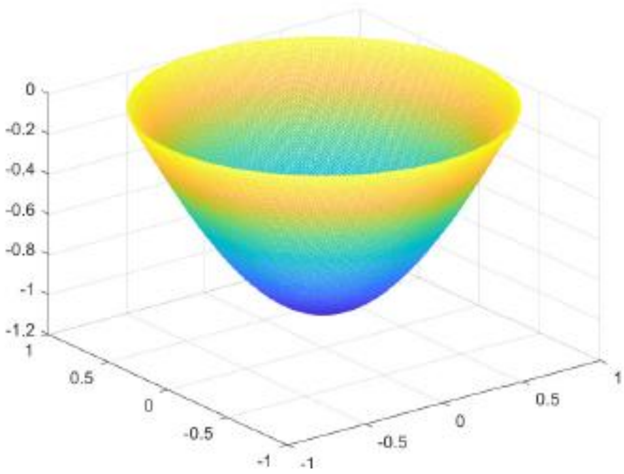
$$\begin{cases} \det \mathbf{D}^2 u = f\,(\ge 0) \ \text{ in } \ \Omega, \\ u = g \ \text{ on } \ \partial\Omega. \end{cases}$$

The solution method discussed in [1], being based on ***operator-splitting***, is modular and can easily accommodate (after an appropriate space discretization) a L^2-projection operator on nonlinear manifolds such as the unit sphere of $L^2(\Omega)$ for problem (1), and the unit sphere of $L^3(\Omega)$ for problem (2).

We will present the results of numerical experiments, for Ω a disk or a square. These results validate the solution method we will discuss.

Reference

[1] R. Glowinski, H. Liu, S. Leung, and J. Qian. A finite element/operator-splitting method for the numerical solution of the two-dimensional elliptic Monge-Ampère equation. *J. Sci. Comp.* (to appear).



Problem (1): Graph of a computed approximate eigenfunction when Ω is the unit disk centered at (0, 0) (h = 1/80). The minimal value of the computed eigenfunction is – 1.034…(should be – 1), and the related computed eigenvalue is 5.40...

This is a joint work with Hao Liu.

Cluster Gauss-Newton method for sampling multiple solutions of nonlinear least squares problems - with applications to pharmacokinetic models

Ken Hayami

Japan National Institute of Informatics

Abstract

Parameter estimation problems of mathematical models can often be formulated as nonlinear least squares problems. Typically, these problems are solved numerically using iterative methods. The solution obtained using these iterative methods usually depends on the choice of the initial iterate. Especially, when there is no unique minimum to the nonlinear least squares problem, the algorithm finds one of the solutions near the initial iterate. Hence, the estimated parameter and subsequent analyses using the estimated parameter depends on the choice of the initial iterate.

One way to reduce the analysis bias due to the choice of the initial iterate is to repeat the algorithm from multiple initial iterates. However, the procedure can be computationally intensive and is not often implemented in practice.

To overcome this problem, we propose the Cluster Gauss-Newton (CGN) method, an efficient algorithm for finding multiple solutions of nonlinear-least squares problems. The algorithm simultaneously solves the nonlinear least squares problem from multiple initial iterates. The algorithm iteratively improves the solutions from these initial iterates similarly to the Gauss-Newton method. However, it uses a global linear approximation instead of the gradient. The global linear approximations are computed collectively among all the initial iterates to minimize the computational cost and increase the robustness against convergence to local minima.

We use mathematical models used in pharmaceutical drug development to demonstrate its use and that the proposed algorithm is computationally more efficient and more robust against local minima compared to the Levenberg-Marquardt method.

This is joint work with Dr. Yasunori Aoki, Mr. Kota Toshimoto, and Professor Yuichi Sugiyama.

Structural total variation regularization with applications in inverse problems

Michael Hintermueller

Humboldt University of Berlin

Abstract

We introduce a function space setting for a wide class of structural/weighted total variation (TV) regularization methods motivated by their applications in inverse problems. In particular, we consider a regularizer that is the appropriate lower semi-continuous envelope (relaxation) of a suitable total variation type functional initially defined for sufficiently smooth functions. We study examples where this relaxation can be expressed explicitly, and we also provide refinements for weighted total variation for a wide range of weights. Since an integral characterization of the relaxation in function space is, in general, not always available, we show that, for a rather general linear inverse problems setting, instead of the classical Tikhonov regularization problem, one can equivalently solve a saddle-point problem where no a priori knowledge of an explicit formulation of the structural-TV functional is needed. In particular, motivated by concrete applications, we deduce corresponding results for linear inverse problems with norm and Poisson log-likelihood data discrepancy terms. Finally, we provide proof-of-concept numerical examples where we solve the saddle-point problem for weighted TV-denoising as well as for MR guided PET image reconstruction.

A preconditioned Riemannian Gauss-Newton Method for Least Squares Inverse Eigenvalue Problem

Xiaoqing Jin

University of Macau

Abstract

Given $l+1$ real symmetric matrices $A_{0,}\, A_{1,}\, \cdots\, A_l \in \mathbb{R}^{n\times n}$ and m real numbers $\lambda_1^* \le \lambda_2^* \le \cdots \le \lambda_m^* (m \le n)$, find a vector $\mathrm{c} = (c_1, \cdots c_n)^T \in \mathbb{R}^n$ and a permutation $\sigma = \{\sigma_1, \sigma_2, \cdots, \sigma_m\}$ with $1 \le \sigma_1 \le \sigma_2 \le \cdots \sigma_m \le n$ to minimize the function

$$f(c,\sigma) := \frac{1}{2}\sum_{i=1}^{m}\left(\lambda_{\sigma_i}(c) - \lambda_i^*\right)^2,$$

where the real numbers $\lambda_1(c) \le \lambda_2(c) \le \cdots \le \lambda_n(c)$ are the eigenvalues of the matrix $A(c)$ defined by

$$\mathrm{A}(c) := A_0 + \sum_{i=1}^{l} c_i A_i.$$

In this talk, we will use the Riemannian geometric method with a suitable preconditioner to solve above problem.

Understanding manifold-structure data via geometric modeling and learning

Rongjie Lai

Rensselaer Polytechnic Institute

Abstract

Analyzing and inferring the underlying global intrinsic structures of data from its local information are critical in many fields. In practice, coherent structures of data allow us to model data as low dimensional manifolds, represented as point clouds, in a possible high dimensional space. Different from image and signal processing which handle functions on flat domains with well-developed tools for processing and learning, manifold-structured data sets are far more challenging due to their complicated geometry. For example, the same geometric object can take very different coordinate representations due to the variety of embeddings, transformations or representations (imagine the same human body shape can have different poses as its nearly isometric embedding ambiguities). These ambiguities make higher-level tasks in manifold-structured data analysis and understanding even more challenging. To overcome these ambiguities, I will first discuss modeling based methods. This approach uses geometric PDEs to adapt the intrinsic manifolds structure of data and extracts various invariant descriptors to characterize and understand data through solutions of differential equations on manifolds. Inspired by recent developments of deep learning, I will also discuss our recent work of a new way of defining convolution on manifolds and demonstrate its potential to conduct geometric deep learning on manifolds. This geometric way of defining convolution provides a natural combination of modeling and learning on manifolds. It enables further applications of comparing, classifying and understanding manifold-structured data by combining with recent advances in deep learning.

Numerical Analysis on multilinear PageRank

Wen Li

South China Normal University

Abstract

In this talk, we discuss the multi-linear PageRank problem, which was first proposed in Gleich, Lim and Yu in 2015, and present some results on the uniqueness of the multilinear PageRank vector, error bounds for the inverse iteration and the perturbation bounds. The new results improve the existing ones. Several numerical examples are given to demonstrate the efficiency of the proposed bounds.

On the accuracy and stability of CN-WSGD schemes

Fu-Rong Lin

Shantou University

Abstract

A CN-WSGD scheme is a discretization scheme for the initial-boundary value problem for a space fractional diffusion equation. That is, the weighted and shifted Grünwald difference (WSGD) scheme is used to discretize the space fractional derivative and the Crank-Nicolson (CN) scheme is used to discretize the temporal derivative. There is a free parameter in a CN-WSGD scheme that affects the stability and the accuracy of the scheme. In general, a CN-WSGD scheme has temporally and spatially second-order accuracy, and there exists a scheme that has spatially third-order accuracy. However, the third-order accuracy scheme is not always stable. In this talk, we present and prove some theoretical results (old and new) on the stability of several CN-WSGD schemes with have been considered in literature, and consider choosing a value for the parameter such that the corresponding CN-WSGD scheme is unconditioned stable and has optimal accuracy. Numerical results are presented to verify the theoretical results.

Scattering Transform and Sparse Linear Classifiers for Art Authentication

Haixia Liu

Huazhong University of Science and Technology

Abstract

Art authentication is an important problem both in art history and art collection. Recently, the scattering transform was proposed as a signal-processing tool aimed at providing a theoretical understanding of deep neural networks and state-of-the-art performance in image classification. In this talk, we use a cascade of wavelet filters and nonlinear (modulus) operations to build translation-invariant and deformation-stable representations. Here we explore the performance of this tool for art authentication purposes. We analyze two databases of art objects (postimpressionist paintings and Renaissance drawings) with the goal of determining which of them were created by van Gogh and Raphael, respectively. Our results show that these tools provide excellent performance, superior to state-of-the-art results. Further, they suggest the benefits of using sparse classifiers in combination with deep networks.

A scale-invariant L1 approach for sparse signal recovery

Yifei Lou

University of Texas at Dallas

Abstract

In this paper, we study the ratio of L_1 and L_2, known as a scale invariant measure to promote sparsity. Due to the non-convexity and non-linearity, there has been little attention to this measure of sparsity. We present a weak null space property (wNSP) for L_1/L_2 and prove that under this wNSP condition any sparse vector is a local minimizer of the model. We also introduce several algorithms to minimize the cost function for recovering sparse signals in both constrained and unconstrained cases. Compared to the recent popular models such as L_p for $0<p<1$ and transformed L1 (TL_1), this model is parameter free. Experiments show that the proposed approach is comparable to the state-of-the-art methods.

Implementation Shortfall for Algorithmic Trading

Alfred Ma

CASH Algo Finance Group Limited

Abstract

Implementation shortfall (Perold, 1988) is defined as the profit and loss difference between paper and real portfolio. In Perold (1988), implementation shortfall is broken down into execution cost and opportunity cost, which are the cost of trading and not trading respectively. The implementation shortfall method of Perold (1988) is not directly applicable to algorithmic trading because the method has a rigid requirement on the time stamp of the trade records of the paper and real portfolio.

In this paper, we formulate a framework to measure implementation shortfall for algorithmic trading. We define the paper portfolio as the backtesting portfolio in algorithmic trading and propose a fast and efficient algorithm inspired by DNA sequence alignment to compute the implementation shortfall with a breakdown of execution cost and opportunity cost in the context of algorithmic trading.

The *QR* Steps with perfect shifts

Nicola Mastronardi

Consiglio Nazionale delle Ricerche Bari

Abstract

In this talk we revisit the problem of performing a *QR* step on an unreduced Hessenberg H matrix when we know an “exact” eigenvalue λ_0 of H. Under exact arithmetic, this eigenvalue will appear on the diagonal of the transformed Hessenberg matrix $\widetilde{H}$ and will be decoupled from the remaining part of the Hessenberg matrix, thus resulting in a deflation.

But it is well known that infinite precision arithmetic the so-called perfect shift can get blurred and that the eigenvalue λ_0 can then not be deflated and/or is perturbed significantly.

In this paper, we develop a new strategy for computing such a *QR* step so that the deflation is almost always successful. We also show how to extend this technique to double *QR* steps with complex conjugate shifts.

Some Recent Results on the Combinatorial Aspect of Sparse Matrix Computation

Esmond G. Ng

Lawrence Berkeley National Laboratory

Abstract

Combinatorial problems are abundant in sparse matrix computation. One such problem is permuting the rows and columns of a sparse matrix to minimize the cost of its factorization. There are different ways of defining the cost (or objective function) to be minimized. In this talk, we consider two common objective functions and ask the question of whether the minimization of each of the two will lead to the same result or not. We conclude with consideration of the practical implication of the result.

Sparse high-dimensional FFT based on rank-1 lattice sampling

Daniel Potts
Chemnitz University of Technology

Abstract

In this talk, we suggest approximate algorithms for the reconstruction of sparse high-dimensional trigonometric polynomials, where the support in frequency domain is unknown. Based on ideas of constructing rank-1 lattices component-by-component, we adaptively construct the index set of frequencies belonging to the non-zero Fourier coefficients in a dimension incremental way. When we restrict the search space in frequency domain to a full grid $[-N, N]^d \cap \mathbb{Z}^d$ of refinement $N \in \mathbb{N}$ and assume that the cardinality of the support of the trigonometric polynomial in frequency domain is bounded by the sparsity $s \in \mathbb{N}$, our method requires $\mathcal{O}(ds^2N)$ samples and $\mathcal{O}(ds^3 + ds^2\, N \log(s\, N))$ arithmetic operations in the case $\sqrt{N} \lesssim s \lesssim N^d$. We discuss an extension of Fourier approximation methods for multivariate functions defined on bounded domains to unbounded ones via a multivariate change of coordinate mapping.

Various numerical examples demonstrate the efficiency of the suggested method.

Joint work with: Robert Nasdala, Lutz Kämmerer, Toni Volkmer

References

[1] R. Nasdala and D. Potts. Transformed Rank-1 Lattices for high-dimensional approximation. arXiv:1805.09106, 2018.

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[3] D. Potts, and T. Volkmer. Sparse high-dimensional FFT based on rank-1 lattice sampling. Appl. Comput. Harm. Anal. 41, 713-748, 2016.

[4] L. Kämmerer, D. Potts, and T. Volkmer. Approximation of multivariate functions by trigonometric polynomials based on rank-1 lattice sampling. J. Complexity 31, 543-576, 2015.

Generalized Krylov subspace methods for l_p- l_q minimization with application to image restoration

Lothar Reichel

Kent State University

Abstract

This talk presents new efficient approaches for the solution of l_p- l_q minimization problems based on the application of successive orthogonal projections onto generalized Krylov subspaces of increasing dimension. The subspaces are generated according to the iteratively reweighted least-squares strategy for the approximation of l_p- and l_q-norms or quasi-norms by using weighted l_2-norms. Computed image restoration examples illustrate the performance of the methods discussed. The talk presents joint work with A. Buccini, G.-X. Huang, A. Lanza, S. Morigi, and F. Sgallari.

Image Restoration and Beyond

Zuowei Shen

National University of Singapore

Abstract

We are living in the era of big data. The discovery, interpretation and usage of the information, knowledge and resources hidden in all sorts of data to benefit human beings and to improve everyone¹s day to day life is a challenge to all of us. The huge amount of data we collect nowadays is so complicated, and yet what we expect from it is so much. This provides many challenges and opportunities to many fields. As images are one of the most useful and commonly used types of data, in this talk, we start from reviewing the development of the wavelet frame (or more general redundant system) based approach for image restoration. We will observe that a good system for any data, including images, should be capable of effectively capturing both global patterns and local features. One of the examples of such system is the wavelet frame. We will then show how models and algorithms of wavelet frame based image restoration are developed via the generic knowledge of images. Then, the specific information of a given image can be used to further improve the models and algorithms. Through this process, we shall reveal some insights and understandings of the wavelet frame based approach for image restoration and its connections to other approaches, e.g. the partial differential equation based methods. Finally, we will also show, with many examples, that ideas given here can go beyond image restoration and can be used in many other applications in data science.

Exponential Quadrature Rule for Fractional Diffusion Equations

Hai-wei Sun

University of Macau

Abstract

In this talk, we study the fractional diffusion equations. After spatial discretization to the fractional diffusion equation by the shifted Grunwald formula, it leads to a system of ordinary differential equations, where the resulting coefficient matrix possesses the Toeplitz-like structure. An exponential quadrature rule is employed to solve such a system of ordinary differential equations. The convergence by the proposed method is theoretically studied. In practical computation, the product of a Toeplitz-like matrix exponential and a vector is calculated by the shift-invert Arnoldi method. Meanwhile, the coefficient matrix satisfies a condition that guarantees the fast approximation by the shift-invert Arnoldi method. Numerical results are given to demonstrate the efficiency of the proposed method.

This is a joint work with Lu Zhang and Hong-kui Pang.

Convex shape priori with level set representation

Xue-Cheng Tai

Hong Kong Baptist University

Abstract

For many applications, we need to use techniques to represent convex shapes and objects. In this work, we use level set method to represent shapes and find a necessary and sufficient condition on the level set function to guarantee the convexity of the represented shapes. We take image segmentation as an example to apply our techniques. Efficient numerical algorithm is developed to solve the variational model.

In order to improve the performance of segmentation for complex images, we also incorporate landmarks into the model. One option is to specify points that the object boundary must contain. Another option is to specify points that the foreground (the object) and the background must contain. Numerical experiments on different images validate the efficiency of the proposed models and algorithms. We want to emphasis that the proposed technique could be used for general shape optimization with convex shapes. For other applications, the numerical algorithms need to be extended and modified.

This talk is based on joint works with S. Luo, S. Yan and J. Liu.

Sparse coding by spiking neural networks: Convergence theory and computational results

Peter P. T. Tang

Intel Corporation

Abstract

In a spiking neural network (SNN), individual neurons operate autonomously and only communicate with other neurons sparingly and asynchronously via spike signals. These characteristics render a massively parallel hardware implementation of SNN a potentially powerful computer, albeit a non von Neumann one. But can one guarantee that a SNN computer solves some important problems reliably? In this presentation, I formulate a mathematical model of one SNN that can be configured for a sparse coding problem for feature extraction. With a moderate but well-defined assumption, we prove that the SNN indeed solves sparse coding. To the best of our knowledge, this is the first rigorous result of this kind.

This work is done jointly with Intel colleagues Tsung-han Lin and Mike Davies.

Decomposition Methods for Computing Directional Stationary Solutions of a Class of Nonsmooth Nonconvex Optimization Problems

Min Tao

Nanjing University

Abstract

Motivated by block partitioned problems arising from group sparsity representation and generalized non-cooperative potential games, this paper presents a basic decomposition method for a broad class of multi-block nonsmooth optimization problems subject to coupled linear constraints on the variables that may additionally be individually constrained. The objective of such an optimization problem is given by the sum of two non-separable functions minus a sum of separable, pointwise maxima of finitely many convex differentiable functions. One of the former two non-separable functions is of the class LC^1, i.e., differentiable with a Lipschitz gradient, while the other summand is *multi-convex*. The subtraction of the separable, pointwise maxima of convex functions induces a partial Difference-of-Convex (DC) structure in the overall objective; yet with all three terms together, the objective is non-smooth and non-DC, but is *blockwise directionally differentiable*. By taking advantage of the (negative) pointwise maximum structure in the objective, the developed algorithm and its convergence result are aimed at the computation of a *blockwise directional stationary solution*, which arguably is the sharpest kind of stationary solutions for this class of nonsmooth problems. This aim is accomplished by combining the alternating direction method of multipliers (ADMM) with a semi-linearized Gauss-Seidel scheme, resulting in a decomposition of the overall problem into subproblems each involving the individual blocks. To arrive at a stationary solution of the desired kind, our algorithm solves multiple convex subprograms at each iteration, one per convex function in each pointwise maximum. In order to lessen the potential computational burden in each iteration, a probabilistic version of the algorithm is presented and its almost sure convergence is established.

Laplace Equation in a Polygon

Nick Trefethen

University of Oxford

Abstract

Consider the Laplace equation in a polygon with continuous Dirichlet boundary data. One could compute the solution u with finite elements, based on a two-dimensional representation of the solution, or integral equations, based on a one-dimensional representation. Here we propose a "zero-dimensional" representation: u is the real part of a rational function with poles exponentially clustering near each vertex. Thanks to an effect first identified by Donald Newman in 1964, the convergence is root-exponential as a function of the number of degrees of freedom, i.e. of the form $\exp\left(-C\sqrt{N}\right)$ with $C > 0$. In practice, with 40 lines of Matlab code, we can solve problems with 3-8 vertices in a second of laptop time, with 8-digit accuracy all the way up to the singularities in the corners. Evaluation of the solution takes around 20 microseconds per point. This is joint work with Abi Gopal.

Biorthogonal Extended Krylov Subspace Methods

Marc Van Barel

Department of Computer Science, KU Leuven

Abstract

Extended Krylov subspace methods generalize classical Krylov, since also products with the inverse of the matrix under consideration are allowed. Recent advances have shown how to efficiently construct an orthogonal basis for the extended subspace, as well as how to build the highly structured projected matrix, named an extended Hessenberg matrix. It was shown that this alternative can lead to faster convergence for particular applications.

In this talk biorthogonal extended Krylov subspace methods are considered for general nonsymmetric matrices. We will show that the data resulting from the oblique projection can be expressed as a nonsymmetric tridiagonal matrix-pair. This is a direct generalization of the classical biorthogonal Krylov subspace method where the projection becomes a single nonsymmetric tridiagonal matrix. To obtain this result we first need to revisit the classical extended Krylov subspace algorithm and prove that the projected matrix can be written efficiently as a structured matrix-pair, where the structure can take several forms, such as, e.g., Hessenberg or inverse Hessenberg. Based on the compact storage of a tridiagonal matrix-pair in the biorthogonal setting, we can develop short recurrences.

We will present several numerical experiments confirming the validity of the approach.

This is joint work with Niel Van Buggenhout and Raf Vandebril.

Preconditioning for non-symmetric Toeplitz matrices and its use in a parallel-in-time solver for evolutionary PDEs

Andrew Wathen

University of Oxford

Abstract

Gil Strang proposed the use of circulant matrices (and the FFT) for preconditioning symmetric Toeplitz (constant-diagonal) matrix systems in 1986 and largely due to the pioneering work of Raymond Chan there is now a well-developed theory which guarantees rapid convergence of the conjugate gradient method for such preconditioned positive definite symmetric systems.

In this talk we describe our recent approach which provides a preconditioned MINRES method with the same guarantees for real nonsymmetric Toeplitz systems regardless of the non-normality. These preconditioners have a particularly potent application as parallel-in-time preconditioners leading to fast parallel solvers for evolutionary PDEs as we will explain.

This is joint work with Jen Pestana, Elle McDonald, Sean Hon and Anthony Goddard.

Regularization Approach for x-ray Image Reconstruction and Restoration

Suhua Wei

Institute of Applied Physics and Computational Mathematics

Abstract

X-ray is an excellent tool to peer into the interior of an object. Image reconstruction means to inverse the object physical parameters using x-ray radiographs. The object image consists of edges and smooth parts and the obtained image contaminated by noise and blur is the transform of the object image. To establish mathematical model for image reconstruction, the regularization approach should consider both recovery of edges and smooth regions. Therefore, two regularization terms will be automatically combined together. Total Variation regularizer is for edges and high-order and fractional-order derivatives are for smooth regions. In this talk, image reconstruction and image restoration mathematical models and numerical algorithms will be given. Numerical tests will show the efficiency of the proposed methods.

Statistical Condition Estimates and Randomized Algorithms for Large-Scale Total Least Squares Problems

Yimin Wei

Fudan University

Abstract

Motivated by the recently popular probabilistic methods for low-rank approximations and randomized algorithms for the least squares problems, we develop randomized algorithms for the total least squares problem with a single right-hand side.

We present the Nyström method for the medium-sized problems. For the large-scale and ill-conditioned cases, we introduce the randomized truncated total least squares with the known or estimated rank as the regularization parameter. We analyze the accuracy of the algorithm randomized truncated total least squares and perform numerical experiments to demonstrate the efficiency of our randomized algorithms. The randomized algorithms can greatly reduce the computational time and still maintain good accuracy with very high probability.

Domain Decomposition Algorithms for IGA and Linear Elasticity

Olof B. Widlund

New York University

Abstract

BDDC and FETI-DP algorithms have proven to be very successful domain decomposition algorithms for solving elliptic finite element and isogeometric analysis problems. Previous work on using these algorithms for scalar elliptic IGA problems have now been extended to three-dimensional elasticity. A main issue in this work is an effort to limit the number of degrees of freedom for a coarse component of these preconditioners. Large scale numerical experiments have been successfully conducted using software developed using the PETSc software library and closely support the theory.

A first paper on compressible elasticity has appeared in Math. Mod. Meth. Appl.

Sci., 28(7), 1337-1370, 2018.

This work has recently been extended to the isogeometric Taylor-Hood elements developed by Bressan and Sangalli, IMA J. Numer. Anal., 33(2), 629--651, 2011. Our work has been greatly inspired by work by Tu and Li, SIAM J. Numer. Anal. 53(2), 720--742, 2015, on the incompressible Stokes problem, but has also required new analysis.

This is a joint work with Professor Luca F. Pavarino, Professor Simone Scacchi and Dr. Stefano Zampini.

Research Projects in the RECSEM REU Program

Kwai Lam Wong

University of Tennessee, Knoxville

Abstract

The Research Experiences in Computational Science, Engineering, and Mathematics (RECSEM) program is a Research Experiences for Undergraduates (REU) site program sponsored by the National Science Foundation (NSF). The RECSEM program complements the growing importance of computational sciences in many advanced degree programs and provides scientific understanding and discovery to undergraduates with an intellectual focus on research projects using high performance computing (HPC). This program aims to deliver a real-world research experience to the students by partnering with teams of scientists who are in the forefront of scientific computing research at the National Institutes of Computational Sciences (NICS), the Innovative Computing Laboratory (ICL), and the Joint Institute for Computational Sciences (JICS) at The University of Tennessee and Oak Ridge National Laboratory. The program directs a group of ten domestic students and ten international students supported by our partner universities in Hong Kong. Together, the students work hands-in-hands to complete their research tasks and share their academic and cultural experiences. Their research projects include software and algorithmic development of a variety engineering simulations, PDE solvers, neural network frameworks, and numerical linear algebra kernels. The students have the opportunity to perform their simulations on the supercomputers equipped with the latest hardware technologies provided by the Extreme Science and Engineering Discovery Environment (XSEDE) organization. In this talk, I will give an overview of the RECSEM program and highlight several on-going research efforts in the last two years.

Central Moments, Stochastic Dominance, Moment Rule, and Diversification

Alan W. K. Wong

Asia University

Abstract

In this paper, we develop some properties to state the relationships between the central moments and stochastic dominance for both the general utility functions and the polynomial utility functions. This leads to draw preferences of both risk averters and risk seekers on their choices of assets with different moments. In addition, we extend the mean-variance (mv) rule to get the moment rule which counts all moments in the decision. We apply the theory to portfolio diversification.

This is a joint research with Raymond H. Chan, Sheung-Chi Chow and Xu Guo.

* The authors would like to thank Wei-han Liu for his helpful comments. The fourth author would like to thank Robert B. Miller and Howard E. Thompson for their continuous guidance and encouragement. This research has been partially supported by grants from The Chinese University of Hong Kong, Hang Seng Management College, Asia University, Lingnan University, the Research Grants Council of Hong Kong (project numbers UGC/IDS14/15 and 12500915), China Postdoctoral Science Foundation (2017M610058), National Natural Science Foundation of China (11626130, 11601227) and Ministry of Science and Technology (MOST), R.O.C.

Tensor Models for Real-time Human Facial Expression Recognition

Hong Yan

City University of Hong Kong

Abstract

In this presentation, we introduce tensor-based models recently developed by our research group for real-time human face tracking and facial expression recognition. We consider a video segment as a third-order tensor and perform incremental singular value decomposition (SVD). The decomposition is updated gradually rather than computed from each segment directly, and this significantly improves the computational speed and makes it possible to implement the tracking process in real-time. The procedure learns a low-rank representation of the tensor. We integrate face tracking with facial expression recognition. Gabor wavelets are effective for recognition. However, there are too many features if we consider multiple scales and orientations of the wavelets. We have recently developed a co-clustering based method to solve this problem. In the co-clustering process, we can extract most discriminant features and eliminate irrelevant ones. Experiments on several video and image databases demonstrate that our system can recognize common facial expressions with high accuracy.

A contour-integral based method for generalized non-Hermitian eigenvalue problems

Guojian Yin

Sun Yat-sen University

Abstract

The contour-integral based eigensolvers are the recent efforts for computing the eigenvalues inside a given region in the complex plane. The best-known members are the Sakurai-Sugiura (SS) method, and the FEAST algorithm. An attractive computational advantage of these methods is that they are easily parallelizable. The FEAST algorithm was developed for the generalized Hermitian eigenvalue problems. It is stable and accurate. However, it may fail when applied to non-Hermitian problems.

In this talk, we will introduce a generalized FEAST algorithm, which aims to extend FEAST to the non-Hermitian problems. Our approach can be summarized as follows:

(i) construct a particular contour integral to form a search subspace containing the desired eigenspace, and

(ii) use the oblique projection technique to extract desired eigenpairs with appropriately chosen test subspace. In addition, in the talk, a contour-integral based method for counting the eigenvalues inside a given region will be introduced. Numerical experiments are reported to illustrate the numerical performance of our methods.

This is a joint work with Professor Raymond H. Chan and Professor Man-Chung Yeung.

Conforming vs non-conforming methods for solving geometric variational problems

Thomas P. Y. Yu

Drexel University

Abstract

Techniques developed in the geometric design community such as splines and subdivision methods are often considered by the FEM community to be difficult to use in scientific computing. This leads to the advocate of non-conforming finite-element methods in many numerical treatments of problems. In this talk, we consider the classical Willmore problem in geometric analysis and the related geometric variational problems for the modelling of biomembranes and Hawking mass in cosmology. At first glance, one may think that a non-conforming method – typically based on piecewise linear (PL) elements -- is simply less accurate than a conforming method based on higher-order elements.

We prove that a class of conforming methods, based on subdivision surface (SS) methods, would converge, while similar non-conforming methods, based on discrete curvature operators for PL surfaces, would fail. Despite the theoretical advantage, it is indeed the case that the SS methods are difficult to implement due to the need to control truncation errors in numerical integration throughout the optimization process. We shall discuss our attempt to handle this difficulty, and also our use of conformal parametrization techniques to resurrect convergence in the PL methods.

If time allows, we will discuss another geometric variational problem arising from the modelling of bilayer materials. In this problem, we propose a conforming (spline) methods that does not require numerical integration. Moreover, the resulted nonconvex optimization problem enjoys the structure of a sparse polynomial optimization problem (POP). Thanks to this connection, a number of convex relaxation techniques are available for solving these nonconvex problems.

Complexity Bounds for Optimization

Jinyun Yuan

Universidade Federal do Paraná, Curitiba

Abstract

We shall discuss the complexity bounds of optimization problems for the worst case in both unconstrained and constrained optimizations. Most interesting is that we give a general complexity bounds for p^{th} order approximation.

A Theory for the growth Rates of Fingers in Richtmyer-Meshkov Instability

Qiang Zhang

City University of Hong Kong

Abstract

Richtmyer-Meshkov instability in compressible fluids is a very complicated phenomenon. It is very difficult to provide accurate theoretical predictions for the growth rates of fingers at the unstable material interface between compressible fluids. This is due to the complication of the shock waves and the rarefaction wave presented in the compressible fluid systems and due to the nonlinearity of finger growth at late times. Numerical simulations have been the main tools for studying the finger growth in Richtmyer-Meshkov instability in compressible fluids.

In this talk, we present a new close-form approximate solution for the growth rate of fingers of Richtmyer-Meshkov instability in compressible fluids. Our theoretical approach is based on analyzing the solutions at early and late times and asymptotically matching these two solutions. Our theory contains no fitting parameters. Furthermore, our solution has no singularity for all physical parameters including all density ratios and all incident shock strength. We show that our theoretical predictions for the growth rates of fingers of Richtmyer-Meshkov instability in compressible fluids are in remarkably good agreements with the results from numerical simulations and with the data from experiments from early to late times. Even for a compressible fluid system with a Mach number of the incident shock being as high as 15.3, our theoretical predictions are still in an excellent agreement with the data from the numerical simulations. This work was supported by the Research Grants Council of HKSAR (project number CityU 11300117).

Simultaneous clustering of multiview biomedical data using manifold optimization

Shuqin Zhang

Fudan University

Abstract

Multiview clustering has attracted much attention in recent years. Several models and algorithms have been proposed for finding the clusters. However, these methods are developed either to find the consistent/common clusters across different views, or to identify the differential clusters among different views. In reality, both consistent and differential clusters may exist in multiview data sets. Thus, development of simultaneous clustering methods such that both the consistent and the differential clusters can be identified is of great importance.

In this work, we proposed one method for simultaneous clustering of multiview data based on manifold optimization. The binary optimization model for finding the clusters is relaxed to a real value optimization problem on the Stiefel manifold, which is solved by the line-search algorithm on manifold. We applied the proposed method to both simulation data and the real data sets. Both studies show that when the underlying clusters are consistent, our method performs competitive to the state-of-the-art algorithms. When there are differential clusters, our method performs much better.

Image Reconstruction by Splitting Deep Learning Regularization from Iterative Inversion

Xiaoqun Zhang

Shanghai Jiao Tong University

Abstract

Image reconstruction from downsampled and corrupted measurements, such as fast MRI and low dose CT, is a mathematically ill-posed inverse problem.

In this work, we propose a general and easy-to-use reconstruction method based on deep learning techniques. In order to address the intractable inversion of general inverse problems, we propose to train a network to refine intermediate images from classical reconstruction procedure to the ground truth, i.e. the intermediate images that satisfy the data consistence will be fed into some chosen denoising networks or generative networks for denoising and removing artifact in each iterative stage. The proposed approach involves only techniques of conventional image reconstruction and usual image representation/denoising deep network learning, without a specifically designed and complicated network structures for a certain physical forward operator. Extensive experiments on MRI reconstruction applied with both stack auto-encoder networks and generative adversarial nets demonstrate the efficiency and accuracy of the proposed method compared with other image reconstruction algorithms.

Intrinsic Complexity and its Scaling Law: From Approximation of Random Vectors to Random Fields

Hongkai Zhao

Department of Mathematics, University of California, Irvine

Abstract

We characterize the intrinsic complexity of a set in a metric space by the least dimension of a linear space that can approximate the set to a given tolerance. This is dual to the characterization using Kolmogorov n-width, the distance from the set to the best n-dimensional linear space. We study the approximation of random vectors (via principal component analysis a.k.a. singular value decomposition) and random fields (via Karhunen–Loève expansion). We provide lower bounds and upper bounds for the intrinsic complexity and its asymptotic scaling law.

Directions

A. Between Airport and Conference Hotel

Conference Hotel information

Hyatt Regency Hong Kong, Shatin (沙田凱悅酒店)

Address: 18 Chak Cheung Street, Sha Tin, New Territories, Hong Kong

(香港新界沙田澤祥街 18 號沙田凱悅酒店)

Telephone: (852) 3723 1234

Email: hongkong.shatin@hyatt.com

Website: https://www.hyatt.com/en-US/hotel/china/hyatt-regency-hong-kong-sha-tin/shahr/maps-parking-transportation

By Bus

(Not recommended for guests who have bulky luggage)

At the Airport Bus Terminus, take Airport Bus A41. Get off at Shatin Central Bus Terminus of a huge mall known as New Town Plaza in Sha Tin. However it is not the terminal stop for the bus, so ask the driver where to get off, or pay attention to the announcement, and press the red button on the rail when it is the next stop. The frequency is 20 minutes, and the journey takes 45-60 minutes depending on traffic conditions.
Alternatively, Airport Bus **E42** runs every 20 minutes, and it is a 75-minute trip, while Airport Bus **N42** is a 1½-hour night bus route and runs at 03:50 am and 04:50 am only.
At Shatin MTR Station, connected by:

- **Taxi**
  You can take a taxi to the hotel. The fare is about HK$70. It will take about 15 minutes.
- **MTR**
  Take the escalator in New Town Plaza, and board the MTR from Sha Tin to University. It is a 9-minute ride. The trains run every 5 to 10 minutes from 06:00 to 24:00. At University MTR Station, take Exit B. You may follow the map below to go to the hotel. The hotel is a three-minute walk from University MTR Station, next to the tall white Cheng Yu Tung building.

By Taxi

A taxi seats at most five. The 40-minute ride costs HKD 350-400 (USD 45-50) subject to traffic conditions. Both red and green taxis are available, the red ones being more expensive. Passengers may request a receipt of payment upon arrival. The address of Hyatt Regency Hong Kong, Shatin is **18 Chak Cheung Street, Shatin.**

*For your easy communication with taxi driver, you may show the following Chinese note card to the driver:

請送我到 **(Please drive me to):** 新界沙田澤祥街 **18** 號沙田凱悅酒店 **Hyatt Regency Hong Kong, Shatin** **18 Chak Cheung Street, Sha Tin, New Territories**

B. Between Conference Hotel and Conference Venue

It takes approximately 10 minutes to walk from Hyatt Regency Hong Kong Shatin to the conference venue Yasumoto International Academic Park (YIA).

Direction from Hyatt Regency Hong Kong, Shatin to Yasumoto International Academic Park (YIA)

A
Hyatt Regency Hong Kong, Shatin

B
University MTR Station

C
Yasumoto International Academic Park (YIA)

C. Between University Station and Conference Venue

It takes approximately 5 minutes to walk from University MTR Station (Exit A) to the conference venue Yasumoto International Academic Park (YIA).

Direction from University MTR Station (Exit A) to Yasumoto International Academic Park (YIA)

A
University MTR Station (Exit A)

B
Yasumoto International Academic Park (YIA)

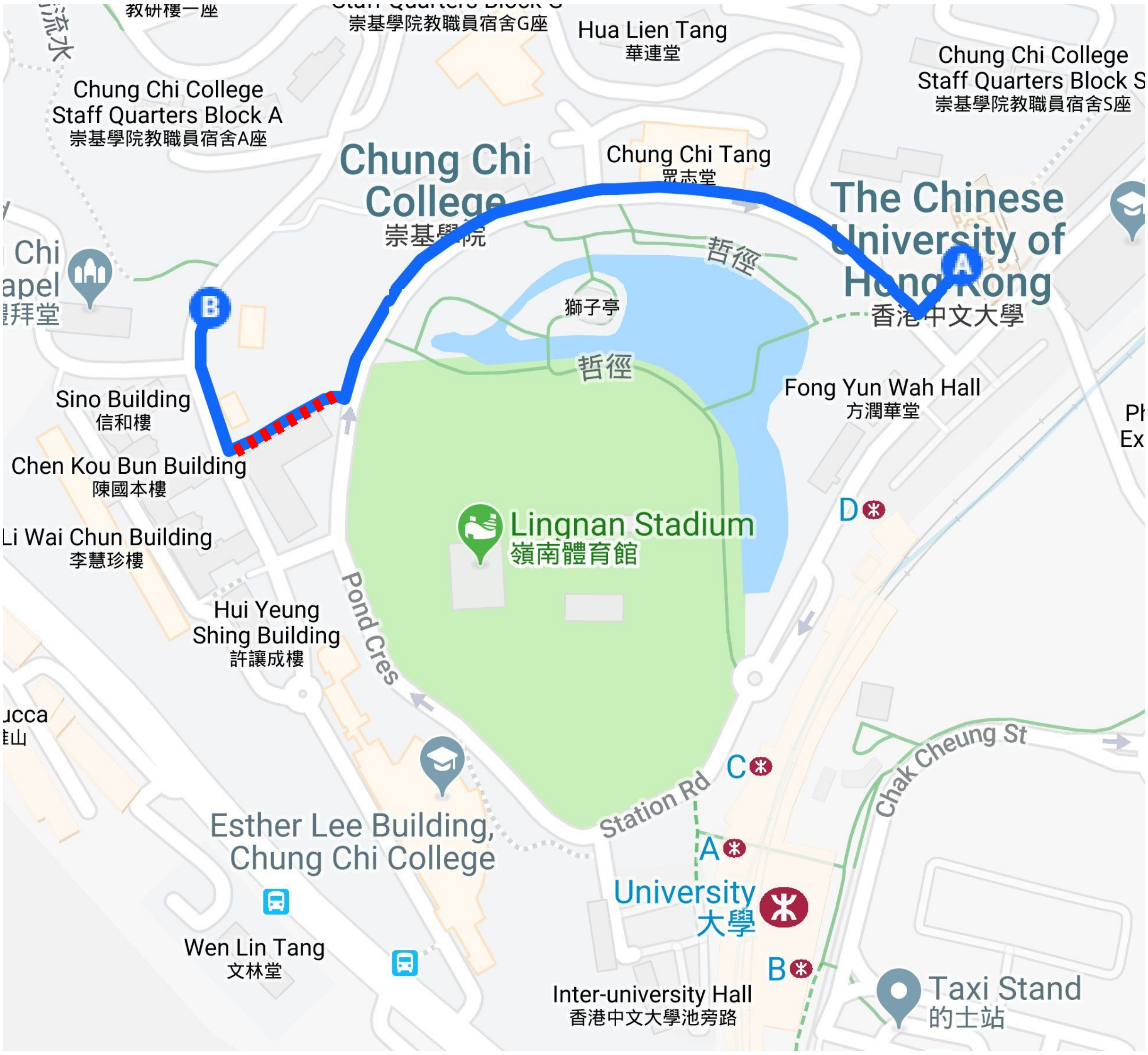
Lunch information (by invitation)

Venue: Chung Chi College Staff Club, The Chinese University of Hong Kong

Date: 5-7 December, 2018 (Wednesday - Friday)

Time: 12:20-14:00

It takes approximately 7 mins to walk from YIA to Staff Club



Direction from Yasumoto International Academic Park (YIA)
to Chung Chi College Staff Club Club

A Yasumoto International Academic Park (YIA)

B Chung Chi College Staff Club

Staircase

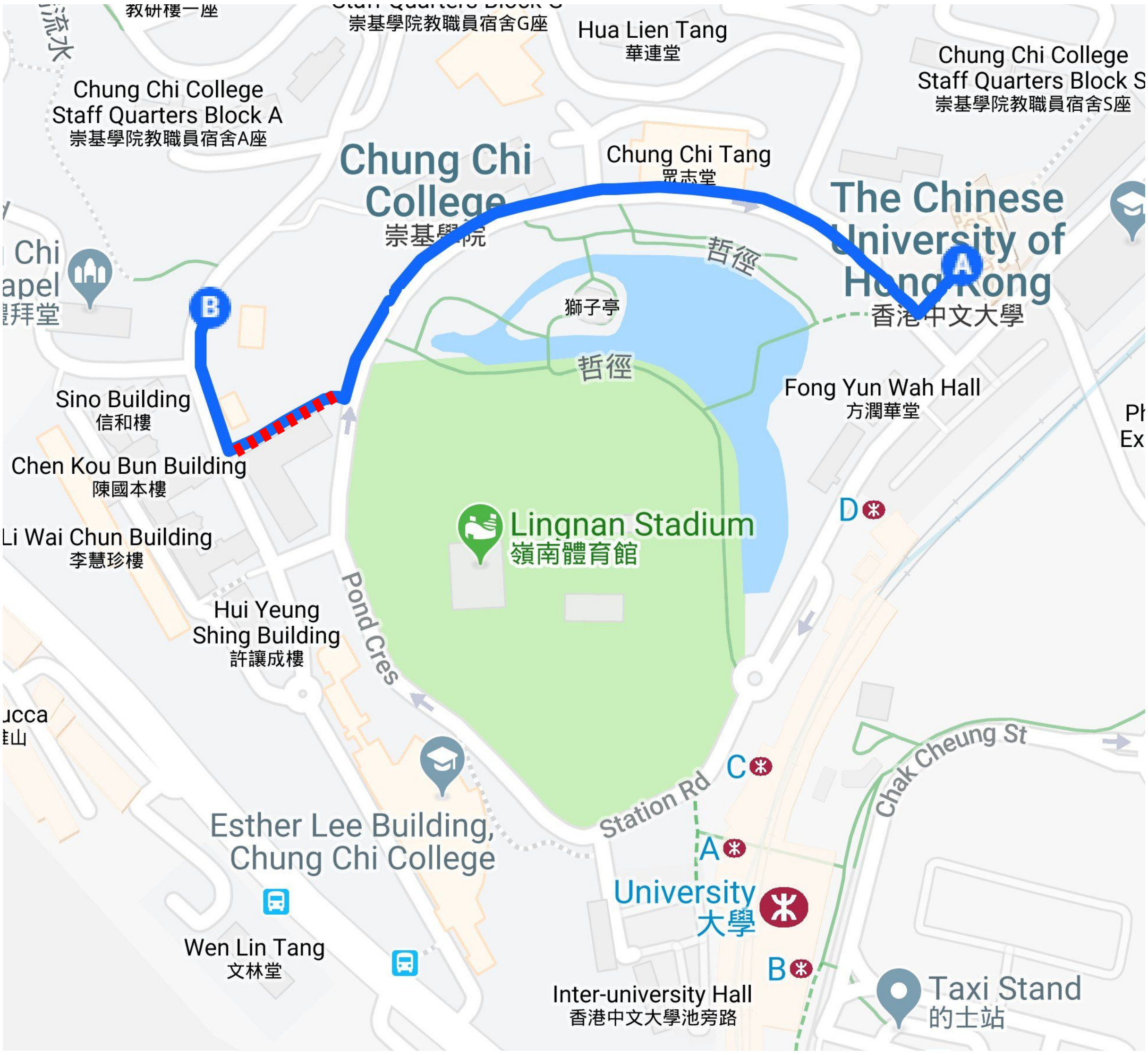
Banquet information (by invitation)

Venue: Chung Chi College Staff Club, The Chinese University of Hong Kong

Date: 7 December, 2018 (Friday)

Time: starts at 6:30pm (Reception from 6pm)

It takes approximately 7 minutes to walk from YIA to Staff Club.



Direction from Yasumoto International Academic Park (YIA)
to Chung Chi College Staff Club Club

- **A** Yasumoto International Academic Park (YIA)
- **B** Chung Chi College Staff Club
- ▪▪▪▪▪▪▪▪▪▪▪ Staircase

Useful Information

1. Wi-fi Account

Wi-fi SSID	CUguest
User ID	icsc2018@conference.cuhk.edu.hk
Password	icsc2018.pma

2. Contact Persons

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Ms. Pauline Chan: 3943 7988 (office)
Ms. Suki Chan: 3943 7989 (office)
Ms. Mabel Fan: 3943 5295 (office)

3. Travel Card

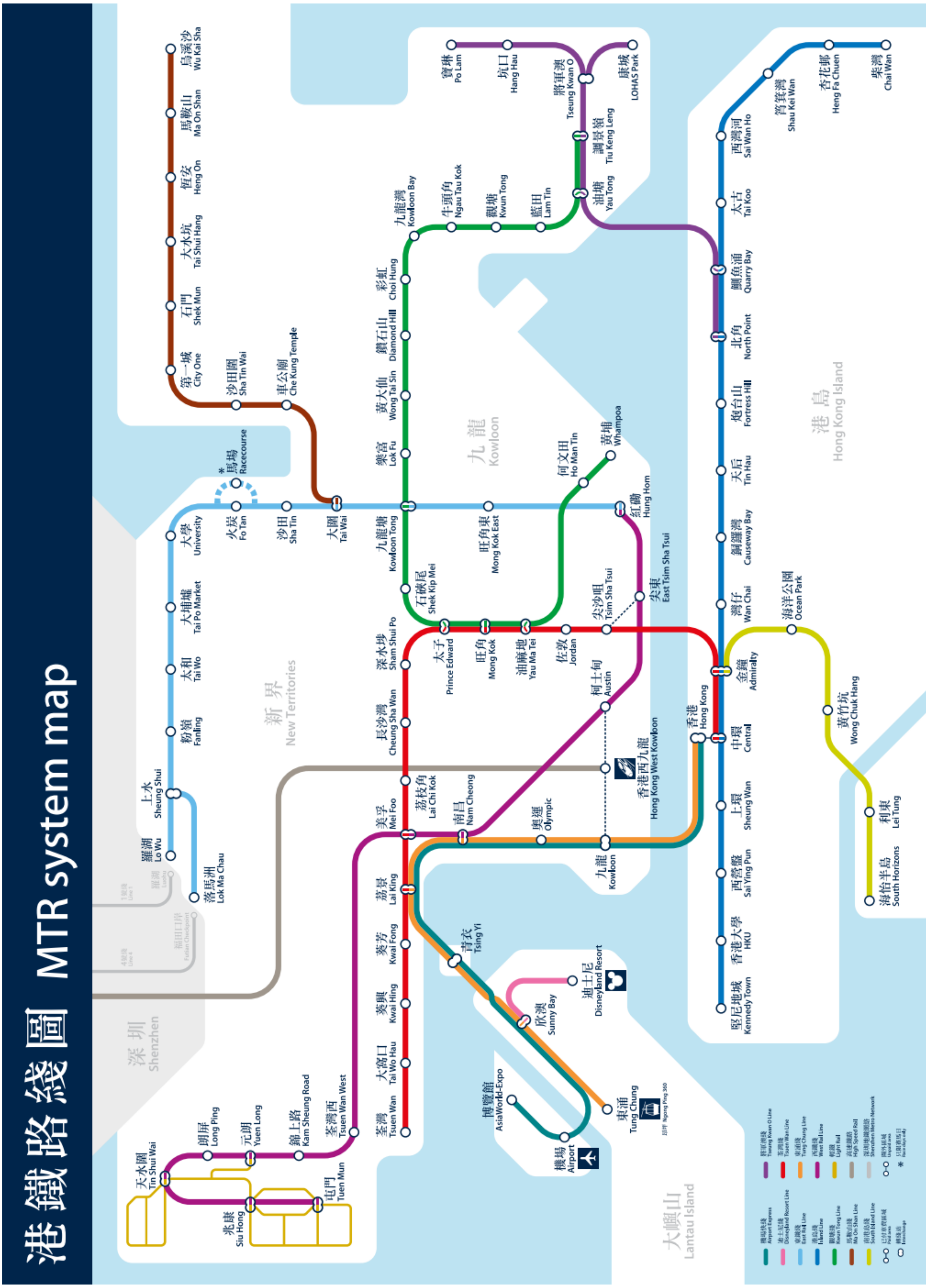
Octopus Card, an electronic fare card, is accepted by almost all forms of public transport and at many fast food chains and stores. It is convenient and eliminates the need for small change. Top up money to it whenever you need to, and any unspent value in On-Loan Octopus is refundable along with the HKD 50 deposit at any MTR Station. *minus HKD 9 handling fee for cards returned within three months.

For more details, please refer to:
http://www.octopus.com.hk/home/en/index.html

4. Emergency Numbers

For any kind of emergency, please contact the Security Unit.
Telephone: 3943 7999
Email: security_unit@cuhk.edu.hk

MTR System Map



To plan your journey, please use ‘train trip planner’:

http://www.mtr.com.hk/en/customer/main/index.html

Reference link: http://www.mtr.com.hk/archive/en/services/routemap.pdf

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