Contents

Introduction

Scientific computing is an active research field which has important applications to nearly every applied discipline such as engineering, physics, imaging, computer vision, computational biology, finance, and so on. Nowadays it has been well recognized as the third approach for doing science, complementing the other two traditional approaches, namely, theories and experiments. As the Pearl River Delta is developing into a high-tech industrial area, the need for scientific computing in Hong Kong will rise dramatically in the next decade. In this conference, top experts from all over the world will review recent developments and explore exciting new directions in the field. One of the aims of the conference is to promote scientific computing in Hong Kong by providing a forum for participants to exchange ideas and discuss their latest research achievements.

In Hong Kong, scientific computing has been developing rapidly in the last decade. Important researches are being carried out in different local institutions and Hong Kong has already received international reputation in the field. In particular, a world-renowned applied mathematician in Hong Kong, Prof Tony F. Chan, has made tremendous contributions to scientific computing throughout his career. Prof. Chan, the former Assistant Director of the US National Science Foundation and now the President of the Hong Kong University of Science and Technology, had collaborated with many researchers in Hong Kong in the past 25 years. For this reason, another aim of the conference is to honor Prof. Chan at his 60th birthday for his contributions to the field and to Hong Kong.

Scientific Committee

- Raymond Chan (Chair), *The Chinese University of Hong Kong*
- Shiu-Yuen Cheng, *The Hong Kong University of Science and Technology*
- Philippe G. Ciarlet, *City University of Hong Kong*
- Li-qun Qi, *The Hong Kong Polytechnic University*
- Zuowei Shen, *National University of Singapore*
- Zhong-ci Shi, *Chinese Academy of Sciences*
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- Centre for Mathematical Imaging and Vision, Hong Kong Baptist University
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- K. C. Wong Education Foundation
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- School of Engineering, The Hong Kong University of Science and Technology
- The Institute of Mathematical Sciences, The Chinese University of Hong Kong

Invited Speakers

- Xavier Bresson, *City University of Hong Kong*
- Emmanuel Candes, *Stanford University*
- Ke Chen, *Dalian University of Technology / University of Liverpool*
- Louis Chen, *National University of Singapore*
- Zhiming Chen, *Chinese Academy of Sciences*
- Philippe G. Ciarlet, *City University of Hong Kong*
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- Roland Glowinski, *University of Houston*
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- David Keyes, *Columbia University / King Abdullah University of Science and Technology*
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- Li-qun Qi, *The Hong Kong Polytechnic University*
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- Zhong-ci Shi, *Chinese Academy of Sciences*
- Stephen Smale, *City University of Hong Kong*
- Gilbert Strang, *Massachusetts Institute of Technology*
- Jiachang Sun, *Chinese Academy of Sciences*
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- Pingwen Zhang, *Peking University*
- Xiaoqun Zhang, *Shanghai Jiao Tong University*
- Hongkai Zhao, *Peking University / University of California, Irvine*
- Hao-min Zhou, *Georgia Institute of Technology*

Program-at-a-Glance

Time	**Jan 4 (Wed)**
Chair	**Raymond Chan**
09:00 - 09:30	Opening and Group Photo
09:30 - 10:00	Stanley Osher
10:00 - 10:30	Emmanuel Candes
10:30 - 10:50	Coffee break
Chair	**Gilbert Strang**
10:50 - 11:20	Björn Engquist
11:20 - 11:50	Eitan Tadmor
11:50 - 12:20	David Keyes
12:20 - 14:00	Lunch
Chair	**Weinan E**
14:00 - 14:30	Gilbert Strang
14:30 - 15:00	Stephen Smale
15:00 - 15:30	Philippe G. Ciarlet
15:30 - 15:50	Coffee break
Chair	**Björn Engquist**
15:50 - 16:20	Weinan E
16:20 - 16:50	Louis Chen
16:50 - 17:20	Zuowei Shen
17:20 - 17:50	Sung-Ha Kang

Time	**Jan 5 (Thu)**
Chair	**Jinchao Xu**
09:30 - 10:00	George Papanicolaou
10:00 - 10:30	Yousef Saad
10:30 - 10:50	Coffee break
Chair	**George Papanicolaou**
10:50 - 11:20	Thomas Y. Hou
11:20 - 11:50	Kaitai Li
11:50 - 12:20	Xiao-ping Wang
12:20 - 14:00	Lunch
Chair	**Thomas Y. Hou**
14:00 - 14:30	Roland Glowinski
14:30 - 15:00	Pingwen Zhang
15:00 - 15:30	Justin W.L. Wan
15:30 - 15:50	Coffee break
Chair	**Roland Glowinski**
15:50 - 16:20	Jinchao Xu
16:20 - 16:50	Xue-cheng Tai
16:50 - 17:20	Michael Ng
18:30 - 21:30	Dinner at Tony's house

Time	**Jan 6 (Fri)**
Chair	**Hongkai Zhao**
09:00 - 09:30	Zhong-ci Shi
09:30 - 10:00	Zhiming Chen
10:00 - 10:30	Tao Tang
10:30 - 10:50	Coffee break
Chair	**Tao Tang**
10:50 - 11:20	Jun-zhi Cui
11:20 - 11:50	Hongkai Zhao
11:50 - 12:20	Felipe Cucker
12:20 - 14:00	Lunch
Chair	**Felipe Cucker**
14:00 - 14:30	Qun Lin
14:30 - 15:00	Ya-xiang Yuan
15:00 - 15:30	Jenn-nan Wang
15:30 - 16:00	Ke Chen
16:00 - 16:20	Coffee break
Chair	**M. Ng & R. Lui**
16:20 - 16:40	W. Zhu & T. Zeng
16:40 - 17:00	T.W. Wong & Z.Q. Shao
17:00 - 17:20	R. Lai & E. Givelberg
17:20 - 17:40	M. Chan & T. Leung
19:00 - 19:30	Banquet Reception
19:30 - 22:30	Banquet

Time	**Jan 7 (Sat)**
Chair	**L. Qi & E. Chung**
09:00 - 09:30	Jiachang Sun
09:30 - 10:00	X. Zhang & A. Yip
10:00 - 10:30	X. Bresson & R. Lui
10:30 - 10:50	Coffee break
Chair	**Jun Zou**
10:50 - 11:20	Li-qun Qi
11:20 - 11:50	Hao-min Zhou
11:50 - 12:20	Shi Jin
12:20 - 12:30	Concluding Remarks
12:30 - 14:00	Lunch
14:00 - 18:30	Hong Kong Tour

Schedule

January 4, Wednesday

Venue:	**LT7, Lee Shau Kee Building, CUHK (Map on p. 50)**
Session Chair	**Raymond Chan**
09:00 - 09:30	Opening Ceremony and Photo Session
09:30 - 10:00	*Stanley Osher* Applications and Implications of Fast Methods for L1 Related Problems (P. 29)
10:00 - 10:30	*Emmanuel Candes* Exact Phase Retrieval via Convex Programming (P. 16)
10:30 - 10:50	Coffee break
Session Chair	**Gilbert Strang**
10:50 - 11:20	*Björn Engquist* Fast Algorithms for High Frequency Wave Propagation (P. 23)
11:20 - 11:50	*Eitan Tadmor* A New Model for Self-organized Dynamics: from Particle to Hydrodynamic Descriptions (P. 33)
11:50 - 12:20	*David Keyes* Missing Mathematics for Extreme-scale Simulation (P. 26)
12:20 - 14:00	Lunch
Session Chair	**Weinan E**
14:00 - 14:30	*Gilbert Strang* Balanced Splitting Methods / Infinite Matrices (P. 32)
14:30 - 15:00	*Stephen Smale* Mathematics of Immunology (P. 32)

15:00 - 15:30	*Philippe G. Ciarlet* Shell Theory - Some Recent Advances and Open Problems (P. 19)
15:30 - 15:50	Coffee break
Session Chair	**Björn Engquist**
15:50 - 16:20	*Weinan E* The Gentlest Ascent Dynamics (P. 23)
16:20 - 16:50	*Louis Chen* Multivariate Normal Approximation by Steins Method (P. 18)
16:50 - 17:20	*Zuowei Shen* MRA Based Wavelet Frame and Applications (P. 31)
17:20 - 17:50	*Sung-Ha Kang* Unsupervised Multiphase Segmentation and Extensions (P. 25)

18:10	Shuttle bus from conference venue at CUHK to Royal Park Hotel

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January 5, Thursday

Venue:	**Cheung On Tak Lecture Theater, LT-E, HKUST (Map on p. 51)**
Session Chair	**Jinchao Xu**
09:30 - 10:00	*George Papanicolaou* Mathematical Problems in Systemic Risk (P. 29)
10:00 - 10:30	*Yousef Saad* Linear Algebra Methods for Data Mining with Applications to Materials (P. 30)
10:30 - 10:50	Coffee break
Session Chair	**George Papanicolaou**
10:50 - 11:20	*Thomas Y. Hou* Sparse Time-frequency Representation of Multiscale Data by Nonlinear Optimization (P. 24)

11:20 - 11:50	*Kaitai Li* A Mathematical Modeling and Numerical Method for the Boundary Layer with Complex Boundary Geometry (P. 27)
11:50 - 12:20	*Xiao-ping Wang* Wetting and Contact Angle Hysteresis on Rough Surfaces (P. 36)
12:20 - 14:00	Lunch
Session Chair	**Thomas Y. Hou**
14:00 - 14:30	*Roland Glowinski* A Numerical Investigation of the Properties of the Nodal Lines of the Solutions of Linear and Nonlinear Eigenvalue Problems (P. 24)
14:30 - 15:00	*Pingwen Zhang* Non-local Behaviors of Interface between Ordered Structures (P. 38)
15:00 - 15:30	*Justin W.L. Wan* Numerical PDE Models and Methods with Applications in Finance and Image Processing (P. 35)
15:30 - 15:50	Coffee break
Session Chair	**Roland Glowinski**
15:50 - 16:20	*Jinchao Xu* Discretization and Precondition of High Order PDEs (P. 36)
16:20 - 16:50	*Xue-cheng Tai* Global Minimization for the Chan-Vese Model (P. 34)
16:50 - 17:20	*Michael Ng* Hub, Authority and Relevance Scores in Multi-Relational Data (P. 28)

Social Event

18:30 - 21:30	Dinner at Tony's house (President's Lodge, see p. 51 for map)
21:30	Shuttle bus from President's Lodge to Royal Park Hotel

January 6, Friday

Venue:	**LT7, Lee Shau Kee Building, CUHK**
Session Chair	**Hongkai Zhao**
09:00 - 09:30	*Zhong-ci Shi* Studies on Wilson Nonconforming Finite Element (P. 31)
09:30 - 10:00	*Zhiming Chen* An Anisotropic Perfectly Matched Layer Method for Three Dimensional Elastic Wave Scattering Problems (P. 18)
10:00 - 10:30	*Tao Tang* Adaptive Time Stepping and Energy Stable Schemes (P. 34)
10:30 - 10:50	Coffee break
Session Chair	**Tao Tang**
10:50 - 11:20	*Jun-zhi Cui* A New Atomic-continuum Model and A Recursively Adaptive Multi-scale Algorithm for Thermo-mechanical Behavior of Heterogeneous Materials (P. 21)
11:20 - 11:50	*Hongkai Zhao* Grid Based Particle Method for Moving Interface Problem (P. 39)
11:50 - 12:20	*Felipe Cucker* On a Problem Posed by Steve Smale (P. 20)
12:20 - 14:00	Lunch
Session Chair	**Felipe Cucker**
14:00 - 14:30	*Qun Lin* Lower Bound by Nonconforming FEMs (P. 27)
14:30 - 15:00	*Ya-xiang Yuan* Subspace Techniques for Nonlinear Optimization (P. 37)

15:00 - 15:30	*Jenn-nan Wang* Inverse Inclusion Problem: Reconstruction and Stability (P. 35)
15:30 - 16:00	*Ke Chen* Selective Variational Image Segmentation: Models and Algorithms (P. 17)
16:00 - 16:20	Coffee break

Contributed Talks

Venue:	**LT7, Lee Shau Kee Building, CUHK**	**LT3, Lee Shau Kee Building, CUHK**
Session Chair	**Michael Ng**	**Ronald Lui**
16:20 - 16:40	*Wei Zhu* Image Denoising Using Mean Curvature of Image Surface (P. 45)	*Tieyong Zeng* Sparsity-driven Multiplicative Noise Removal (P. 44)
16:40 - 17:00	*Tsz Wai Wong* Applications of Computational Quasiconformal Geometry on Medical Morphometry and Computer Graphics (P. 44)	*Zhi-Qiang Shao* Global Structure Stability of Riemann Solutions for Linearly Degenerate Hyperbolic Conservation Laws under Small BV Perturbations of the Initial Data (P. 43)
17:00 - 17:20	*Rongjie Lai* Intrinsic Surface Processing and Applications to 3D Medical Imaging (P. 42)	*Edward Givelberg* A Weak Formulation of the Immersed Boundary Method (P. 41)
17:20 - 17:40	*Michael K.H. Chan* Fluid Motion in a Triaxial Ellipsoidal Cavity Driven by Libration (P. 41)	*Tim Leung* A Fast Local Level Set Method for Inverse Gravimetry (P.42)

18:00	Shuttle bus from conference venue at CUHK to Royal Park Hotel

Social Event

18:50	Shuttle bus from Royal Park Hotel to Regal Riverside Hotel
19:00 - 19:30	Banquet Reception at Regal Riverside Hotel
19:30 - 22:30	Banquet at Regal Riverside Hotel
22:30	Shuttle bus from Regal Riverside Hotel to Royal Park Hotel

January 7, Saturday

Venue:	**LT7, Lee Shau Kee Building, CUHK**
Session Chair	**Li-qun Qi**
09:00 - 09:30	*Jiachang Sun* On Pre-transformed Methods for PDE Eigen-problems (P. 33)

Venue:	**LT7, Lee Shau Kee Building, CUHK**	**LT3, Lee Shau Kee Building, CUHK**
Session Chair	**Li-qun Qi**	**Eric Chung**
09:30 - 10:00	*Xiaoqun Zhang* Sources Reconstruction for 3D Bioluminescence Tomography with Sparse Regularization (P. 38)	*Andy Yip* A Fast Algorithm for Additive Image Segmentation (P. 37)
10:00 - 10:30	*Xavier Bresson* Completely Convex Formulation of the Chan-Vese Image Segmentation Model (P. 16)	*Ronald Lui* Medical Morphometry and Computer Visions Using Quasi-conformal Teichmuller Theory (P. 28)
10:30 - 10:50	Coffee break	

Venue:	**LT7, Lee Shau Kee Building, CUHK**
Session Chair	**Jun Zou**
10:50 - 11:20	*Li-qun Qi* Spectral Theory of Higher Order Tensors (P. 30)
11:20 - 11:50	*Hao-min Zhou* A Fast Algorithm for the Shortest Path Based on Initial Value ODES and Intermittent Diffusion (P. 39)
11:50 - 12:20	*Shi Jin* New Multiscale Surface Hopping Method for the Schrödinger Equation with Conical Crossings (P. 25)
12:20 - 12:30	Concluding remarks
12:30 - 14:00	Lunch

Social Event

14:00 - 18:30	Tour (Bus leaves at 14:00 at CUHK and stops at Royal Park Hotel at 14:15 before the tour. Tour ends at 18:30 at 1881 Heritage shopping mall)

Titles and Abstracts

Invited Talks

Completely Convex Formulation of the Chan-Vese Image Segmentation Model

Xavier Bresson
Department of Computer Science
City University of Hong Kong
xbresson@cityu.edu.hk

Abstract

The active contours without edges model of Chan and Vese is a popular method for computing the segmentation of an image into two phases. The minimization problem is non-convex even when the optimal region constants are known a priori. In [Chan-Esedoglu-Nikolova 2006], authors provided a method to compute global minimizers by showing that solutions could be obtained from a convex relaxation. In this talk, we propose a convex relaxation approach to solve the case in which both the segmentation and the optimal constants are unknown for two phases and multiple phases. In other words, we propose a convex relaxation of the popular K-means algorithm. Although the proposed relaxation technique is not guaranteed to find exact global minimizers of the original problem, our experiments show that our method computes tight approximations of the optimal solutions.

Exact Phase Retrieval via Convex Programming

Emmanuel Candes
Department of Mathematics
Stanford University
candes@stanford.edu

Abstract

This talk introduces a novel framework for phase retrieval, a problem which arises in X-ray crystallography, diffraction imaging, astronomical imaging and many other applications. Our approach combines multiple structured illuminations together with ideas from convex programming to recover the phase from intensity measurements, typically from the modulus of the diffracted wave. We demonstrate empirically that any complex-valued object can be recovered from the knowledge of the magnitude of just a few diffracted patterns by solving a simple convex optimization problem inspired by the recent literature on matrix completion. More importantly, we also demonstrate that our noise-aware algorithms are stable in the sense that the reconstruction degrades gracefully as the signal-to-noise ratio decreases. Finally, we present some novel theory showing that our entire approach may be provably surprisingly effective.

Selective Variational Image Segmentation: Models and Algorithms

Ke Chen
Department of Mathematical Sciences
Dalian University of Technology / University of Liverpool
K.Chen@liv.ac.uk

Abstract

Image segmentation is an important processing task in a number of real life applications. Although edge based models have been in wide use for much longer time, region based models offer more robust methods for many challenging problems. Following the seminal works of Osher-Sethian (1988), Mumford-Shah (1989) and Chan-Vese (2001), more and more image segmentation models are proposed, refined and tested. However almost all these models aim to identify all edges and features in an image and such global models may not be needed in some applications where extraction of an particular feature is intended.

In this talk, I present some new work on local and selective segmentation models and algorithms which have applications in medical imaging. First I review fast algorithms for solving the familiar segmentation models in two and three dimensions. Then I discuss selective segmentation and refined models in 2D where pre-defined geometric constraints guide local segmentation in the spirit of Chan-Vese.

Finally I present two generalized models and algorithms in 3D and some numerical experiments to demonstrate the robustness of our new models and algorithms.

Collaborators related to this work include
Noor Badshah (Peshawar, Pakistan), Jian-ping Zhang and Bo Yu (Dalian, China), Lavdie Rada (Liverpool).

Multivariate Normal Approximation by Steins Method

Louis Chen
Department of Mathematics
National University of Singapore
matchyl@nus.edu.sg

Abstract

In this talk I will explain Steins ideas for normal approximation, the concentration inequality approach and generalizations to the multivariate normal approximation.

An Anisotropic Perfectly Matched Layer Method for Three Dimensional Elastic Wave Scattering Problems

Zhiming Chen
Institute of Computational Mathematics
Chinese Academy of Sciences
zmchen@lsec.cc.ac.cn

Abstract

We propose an anisotropic perfectly matched layer (PML) method for solving the time harmonic elastic wave scattering problem in which the PML coordinate stretching is performed only in one direction outside the cuboid domain.

The PML parameters such as the thickness of the layer and the fictitious medium property are determined through sharp a posteriori error estimates. The adaptive finite element method based on a posteriori error estimate is proposed to solve the PML equation which produces automatically a coarse mesh size away from the fixed domain and thus makes the total computational costs insensitive to the thickness of the PML absorbing layer. Numerical experiments are included. This talk is based on a joint work with Xiaohui Zhang.

Shell Theory - Some Recent Advances and Open Problems

Philippe G. Ciarlet
Department of Mathematics
City University of Hong Kong
mapgc@cityu.edu.hk

Abstract

Intrinsic methods in elasticity have been introduced in a landmark series of papers by Wei-Zhang Chien in 1944. During the last two decades, Professor Wojciech Pietraszkiewicz and his group have achieved major advances in their analysis from the mechanical and engineering viewpoints, as well as in their actual numerical implementation.

However, it was only in 2005 that their mathematical analysis began to be carried out in earnest, first for three-dimensional elasticity and more recently for elastic shells, by the author and his group.

This presentation, which is intended for a general audience, will briefly review and discuss various problems as yet unresolved when this approach is applied to shell structures.

In the classical approach, the main mathematical challenge is to establish that the associated energy has a minimizer. In the linear case, this is achieved through a "Korn inequality on a surface", which guarantees the positive-definiteness of the associated energy. In the nonlinear case, the problem remains basically open for Koiter's model, which is one of the most commonly used nonlinear models in numerical simulations.

In the intrinsic approach, the main challenges lie not only in the mathematical analysis, but in effect in the modeling itself. Since the new unknowns are the change of metric and change of curvature tensor fields (instead of the displacement field in the classical approach), the Gauss and Codazzi-Mainardi compatibility equations conditions (or other equivalent equations) must be satisfied by these new unknowns, in order that they indeed correspond to a displacement of the middle surface of the shell. Another challenge is to adequately express boundary conditions in terms of these new unknowns.

We will briefly review the existence theorems that has been recently obtained in the linear case. Besides, we will give in particular an explicit form of the compatibility conditions, as well as an explicit "Cesaro-Volterra integral formula on a surface" for reconstructing a displacement field from the knowledge of these new unknowns.

On a Problem Posed by Steve Smale

Felipe Cucker
Department of Mathematics
City University of Hong Kong
macucker@math.cityu.edu.hk

Abstract

The 17th of the problems proposed by Steve Smale for the 21st century asks for the existence of a deterministic algorithm computing an approximate solution of a system of n complex polynomials in n unknowns in time polynomial, on the average, in the size N of the input system. In this talk we summarize the advances made as of today in this problem.

A New Atomic-continuum Model and A Recursively Adaptive Multi-scale Algorithm for Thermo-mechanical Behavior of Heterogeneous Materials

Jun-zhi Cui
Academy of Mathematics and System Sciences
Chinese Academy of Sciences
cjz@lsec.cc.ac.cn

Abstract

It is well known that performances of materials are determined by atoms and various level micro-structures composed by them. The behaviors of materials and structures in scales larger than micrometer is described by macro-continuum model, while in nano-scales, the behaviors are described by atomistic models. Till now there is no model suitable in nano-micro-scale range, which is acknowledged effectiveness. In this paper, a new atomic-continuum model and a recursively adaptive multi-scale algorithm for thermo-mechanical behavior of materials is systematically presented [2].

First, an atomistic-continuum coupled model for thermo-mechanics behavior of materials in micro-nano scale range is discussed. The atomic motion is decomposed into "structure deformations" and "thermal vibrations". For "structure deformations", the non-local stress-strain relationship in nano-micro scales is defined by means of the representative volume element containing a cluster of atoms, and the conception of deformation environment [1] as well. The energy transportation rate and free energy of inhomogeneous atom cluster are obtained. Then the free energy density is analysized by the deformation environment function in the extended representative volume element, the entropy density and internal energy density as well. And then the atomic-continuum equations are constructed based on momentum conservation and energy conservation. The non-locality of atomistic interactions is built into the thermo-mechanical constitutive equations. As the deformation of atomic lattice is homogeneous, the model naturally leads to Cauchy-Born model, and the high order strain gradient models can be also obtained by some high order deformation approximation. The expressions corresponding to macro thermo-mechanical constitutive parameters are also given.

Second, a recursively adaptive multi-scale algorithm for thermo-mechanics computation, which couples macro continuum model, the atomic-continuum model and MD model, is developed. In the algorithm, the structure is adaptively decomposed into three regions inserted one by one. The largest is corresponding to whole structure with macro continuum model, the smaller is with the atomic-continuum model, and the smallest is in strongly nonlinear deformation with MD model. The overall flowchart of the algorithm is of recursion. The coupling between coarse scale model and fine scale model is somewhat like the predictor-corrector algorithm. Coarse scale algorithm acts as a predictor and fine scale algorithm as a corrector. Constructing thermal and mechanical boundary condition and initial conditions for MD is a main difficulty. An approaches on prescribing the boundary and initial conditions are developed.

This work is supported by the National Basic Research Program of China (973 Program 2010CB832702), the National Natural Science Foundation of China (90916027), and also supported by the State Key Laboratory of Science and Engineering Computing.

This is a joint work with M.Z. Xiang and B.W. Li.

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[3] M. Xiang, J. Cui, X. Tian, *A nonlocal continuum model based on atomistic model at zero temperature*, in: IOP Conference Series: Materials Science and Engineering, Vol. 10, IOP Publishing, 2010, p. 012070.

The Gentlest Ascent Dynamics

Weinan E
Department of Mathematics and PACM
Peking University / Princeton University
weinan@math.princeton.edu

Abstract

The gentlest ascent dynamics (GAD) is a simple modification of the steepest decent dynamics that can be used to (1) find saddle points of functions; (2) explore high dimensional state space; (3) study rare transition events between metastable states of a random dynamical system; (4) study subcritical instabilities and (5) provide candidates for global minimization.

I will discuss the different variants of the gentlest ascent dynamics, their mathematical properties and various applications.

This is a joint work with Jianfeng Lu, Amit Samanta and Xiang Zhou.

Fast Algorithms for High Frequency Wave Propagation

Björn Engquist
Department of Mathematics
The University of Texas at Austin
engquist@math.utexas.edu

Abstract

Direct numerical simulation of high frequency wave propagation typically requires a very large number of unknowns. We will consider fast algorithms for iterative methods applied to frequency domain equations. For integral formulations we present a fast multipole method based on directional decomposition with near optimal order of complexity. For variable coefficient Helmholtz differential equations we develop new preconditioners based on sweeping processes. Hierarchical matrix techniques for compression or moving perfectly matched layers play important roles in the algorithms. Also here the number of operations scales essentially linearly in the number of unknowns.

A Numerical Investigation of the Properties of the Nodal Lines of the Solutions of Linear and Nonlinear Eigenvalue Problems

Roland Glowinski
Department of Mathematics
University of Houston
roland@math.uh.edu

Abstract

The properties of the nodal lines (*) of the solutions of linear and nonlinear eigenvalue problems for elliptic operator have been investigated by analysts and differential geometers. Are of interest in particular the way the nodal lines intersect and reconnect to the boundary (if there is one), and how geometrical symmetries affect these properties. The main goal of this presentation is to investigate computationally the above mentioned properties, via the numerical solution of linear and nonlinear eigenvalue problems for the Laplace operator in bounded domain of $\mathbb{R}^2$, and the Laplace-Beltrami operator for bounded surfaces of $\mathbb{R}^3$ such as torus and other surfaces with and without symmetries.

(*) That is the lines where the solution changes sign.

Sparse Time-frequency Representation of Multiscale Data by Nonlinear Optimization

Thomas Y. Hou
Applied and Computional Mathematics
California Institute of Technology
hou@cms.caltech.edu

Abstract

We introduce a data-driven time-frequency analysis method for analyzing nonlinear and non-stationary data. This method is inspired by the Empirical Mode Decomposition method (EMD) and the recently developed compressed sensing theory. The main idea is to look for the sparsest representation of multiscale data within the largest possible dictionary consisting of intrinsic mode functions. We formulate this as a nonlinear optimization problem. Further, we propose an iterative algorithm to solve this nonlinear optimization problem recursively. Numerical examples will be given to demonstrate the robustness of our method and comparison will be made with the EMD method. One advantage of performing such decomposition is to preserve some intrinsic physical properties of the signal, such as trend and instantaneous frequency. Our method shares many important properties of the original EMD method, but does not suffer from some of its drawbacks such as the instability to noise, stopping criterion, and mode mixing etc.

New Multiscale Surface Hopping Method for the Schrödinger Equation with Conical Crossings

Shi Jin
Department of Mathematics
Shanghai Jiao Tong University / University of Wisconsin
jin@math.wisc.edu

Abstract

In a nucleonic propagation through conical crossings of electronic energy levels, the codimension two conical crossings are the simplest energy level crossings, which affect the Born-Oppenheimer approximation in the zeroth order term. We develop multiscale surface hopping methods for the Schrödinger equation with conical crossings. The first approach is based on the semiclassical approximation governed by the Liouville equations, which are valid away from the conical crossing manifold. At the crossing manifold, electrons hop to another energy level with the probability determined by the Landau-Zener formula. This hopping mechanics is formulated as an interface condition, which is then built into the numerical flux for solving the underlying Liouville equation for each energy level. We also develop a multiscale coupling method that combines the Gaussian beam method away from the hopping zone and a direct Schrödinger solver in the hopping zone, in order to capture accurately phase information.

Unsupervised Multiphase Segmentation and Extensions

Sung Ha Kang
School of Mathematics
Georgia Institute of Technology
kang@math.gatech.edu

Abstract

Image segmentation separates the image into different regions to simplify the image and identify the objects easily. This talk will focus on the multiphase aspect of such problem, in particular unsupervised model, its analytical properties and its extensions to various applications. This talk may include a model segmenting piecewise constant images with irregular object boundaries.

Missing Mathematics for Extreme-scale Simulation

David Keyes
Department of Applied Physics and Applied Mathematics
Columbia University / King Abdullah University of Science and Technology
kd2112@columbia.edu

Abstract

An oft-quoted motivation for extreme computing is to 'take the gloves off' with critical energy and environmental simulations: improve prediction by relaxing the decoupling, rolling out the full physics, cranking up the resolution, and quantifying the uncertainty. Meeting these objectives will indeed justify the daunting development, acquisition, and operation costs of the hardware. New hardware is, however, only one challenge and perhaps neither the highest risk nor the highest payoff. Much mathematics (and software) appears to be missing if the hardware is to be used at its potential. For instance, the promises of multiphysics simulation will not be realized in extreme-scale computational environments in the primary manner through which codes are coupled today, through divide-and conquer operator splitting. Furthermore, today's successful, decoupled applications will need to be substantially rewritten after two decades of algorithm refinement in a period of programming model stability. While undertaking the latter, it may be natural to rethink the former.

A Mathematical Modeling and Numerical Method for the Boundary Layer with Complex Boundary Geometry

Kaitai Li
College of Science
Xi'an Jiaotong University
ktli@mail.xjtu.edu.cn

Abstract

In order to provide more precision of drag's computation, we consider a mathematical modeling and numerical method of boundary layer with complex boundary geometry. Assume that the solution of the Navier-Stokes equations can be made Taylor expansion with respect to the transverse variable ξ along normal to the boundary

$$\mathbf{u}(x,\xi) = \mathbf{u}_0(x) + \mathbf{u}_1(x)\xi + \mathbf{u}_2(x)\xi^2 + \cdots p(x,\xi) = p(0)x + p_1(x)\xi + p_2(x)\xi^2 + \cdots$$

where $\mathbf{u}_0(x)$ is the velocity of boundary Γ_0, which is known. $(\mathbf{u}, p)$ will be imposed the interface condition , on the top boundary Γ_t, an artificial interface boundary $\sigma \cdot n|_{\Gamma_t^-} = \sigma \cdot n|_{\Gamma_t^+}$, $\sigma^{ij}(\mathbf{u}, p)n_j = (2\mu e^{ij}(u) - g^{ij}p)n_j = (\mu(\nabla^i u^j + \nabla^j \mathbf{u}^i) - g^{ij}p)n_j$.

We will provide a boundary equations for $(\mathbf{u}_1, \mathbf{u}_2, p_0, p_1, p_2)$ in a semi-geodesic coordinate based on the boundary Γ_0, an alternative iteration with the Navier-Stokes equations on the exterior domain leads a more precision of drag computation.

Keywords the boundary layer; the interface condition; the transverse variable.

Lower Bound by Nonconforming FEMs

Qun Lin
Academy of Mathematics and Systems Science
Chinese Academy of Sciences
linq@lsec.cc.ac.cn

Abstract

Considering the eigenvalue bounds of PDEs, there are two kinds of FEMs: one is conforming, the other is nonconforming. The former always gives always the upper bounds while the latter is uncertain.

We proved first that the simplest nonconforming element (so called Morley element) gives successfully the lower bounds for eigenvalues of the biharmonic equation. The proof argument moves then to other equations, e.g., Laplace, Stokes and Steklov equations, showing how to modify the standard nonconforming elements in order to get satisfied lower bounds.

This is a joint work with Hehu Xie.

Medical Morphometry and Computer Visions Using Quasi-conformal Teichmuller Theory

Ronald Lui
Department of Mathematics
The Chinese University of Hong Kong
lmlui@math.cuhk.edu.hk

Abstract

In medical imaging and computer visions, studying the geometry and the deformation of 2D/3D shapes are of utmost importance. For example, comparing shape differences between anatomical structures (such as human brains) is crucial for disease analysis. Quasi-conformal Teichmuller Theory, which studies geometric deformations between shapes, is an ideal tool for this purpose. In practice, 2D/3D shapes are usually represented discretely by triangulation meshes. We therefore need to have a discrete version of Quasi-conformal theory on discrete meshes. In this talk, I will firstly talk about how can develop a discrete analogue of QC geometry on meshes. I will then talk about how computational QC geometry can be applied to medical imaging and computer visions applications.

This is a joint work with Tony F. Chan, Alvin Wong and S-T Yau.

Hub, Authority and Relevance Scores in Multi-Relational Data

Michael Ng
Department of Mathematics
Hong Kong Baptist University
mng@math.hkbu.edu.hk

Abstract

In this talk, we discuss a framework HAR to study the hub and authority scores of objects, and the relevance scores of relations in multi-relational data for query search. In the framework, an iterative algorithm for solving a set of tensor equations arising from query search is studied. Experimental results are also presented to demonstrate the performance of the proposed algorithm.

Applications and Implications of Fast Methods for L1 Related Problems

Stanley Osher
Department of Mathematics
University of California, Los Angeles
sjo@math.ucla.edu

Abstract

New and newly revised fast mathods for optimization problems involving L1, total variation, tight frame and nonlocal means have led to innumerable interesting applications. I will discuss these applications, ranging from multienergy CT to retinex to surveillance as well as the methods and future applications. This is joint work with many people.

Mathematical Problems in Systemic Risk

George Papanicolaou
Department of Mathematics
Stanford University
papanico@math.stanford.edu

Abstract

Complex systems with many interconnected components can fail only if a large number of the components can fail at the same time, which is systemic failure. I will introduce several models of such systems and discuss their properties. The main tool for their analysis is large deviations theory, which I will also introduce briefly. I will then discuss mean field models in more detail and give examples from several fields: Physics (dynamic phase transitions), finance, etc.

Spectral Theory of Higher Order Tensors

Li-qun Qi
Department of Applied Mathematics
The Hong Kong Polytechnic University
maqilq@polyu.edu.hk

Abstract

In 2005, independently, Lim and Qi defined eigenvalues and eigenvectors of a real symmetric tensor, and explored their practical application in determining positive definiteness of an even degree multivariate form. This work extended the classical concept of eigenvalues of square matrices, forms an important part of numerical multi-linear algebra, and has found applications or links with automatic control, statistical data analysis, optimization, magnetic resonance imaging, solid mechanics, quantum physics, higher order Markov chains, spectral hypergraph theory, Finsler geometry, etc, and attracted attention of mathematicians from different disciplines. It now forms a new area of applied mathematics and computational mathematics – the spectral theory of higher-order tensors.

Linear Algebra Methods for Data Mining with Applications to Materials

Yousef Saad
Department of Computer Science and Engineering
University of Minnesota
saad@cs.umn.edu

Abstract

Linear algebra techniques constitute the tool of choice in many disciplines loosely grouped under the area of "Data Mining". This area includes information retrieval, pattern recognition, classification, learning, image analysis, recommender systems, graph mining, etc... It is the source of many new, interesting, and sometimes challenging linear algebra problems. In fact, one can argue that while the current era of numerical linear algebra has been shaped largely by problems arising from PDEs and CFD, these new disciplines are now starting to shape the "next chapter" in numerical linear algebra. Two common themes in all of these disciplines are those of (1) clustering (trying to group similar objects together) and (2) dimension reduction (finding some low-dimensional representation of some data). We will begin by illustrating some of these problems and then show a few numerical algorithms for solving them. We will then discuss our first experiments in applying some of these techniques in materials science, in an area loosely labeled 'materials informatics'. One problem considered here is to try to find order in the data given from the constitent atoms of a chemical compound. Another is to determine quantities such as metling point or band-gap again from the data obtained from atoms.

MRA Based Wavelet Frame and Applications

Zuowei Shen
Department of Mathematics
National University of Singapore
matzuows@nus.edu.sg

Abstract

One of the major driving forces in the area of applied and computational harmonic analysis during the last two decades is the development and the analysis of redundant systems that produce sparse approximations for classes of functions of interest. Such redundant systems include wavelet frames, ridgelets, curvelets and shearlets, to name a few. This talk focuses on tight wavelet frames that are derived from multiresolution analysis and their applications in imaging. The pillar of this theory is the unitary extension principle and its various generalizations, hence we will first give a brief survey on the development of extension principles. The extension principles allow for systematic constructions of wavelet frames that can be tailored to, and effectively used in, various problems in imaging science. We will discuss some of these applications of wavelet frames. The discussion will include frame-based image analysis and restorations, image inpainting, image denoising, image deblurring and blind deblurring, image decomposition, segmentation and CT image reconstruction.

Studies on Wilson Nonconforming Finite Element

Zhong-ci Shi
Institute of Computational Mathematics
Chinese Academy of Sciences
shi@lsec.cc.ac.cn

Abstract

Wilson nonconforming finite element (1973) is a very useful rectangular element in practice. It is shown in many engineering applications that the convergence behavior of this element is better than that of the commonly used bilinear element. However, mathematical studies carried out so far cannot justify it. I have spent many years on this problem. The results obtained by use of standard finite element analysis are not satisfied. Recently (2007–) we tackle this problem from a different view point, i.e. from mechanics, where the Wilson element was originated. We have succeeded in proving both mathematically and numerically that the Wilson element is free of shear locking for a wide class of bending dominated plane elasticity problems, while the bilinear element suffers from shear locking. Therefore, we elucidate a long-standing folklore: why Wilson element does a better job in many practical applications than the bilinear element.

Mathematics of Immunology

Stephen Smale
Department of Mathematics
City University of Hong Kong
smale@cityu.edu.hk

Abstract

We will discuss the peptide binding problem where we have quite accurate predictions. Also results on serotyping clusters will be given.

Balanced Splitting Methods / Infinite Matrices

Gilbert Strang
Department of Mathematics
Massachusetts Institute of Technology
gs@math.mit.edu

Abstract

Most of this talk is about a problem that constantly arises in scientific computing. The last part is about an algebra problem – for finite and infinite matrices.

Differential equations often have diffusion and advection and reaction terms. Those are treated differently, and separately when possible. Diffusion might be implicit and advection explicit. Reaction is highly nonlinear, but local. If we separate the transport terms $T(u)$ from the reaction terms $R(u)$, we may "split" each time step into separate integrations. Since they don't commute, the overall step has only first-order accuracy. But second order is achieved by a half-step based on T, a full step based on R, and a half-step based on T.

Problem: An error can appear in the steady state. The solution to $T(u)+R(u) = 0$ may not solve $T(u) = 0$ and $R(u) = 0$ separately. Solution: Adjust to $T(u) + c_n$ and $R(u) - c_n$ by a balancing vector c_n at each step. If we choose $c_n = (R(u_n) - T(u_n))/2$ then each part can converge to the correct steady state. But stability becomes harder to ensure and Ray Speth has created a "rebalanced splitting" that is equally accurate and much more stable.

For two problems on banded doubly infinite matrices there is progress to report:
1. Is the triangular factorization $A = LPU$ still possible ? Notice the position of P !
2. Which is the 'main diagonal' of that infinite matrix ?

On Pre-transformed Methods for PDE Eigen-problems

Jiachang Sun
Institute of Software
Chinese Academy of Sciences
sun@mail.rdcps.ac.cn

Abstract

As well-known, pre-conditioning methods have been greatly successful for linear solver in scientific computing. However, comparing with linear solver, eigen-solver now is still less efficient now. How to make eigen-solver to be more efficient is one of the grand challenges we have faced on in scientific computing. In this talk we will report so-called pre-transformed methods and its application to 2-nd order PDE eigen-problems in 2-D and 3-D by basis mapping or similar transformation.

A New Model for Self-organized Dynamics: from Particle to Hydrodynamic Descriptions

Eitan Tadmor
Department of Mathematics
University of Maryland
tadmor@cscamm.umd.edu

Abstract

Self-organized dynamics is driven by "rules of engagement", which describe how each agent interacts with its neighbors. They consist of long-term attraction, mid-range alignment and short-range repulsion. Many self-propelled models are driven by the balance between these three forces, which yield emerging structures of interest. Examples range from consensus of voters and traffic flows to the formation of flocks of birds or school of fish, tumor growth etc.

We introduce a new particle-based model, driven by self-alignment, which addresses several drawbacks of existing models for self-organized dynamics. The model is independent of the number of agents: only their geometry in phase space is involved. We will explain the emerging flocking behavior of the proposed model in the presence of non-symmetric interactions which decay sufficiently slow, and discuss the difficulties of tracing graph connectivity otherwise. The methodology is based on the new notion of active sets, which carries over from particle to kinetic and hydrodynamic descriptions, and we discuss the unconditional flocking at the level of hydrodynamic description.

Global Minimization for the Chan-Vese Model

Xue-cheng Tai
Department of Mathematics
University of Bergen
tai@mi.uib.no

Abstract

We propose an exact convex formulation of the Chan-Vese model with 4 regions. A global solution is guaranteed if the data term satisfies a (mild) submodularity condition. Theoretical and experimental arguments are given that such a condition will hold in practice for the most commonly used type of data terms. Otherwise, a convex truncation scheme is proposed which can produce global solutions in practice, should this not be the case.

Adaptive Time Stepping and Energy Stable Schemes

Tao Tang
Department of Mathematics
Hong Kong Baptist University
ttang@hkbu.edu.hk

Abstract

Numerical simulations for many physical problems require large time integration; as a result large time-stepping methods become necessary. In this talk, we will concentrate on the adaptive time stepping methods for physical problems with energy stable properties. The physical problems involving complex fluids, phase separations, epitaxial growth of thin films, etc. By using the energy stable schemes, we are able to propose some time adaptivity strategies to resolve both the solution dynamics and the steady state solutions. Numerical simulation results will be reported and discussed.

Numerical PDE Models and Methods with Applications in Finance and Image Processing

Justin W.L. Wan
David R. Cheriton School of Computer Science
University of Waterloo
jwlwan@cs.uwaterloo.ca

Abstract

In this talk, we will present a number of numerical PDE methods and models which are inspired by the work of Tony Chan in multigrid and image processing. In finance, many pricing problems can be formulated as optimal control problems, leading to nonlinear Hamilton-Jacobi-Bellman (HJB) or Hamilton-Jacobi-Bellman-Isaacs (HJBI) equations. These equations are highly nonlinear and standard methods such as policy iteration can be very slow. We propose a "gray box" multigrid method which is able to solve HJB and HJBI equations with mesh-independent convergence rate. Many image problems such as segmentation and inpainting can also be formulated by PDEs. We will present 3D models for image segmentation and image inpainting motivated by applications in cell image analysis. The segmentation approach is motivated by the Chan-Vese active contour model and the inpainting approach by the TV and Euler-Elastica models. Numerical results are given for problems in finance and medical imaging.

Inverse Inclusion Problem: Reconstruction and Stability

Jenn-nan Wang
Department of Mathematics
National Taiwan University
jnwang@math.ntu.edu.tw

Abstract

In this talk, I would like to discuss a reconstruction method for determining an inclusion by boundary measurements in the static or stationary acoustic equation. This inverse problem is notoriously ill-posed. I will discuss how the stability depends on different parameters.

Wetting and Contact Angle Hysteresis on Rough Surfaces

Xiao-ping Wang
Department of Mathematics
The Hong Kong University of Science and Technology
mawang@ust.hk

Abstract

We analyze the wetting hysteresis on rough and chemically patterned surfaces from a phase-field model for immiscible two phase fluid. In the slow motion, the dynamic equations of the interface as well as the contact angle can be derived from the matched asymptotic expansions. The contact angle hysteresis can then be studied from these equations.

Discretization and Precondition of High Order PDEs

Jinchao Xu
Department of Mathematics
Peking University / Pennsylvania State University
xu@math.psu.edu

Abstract

For biharmonic equations (on concave domains), some "natural" mixed finite element methods may be non-optimal or simply divergent. But this type of elements, as demonstrated in this talk based on a joint work with Shuo Zhang, can be used for constructing (nearly) optimal preconditioner for both conforming (such as Agyris) and nonconforming (such as Morley) finite elements for biharmonic equations discretized on unstructured grids. The resulting preconditioner reduces the solution of a discrete biharmonic equation to the solution of several discrete Laplacian equations together with some local relaxation methods (such as Gauss-Seidel).

A Fast Algorithm for Additive Image Segmentation

Andy Yip
Department of Mathematics
National University of Singapore
andyyip@nus.edu.sg

Abstract

In this talk, I will present a fast algorithm for computing a solution to the additive segmentation model. The additive model is used to model images that contain a known number of overlapping transparent objects. It has applications medical and biological imaging such as X-ray, MRI and microscopy. The model consists of Euler's elastica for regularization. Thus, the first-order optimality condition is a fourth order PDE, which is difficult to optimize efficiently. The algorithm that we propose is based on lagging the high-order terms in the Euler-Lagrange equation behind. The resulting equation is associated with a constrained total variation minimization problem which is then solved using the Augmented Lagrangian Method. The method is shown to be much efficieint than the basic forward Euler scheme.

Subspace Techniques for Nonlinear Optimization*

Ya-xiang Yuan
Institute of Computational Mathematics and Scientific/Engineering Computing
Chinese Academy of Sciences
yyx@lsec.cc.ac.cn

Abstract

In this talk, we review some recent advances on subspace techniques used in numerical methods for nonlinear optimization. Particularly we discuss the combination of subspace techniques and trust region techniques for nonlinear optimization, both unconstrained problems and constrained problems. Subspace techniques for nonlinear equations with applications in protein structures, and subspace algorithms for some special non-smooth optimization problems such as L1 minimization problem and matrix decomposition problems are also discussed.

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Non-local Behaviors of Interface between Ordered Structures

Pingwen Zhang
School of Mathematical Sciences
Peking University
pzhang@pku.edu.cn

Abstract

Interface is thought to be local transition-zone between two bulks. However, in this presentation, we will demonstrate some non-local behaviors of interface between ordered phases in block copolymers. Due to the loss of isotropy, various novel phenomena about interface are observed in calculations. In order to minimize the free-energy of the system, interface chooses to be non-planar, stretch and twist the bulk material in large areas or even reconstruct to form new structures. Our numerical results have extended our understandings of interfaces.

Sources Reconstruction for 3D Bioluminescence Tomography with Sparse Regularization

Xiaoqun Zhang
Department of Mathematics
Shanghai Jiaotong University
xqzhang@sjtu.edu.cn

Abstract

Through restoration of the light source information in small animals in vivo, optical molecular imaging, such as fluorescence molecular tomography (FMT) and bioluminescence tomography (BLT), can depict biological and physiological changes observed using molecular probes. A priori information plays an indispensable role in tomographic reconstruction. We consider both Gaussian and Poisson MAP restoration model together with sparsity a priori information. In Gaussian noise case, the proposed ℓ^1 minimization is validated with simulated data, Monte Carlo-based synthetic data and a mouse-shaped phantom. Testing with different noise levels and single/multiple source settings at different depths demonstrates the improved performance of this algorithm. In Poisson noise case, we show numerically that although several ℓ^1 minimization algorithms are efficient for compressive sensing reconstruction, they fail for BLT reconstruction. Instead, we propose a novel greedy algorithm for ℓ^0 regularization to reconstruct sparse solutions for BLT problem. Numerical experiments on simulated data both by forward system matrix and Monte-Carlo method show the accuracy and efficiency of the proposed method.

Grid Based Particle Method for Moving Interface Problem

Hongkai Zhao
Department of Mathematics
Peking University / University of California, Irvine
zhao@math.uci.edu

Abstract

I will introduce our recently developed grid based particle method (GBPM) with applications to various moving interface problems. The key idea is to use quasi-uniformly sampled meshless particles associated with an underlying grid. Due to meshless points, many operations, such as removing and adding points, become easy. At the same time local approximation can be constructed in intrinsic local coordinate system. It has the accuracy and efficiency of particle method. At the same time, due to the association with an underlying grid, it has Eulerian reference as well. So topological changes can be handled easily. Moreover, local adaptivity, open curves and open surfaces can be dealt with naturally for the GBPM. We will demonstrate our method for various interface motions that may involve solving PDE on surfaces with local and/or global constraints.

A Fast Algorithm for the Shortest Path Based on Initial Value ODES and Intermittent Diffusion

Hao-min Zhou
School of Mathematics
Georgia Institute of Technology
hmzhou@math.gatech.edu

Abstract

We propose a fast algorithm for finding the shortest path connecting two points while avoiding obstacles in a region by solving an initial value ODE problem. The idea is the shortest path enjoys a simple structure, which enables us to reduce the set of feasible paths dramatically to a finite dimensional set. Then a gradient descent leads us to local minimal paths. A stochastic based method Intermittent Diffusion is then used to find the global minimal path. We incorporate level set method to handle any shape of obstacles. Also the method is dimension independent, which enables us to extend the method to 3D without difficulty. This presentation is based on joint work with S. N. Chow and J. Lu (Georgia Tech)

Titles and Abstracts

Contributed Talks

Fluid Motion in a Triaxial Ellipsoidal Cavity Driven by Libration

Michael K.H. Chan
Department of Mathematics
The University of Hong Kong
mkhchan@hkucc.hku.hk

Abstract

Deformed by tidal forces and rotational effects, the cavity of a planetary fluid core is usually in the shape of non-spherical geometry. Gravitational interaction between a planet and its parent star or moon exerts a torque on the planet and forces its latitudinal libration which drives fluid motion in non-spherical planetary cores via viscous and topographic coupling between the planetary mantle and fluid core. We shall present an asymptotic theory – a mathematical solution of the Navior-Stokes solution in spheroidal geometry with small viscosity – describing the fluid motion driven by latitudinal libration. We shall also present an efficient finite element method for simulating nonlinear flows in latitudinally librating, triaxial ellipsoidal cavities with stability properties and error estimates of the time-dependent finite element solution.

This is a joint work with Keke Zhang, Xinhao Liao and Jun Zou.

A Weak Formulation of the Immersed Boundary Method

Edward Givelberg
Department of Physics and Astronomy
The Johns Hopkins University
givelberg@pha.jhu.edu

Abstract

A new method of spatial discretization for immersed boundary computations is introduced. Fluid velocity and pressure are obtained as weak solutions of the discretized fluid equations with respect to a wavelet basis of functions. The scaling function of the fluid velocity basis may be chosen to be identical to Peskin's discrete approximation to the Dirac delta function. On a regular rectangular grid the discretized equations are solved using the fast Fourier transform, retaining the efficiency of the immersed boundary method. We show experimental numerical evidence that the rate of volume loss of our method is better than that of the finite difference immersed boundary method. Our formulation offers new insights into the immersed boundary method and leads to new extensions and applications.

Intrinsic Surface Processing and Applications to 3D Medical Imaging

Rongjie Lai
Department of Mathematics
University of Southern California
rongjiel@usc.edu

Abstract

Rapid development of 3D data acquisition technologies stimulates researches on 3D surface analysis in medical imaging. Intrinsic differential geometry techniques are crucial to either process or analyze surfaces. In this talk, I will present our recent work on 3D brain surface analysis. By combining our work on intrinsic image processing on surfaces and Laplace-Beltrami eigen-geometry, I will show our results on skeleton construction, feature extraction, pattern identification, surface deformation and surface mapping in 3D brain imaging. The intrinsic features of our approaches guarantee that our methods are robust to surfaces rotation and translation variations.

A Fast Local Level Set Method for Inverse Gravimetry

Tim Leung
Department of Mathematics
Hong Kong University of Science and Technology
masyleung@ust.hk

Abstract

In this talk we present a fast local level set method for the inverse problem of gravimetry. The theoretical foundation for our approach is based on the following uniqueness result: if an open set D is star-shaped or x3-convex with respect to its center of gravity, then its exterior potential uniquely determines the open set D. To achieve this purpose constructively, the first challenge is how to parametrize this open set D as its boundary may have a variety of possible shapes. To describe those different shapes we propose to use a level-set function to parametrize the unknown boundary of this open set. The second challenge is how to deal with the issue of partial data as gravimetric measurements are only made on a part of a given reference domain W. To overcome this difficulty, we propose a linear numerical continuation approach based on the single layer representation to find potentials on the boundary of some artificial domain containing the unknown set D. The third challenge is how to speed up the level set inversion process. Based on some features of the underlying inverse gravimetry problem such as the potential density being constant inside the unknown domain, we propose a novel numerical approach which is able to take advantage of these features so that the computational speed is accelerated by an order of magnitude.

Global Structure Stability of Riemann Solutions for Linearly Degenerate Hyperbolic Conservation Laws under Small BV Perturbations of the Initial Data

Zhi-Qiang Shao
Department of Mathematics
Fuzhou University
zqshao_fzu@yahoo.com.cn

Abstract

In this paper, we study the global structure stability of the Riemann solution $u = U(\frac{x}{t})$ for general $n \times n$ quasilinear hyperbolic systems of conservation laws under a small BV perturbation of the Riemann initial data. We prove the global existence and uniqueness of piecewise C^1 solution containing only n contact discontinuities to a class of the generalized Riemann problem, which can be regarded as a small BV perturbation of the corresponding Riemann problem, for general $n\times n$ linearly degenerate quasilinear hyperbolic system of conservation laws; moreover, this solution has a global structure similar to the one of the self-similar solution $u = U(\frac{x}{t})$ to the corresponding Riemann problem. Our result indicates that this kind of Riemann solution $u = U(\frac{x}{t})$ mentioned above for general $n \times n$ quasilinear hyperbolic systems of conservation laws possesses a global nonlinear structure stability under a small BV perturbation of the Riemann initial data. Applications include the one-dimensional Born-Infeld system arising in the string theory and high energy physics.

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Computational Quasiconformal Geometry and its Applications in Computer Graphics

Tsz Wai Wong
Department of Mathematics
University of California, Irvine
tszww@uci.edu

Abstract

Conformal mappings have been widely applied in computer graphics, such as texture mapping, where the mappings are constructed to be as conformal as possible to reduce geometric distortions. A direct generalization of conformal mapping is quasiconformal mapping, where bounded conformality distortions are allowed. All diffeomorphisms can then be considered using quasiconformal geometry. In this talk, we explore how the theories of quasiconformal mappings and their computations are useful in areas not considered by conformal geometry, such as the compression texture mappings, and the inpainting and refinement of surface diffeomorphisms.

Sparsity-driven Multiplicative Noise Removal

Tieyong Zeng
Department of Mathematics
Hong Kong Baptist University
zeng@hkbu.edu.hk

Abstract

Multiplicative noise removal is a challenging image processing problem, and most existing methods are based on the Maximum A Posteriori (MAP) formulation and the logarithmic transformation of multiplicative denoising problems into additive denoising problems. On the other hand, sparse representations of images have shown to be efficient approaches for image recovery. Following this idea, we propose in this talk to learn a dictionary from the logarithmic transformed image, an then to use it in a variational model built for noise removal. Extensive experimental results suggest that in terms of visual quality, PSNR and Mean Absolute Deviation Error, the proposed algorithm outperforms state-of-the-art methods.

Image Denoising Using Mean Curvature of Image Surface

Wei Zhu
Department of Applied Mathematics and Statistics
State University of New York at Stony Brook
zhu@ams.sunysb.edu

Abstract

We propose a new variational model for image denoising, which employs the L^1-norm of the mean curvature of the image surface $(x; f(x))$ of a given image $f : \Omega \to \mathbb{R}$. Besides eliminating noise and preserving edges of objects efficiently, the proposed model can keep corners of objects and grey-scale intensity contrasts of images, and also ameliorate the staircase effect. In this talk, we will present preliminarily analytical results to explain why the model can preserve object corners and image contrasts. We will also present numerical results to demonstrate these features. Moreover, we will compare experimental results obtained by using the proposed model with those by the classical Rudin-Osher-Fatemi model and two related high order models – the Euler's Elastica model and the Lysaker-Lundervold-Tai model.

Information

Accommodation and Directions

Conference Hotel : Royal Park Hotel

Royal Park Hotel is 5-minute walk from Shatin MTR Station, see map on p. 52. For enquires,

Address :	8 Pak Hok Ting Street, Shatin, Hong Kong
Tel :	(852) 2601-2111
Fax :	(852) 2601-3666
Web Site :	`www.royalpark.com.hk`

- Direction from the airport to Royal Park Hotel:
  `www.math.cuhk.edu.hk/special/icsc2012/hotel.html`
- Direction from Royal Park Hotel to CUHK and HKUST conference venue:
  `www.math.cuhk.edu.hk/special/icsc2012/venue.html`

Conference Venue : The Chinese University of Hong Kong

Date :	January 4, 6 and 7, 2012
Address :	Lecture Theater 7 1/F, Lee Shau Kee Building The Chinese University of Hong Kong

On January 4, 6 and 7, there will be a bus from Royal Park Hotel to CUHK conference venue in the morning at 08:30 and back to the conference hotel after the end of the conference.

- For CUHK campus map see p. 50

Conference Venue : The Hong Kong University of Science and Technology

Date :	January 5, 2012
Address :	Cheung On Tak Lecture Theater, LT-E The Hong Kong University of Science and Technology

On January 5, there will be a bus from Royal Park Hotel to HKUST conference venue in the morning at 08:30 and back to the conference hotel after the dinner at Tony's house.

- For HKUST campus map see p. 51

Meals

Breakfast :	at Royal Park Hotel for all invited speakers and their spouses.
Lunch :	at CUHK/HKUST for all invited speakers and paid participants.

Shuttle Bus Schedule

January 4, 2012 (Wednesday)

08:30	Royal Park Hotel to Conference Venue at CUHK
18:10	Conference Venue to Royal Park Hotel

January 5, 2012 (Thursday)

08:30	Royal Park Hotel to Conference Venue at HKUST
21:30	President's Lodge, HKUST to Royal Park Hotel

January 6, 2012 (Friday)

08:30	Royal Park Hotel to Conference Venue at CUHK
18:00	Conference Venue to Royal Park Hotel
18:50	Royal Park Hotel to Banquet at Regal Riverside Hotel
22:30	Regal Riverside Hotel to Royal Park Hotel

January 7, 2012 (Saturday)

08:30	Royal Park Hotel to Conference Venue at CUHK
14:00	Half-day Tour starts at CUHK (stops by Royal Park Hotel at 14:15)

Contact

You may call the following numbers when you need assistance in Hong Kong :

Pauline Chan :	(852) 3943-7988 (Office)
Raymond Chan :	(852) 9714-9017 (Mobile)
Ronald Lui :	(852) 9355-5418 (Mobile)

Wi-Fi Access to Internet

The Chinese University of Hong Kong (CUHK):

SSID :	**CUguest**
User ID :	g******@guest.cuhk.edu.hk (*please use your assigned login ID number which is shown on your badge*)
Password :	tonychan60

1) Please choose and click "CUguest" in the list of available wireless networks.
2) After successful connection, open a web browser and visit any website (e.g. www.google.com).
3) The web browser will then automatically lead you to a CUguest Wi-Fi Service Login Page.
4) Please enter "your own user ID" and password
5) A window showing "Login successful" will pop up and you can now access the Internet.

The University of Science and Technology (HKUST):

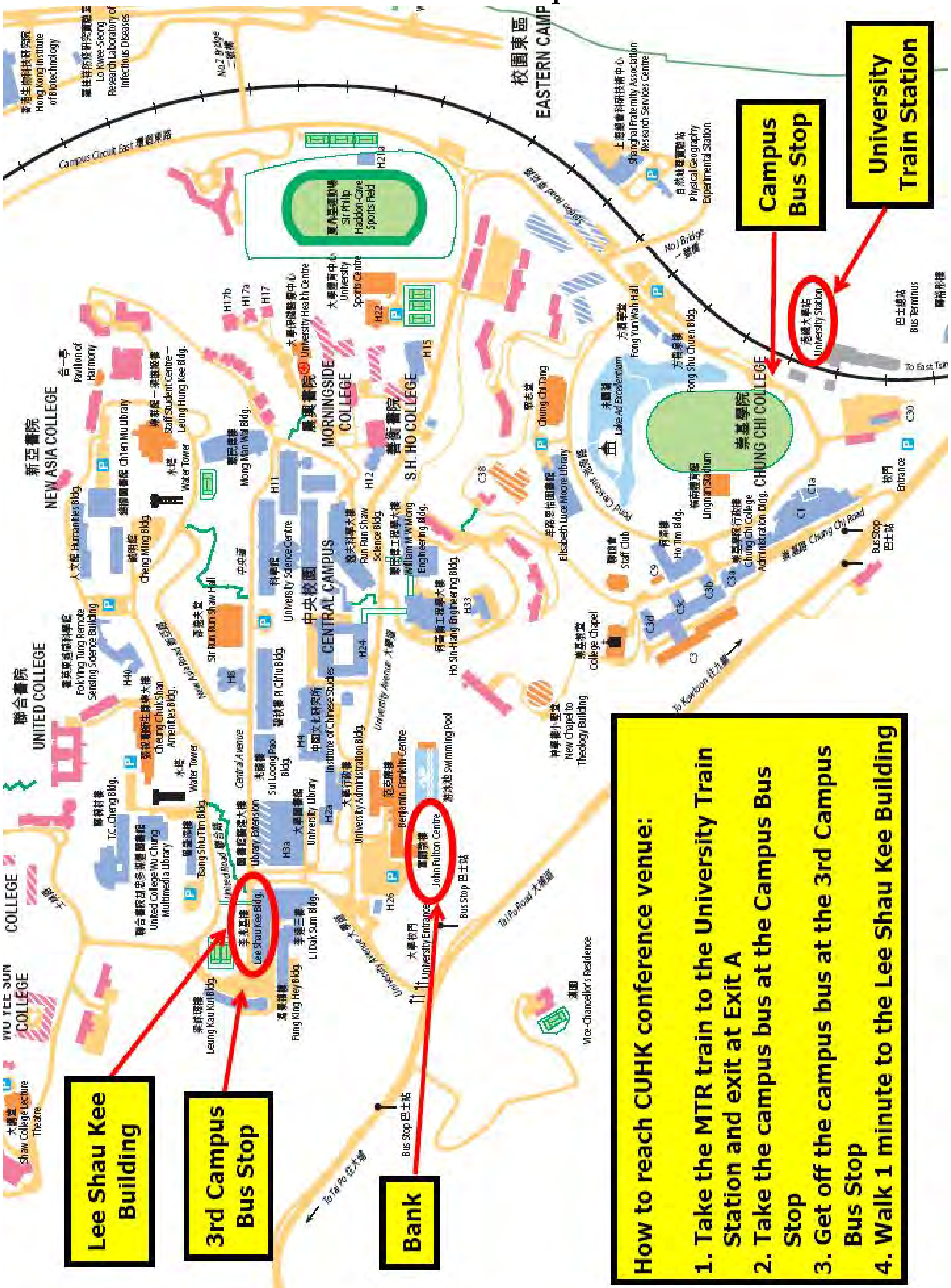
SSID :	**Removed**
User ID :	**Removed**
Password :	**Removed**

1) Please choose and click "sMobilenet" in the list of available wireless networks.
2) After successful connection, the network authentication dialogue box should pop-up.
3) Please enter the above user ID and password
4) Click "connect" in the Windows Security Alert pop-up and you can now access the Internet.

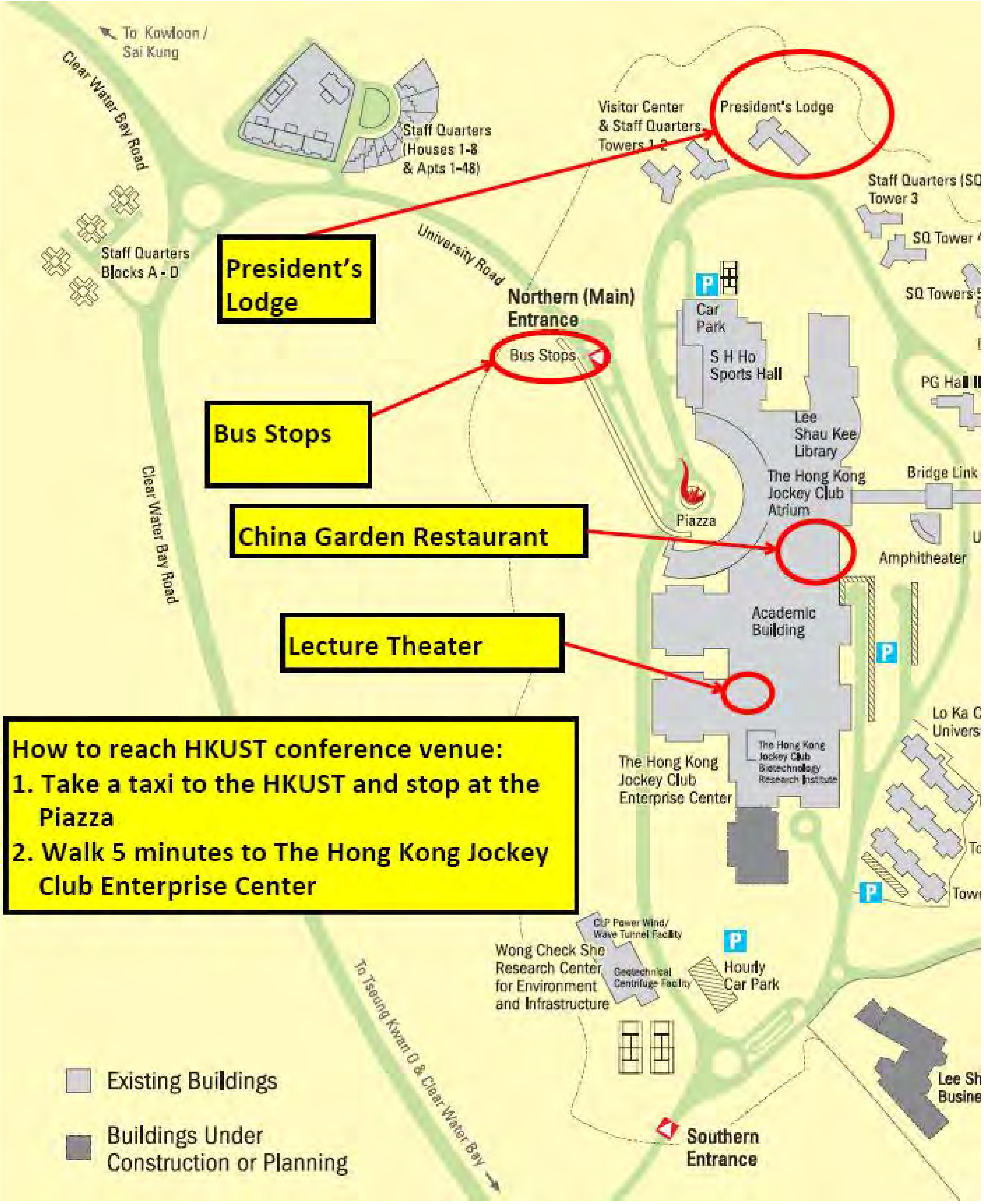
If you have any problem in using the Wi-Fi network service, please feel free to contact our staff or conference helpers. A set of detailed and illustrated instruction sheets is also available at the registration desk or you can visit the following websites beforehand :

`http://www.cuhk.edu.hk/itsc/network/wlan/cuguest-userguide.html` (CUHK)
`http://www.ust.hk/itsc/wireless/index.html` (HKUST)

CUHK Map


University Train Station
Campus Bus Stop
Lee Shau Kee Building
3rd Campus Bus Stop
Bank
How to reach CUHK conference venue:
1. Take the MTR train to the University Train Station and exit at Exit A
2. Take the campus bus at the Campus Bus Stop
3. Get off the campus bus at the 3rd Campus Bus Stop
4. Walk 1 minute to the Lee Shau Kee Building
EASTERN CAMPUS
CENTRAL CAMPUS
NEW ASIA COLLEGE
UNITED COLLEGE
CHUNG CHI COLLEGE
MORNINGSIDE COLLEGE
S.H. HO COLLEGE

HKUST Map



To Kowloon / Sai Kung
Clear Water Bay Road
Staff Quarters (Houses 1-8 & Apts 1-48)
Visitor Center & Staff Quarters Towers 1-2
President's Lodge
Staff Quarters Blocks A - D
President's Lodge
University Road
Northern (Main) Entrance
Bus Stops
Bus Stops
Car Park
S H Ho Sports Hall
Lee Shau Kee Library
The Hong Kong Jockey Club Atrium
Piazza
Bridge Link
China Garden Restaurant
Amphitheater
Clear Water Bay Road
Academic Building
Lecture Theater
How to reach HKUST conference venue:
1. Take a taxi to the HKUST and stop at the Piazza
2. Walk 5 minutes to The Hong Kong Jockey Club Enterprise Center
The Hong Kong Jockey Club Enterprise Center
The Hong Kong Jockey Club Biotechnology Research Institute
CLP Power Wind/ Wave Tunnel Facility
Wong Check She Research Center for Environment and Infrastructure
Geotechnical Centrifuge Facility
Hourly Car Park
To Tseung Kwan O & Clear Water Bay
Existing Buildings
Buildings Under Construction or Planning
Southern Entrance

Direction from Royal Park Hotel to Shatin MTR Station

Social Events

January 4

09:15 Group photo at the conference venue.

January 5

18:30 Dinner at Prof. Tony Chan's House (President's Lodge inside HKUST, see map on p. 51) **for all invited speakers and their spouses**.
21:30 Bus leaves from President's Lodge to Royal Park Hotel.

- Conference ends at 17:20 at HKUST on January 5. There is a HKUST campus tour between 17:20 and 18:30.
- Taxi from Royal Park Hotel to HKUST costs around US$ 25 and takes about 30 minutes.

January 6

Banquet at Regal Riverside Hotel **for all invited speakers, their spouses, and paid participants**.

18:50 Bus leaves from Royal Park Hotel to Regal Riverside Hotel.
19:00 Reception at Bauhinia Room, 3/F, Regal Riverside Hotel.
19:30 Banquet at Bauhinia Room, 3/F, Regal Riverside Hotel.
22:30 Bus leaves from Regal Riverside Hotel to Royal Park Hotel.

- Address of Regal Riverside Hotel: 34 - 36 Tai Chung Kiu Road, Shatin, Hong Kong.
- Banquet tickets (HK$ 550 each) are available at the registration desk for other participants and companions on January 4.

January 7

Tour of Hong Kong from 14:00 to 18:30 **for all invited speakers, their spouses, and paid participants**. Bus leaves at 14:00 at CUHK, stops at Royal Park Hotel at 14:15 before starting the tour.

The first stop of the tour is the Kowloon Walled City Park. This is one of the most historic sites in Hong Kong, which preserves many architectures in the past. See `www.lcsd.gov.hk/parks/kwcp/en/index.php`

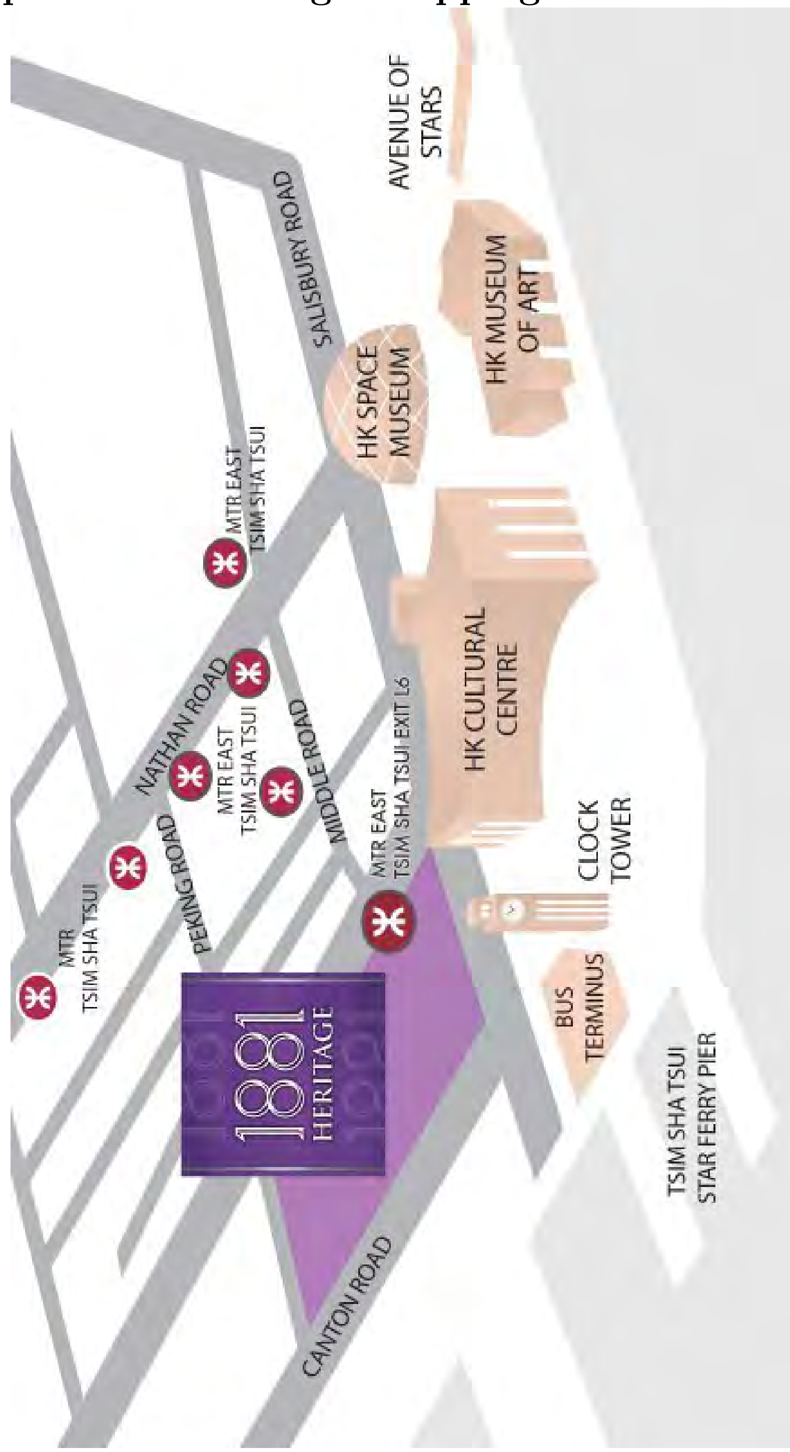
The second stop is a large Buddhist temple complex – Chi Lin Nunnery. This construction is based on traditional Chinese architectural techniques dating from the Tang Dynasty (618 - 907 A.D.) that uses special interlocking systems cut into the wood to hold them in place. The Chi Lin Nunnery buildings are the only buildings to be built in this style in modern day Hong Kong. See `www.discoverhongkong.com/eng/attractions/culture-chilin-nunnery.html`


Next, we will visit *sky100* which is the highest indoor observation deck in Hong Kong! Soaring high above the city on the 100th floor of the International Commerce Centre, the tallest building in town, *sky100* offers visitors a magical bird's-eye sweep of this world-famous sight with an unbeatable 360° panoramic view. The official website of *sky100* is `www.sky100.com.hk/index.php`


The tour ends at the 1881 Heritage shopping mall which is the former Marine Police Headquarters that has recently been rejuvenated and re-integrated as a high-end shopping site. The official website of 1881 Heritage is `www.1881heritage.com/flash/#/en/home/`

- The tour ends at 18:30.
- Dinner is not included.
- Participants can go back to Royal Park Hotel via Tsim Sha Tsui MTR station which is a 5-minute walk from the 1881 Heritage shopping mall. (See map on p. 55)
- Tour tickets (HK$ 300 each) are available at the registration desk on January 4 and 6.

Map of 1881 Heritage Shopping Mall and around



List of Participants

- Xavier Bresson, *City University of Hong Kong*
- Xiaohao Cai, *The Chinese University of Hong Kong*
- Emmanuel Candes, *Stanford University*
- Hiu Ning Chan, *The Chinese University of Hong Kong*
- Michael K. H. Chan, *The University of Hong Kong*
- Raymond Chan, *The Chinese University of Hong Kong*
- Tony Chan, *The Hong Kong University of Science and Technology*
- Ke Chen, *Dalian University of Technology / University of Liverpool*
- Louis Chen, *National University of Singapore*
- Xiaojun Chen, *The Hong Kong Polytechnic University*
- Zhiming Chen, *Chinese Academy of Sciences*
- Shiu-Yuen Cheng, *The Hong Kong University of Science and Technology*
- I-Liang Chern, *National Taiwan University*
- Chi Lam Cho, *The Chinese University of Hong Kong*
- Yat Tin Chow, *The Chinese University of Hong Kong*
- Eric Chung, *The Chinese University of Hong Kong*
- Philippe G. Ciarlet, *City University of Hong Kong*
- Felipe Cucker, *City University of Hong Kong*
- Jun-zhi Cui, *Chinese Academy of Sciences*
- Lipeng Dai, *The Chinese University of Hong Kong*
- Xiaomao Deng, *Chinese Academy of Sciences*
- Xiaojun Duan, *National University of Defense Technology*
- Weinan E, *Peking University / Princeton University*
- Yalchin Efendiev, *Texas A&M University*

- Björn Engquist, *The University of Texas at Austin*
- Roland Glowinski, *University of Houston*
- Joachim Heinze, *Springer-Verlag GmbH*
- Lei L. Hou, *Shanghai University*
- Thomas Y. Hou, *California Institute of Technology*
- Johan Shu-ren Hysing, *Shanghai Jiao Tong University*
- Khalide Jbilou, *Université du Littoral Côte d'Opale*
- Shi Jin, *Shanghai Jiao Tong University / University of Wisconsin*
- Sung Ha Kang, *Georgia Institute of Technology*
- David Keyes, *Columbia University / King Abdullah University of Science and Technology*
- Fande Kong, *Chinese Academy of Sciences*
- Yoo Young Koo, *Yonsei University*
- Rongjie Lai, *University of Southern California*
- Ka Chun Lam, *The Chinese University of Hong Kong*
- Ka-Sing Lau, *The Chinese University of Hong Kong*
- Chak Shing Lee, *The Chinese University of Hong Kong*
- Tsz Ho Lee, *The Chinese University of Hong Kong*
- Tim Leung, *The Hong Kong University of Science and Technology*
- Wing Tat Leung, *The Chinese University of Hong Kong*
- Chi-kwong Li, *The College of William and Mary*
- Kaitai Li, *Xi'an Jiaotong University*
- Wenbin Li, *The Hong Kong University of Science and Technology*
- Jae Kun Lim, *Hankyong National University*
- Qun Lin, *Chinese Academy of Sciences*
- Feng Ling, *Zhaoqing University*
- Dongjie Liu, *Shanghai University*

- Haixia Liu, *The Chinese University of Hong Kong*
- Jiewei Liu, *The Hong Kong University of Science and Technology*
- Keji Liu, *The Chinese University of Hong Kong*
- Ronald Lui, *The Chinese University of Hong Kong*
- Li Luo, *Chinese Academy of Sciences*
- Tsz Fan Mak, *The Chinese University of Hong Kong*
- Jie Min, *The Chinese University of Hong Kong*
- Esmond G. Ng, *Lawrence Berkeley National Laboratory*
- Michael Ng, *Hong Kong Baptist University*
- Qiang Niu, *Xi'an Jiaotong-Liverpool University*
- Stanley Osher, *University of California, Los Angeles*
- Zhi-Feng Pang, *Henan University*
- George Papanicolaou, *Stanford University*
- Li-qun Qi, *The Hong Kong Polytechnic University*
- Yousef Saad, *University of Minnesota*
- Sally S. Shao, *Cleveland State University*
- Zhi-Qiang Shao, *Fuzhou University*
- Xiaoqin Shen, *Xi'an University of Technology*
- Zuowei Shen, *National University of Singapore*
- Feng Shi, *Chinese Academy of Sciences*
- Yu-Ying Shi, *North China Electric Power University*
- Zhong-ci Shi, *Chinese Academy of Sciences*
- Stephen Smale, *City University of Hong Kong*
- Gilbert Strang, *Massachusetts Institute of Technology*
- Feng Sun, *The University of Hong Kong*
- Jiachang Sun, *Chinese Academy of Sciences*

- Eitan Tadmor, *University of Maryland*
- Xue-cheng Tai, *University of Bergen*
- Tao Tang, *Hong Kong Baptist University*
- Ahmed Touhami, *Hassan 1st University, Morocco*
- Man Ho Tsang, *The Chinese University of Hong Kong*
- Justin W.L. Wan, *University of Waterloo*
- Jenn-nan Wang, *National Taiwan University*
- Shiping Wang, *The Chinese University of Hong Kong*
- Tianming Wang, *The Chinese University of Hong Kong*
- Xiao-ping Wang, *The Hong Kong University of Science and Technology*
- Chengfeng Wen, *The Chinese University of Hong Kong*
- Tsz Wai Wong, *University of California, Irvine, USA*
- Meihua Xie, *National University of Defense Technology*
- Jinchao Xu, *Peking University / Pennsylvania State University*
- Jing Xu, *Zhejiang Gongshang University*
- Xinyi Xu, *The Chinese University of Hong Kong*
- Kan Yan, *The Chinese University of Hong Kong*
- Zhengzheng Yan, *Chinese Academy of Sciences*
- Shing-Tung Yau, *Harvard University / The Chinese University of Hong Kong*
- Akinade Yemi, *Globalair Services and Logistics International Ltd.*
- Man-Chung Yeung, *University of Wyoming*
- Guojian Yin, *The Chinese University of Hong Kong*
- Shihui Ying, *Shanghai University*
- Andy Yip, *National University of Singapore*
- Ronghao Yu, *The Hong Kong University of Science and Technology*
- Tang Fei Yu, *The Chinese University of Hong Kong*

- Xiaoming Yuan, *Hong Kong Baptist University*
- Ya-xiang Yuan, *Chinese Academy of Sciences*
- Man Chun Yuen, *The Chinese University of Hong Kong*
- Tieyong Zeng, *Hong Kong Baptist University*
- Pingwen Zhang, *Peking University*
- Qi Zhang, *The Chinese University of Hong Kong*
- Qian Zhang, *The Hong Kong University of Science and Technology*
- Xiaoqun Zhang, *Shanghai Jiao Tong University*
- Hongkai Zhao, *Peking University / University of California, Irvine*
- Liuqiang Zhong, *South China Normal University / The Chinese University of Hong Kong*
- Hua Zhong, *The Hong Kong University of Science and Technology*
- Hao-min Zhou, *Georgia Institute of Technology*
- Qianwen Zhou, *The Chinese University of Hong Kong*
- Wei Zhu, *The University of Alabama*
- Jun Zou, *The Chinese University of Hong Kong*